Project Development and Definition

European Construction Institute

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Its vision is of:

A strong, globally competitive European engineering and construction industry able to meet the challenges of world class project delivery

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Author's note

My career has included responsibility for many projects, large and small, with varying degrees of complexity. It has become crystal clear both from my own experience and from discussion with many others involved in project management, that the quality (or lack of it) of the initial development and definition work will have a major influence on the success of the project; it is arguably the single greatest factor in influencing the outcome. Even where a project is judged to be an overall success despite deficient development and definition, it is most probable that it would have been executed more efficiently (and hence at lower cost and possibly shorter duration) had the appropriate development work been carried out.

Most published literature covering engineering project management does address project development and definition, but typically it occupies only a small part of the whole. Given that most of the key strategic project decision making and more detailed planning should be carried out in this development and definition phase, which have a major impact upon project outcome, I consider that it is entirely appropriate to produce a handbook which focuses entirely on this. Some readers may conclude that it addresses most aspects of project management. This is in fact so and I make no apology for it as the definition phase properly executed will need to address such issues.

The requirement for good quality development and definition applies to all projects large and small. Indeed, the extent of work required properly to develop some (more complex) small projects will be proportionately far greater than for most large projects, yet it is these smaller projects which more commonly suffer from lack of adequate preparatory development and definition.

I believe that my comments are generally valid for all types of projects, although the exact requirements for each type will be quite different. This handbook will confine itself to the development and definition of engineering projects aimed at constructing, extending or modifying manufacturing facilities and associated infrastructure in the process industries.

It is my sincere hope that the handbook will provide useful guidance and information to all those involved in the development and definition of engineering projects and thereby improve project overall performance and likelihood of success. Additionally, it should help them to convince others of the vital need for such work prior to embarking upon project implementation.

Chris Fox
September 2005

Acknowledgements

The contents of this handbook are substantially based upon my own experience including learning both from successes and from mistakes; any deficiencies are mine. Nonetheless, the content has been greatly enhanced by valuable information and advice freely given to me by a number of experienced professionals based upon their experience and the practises of the companies they are employed by. They are listed below and I express my sincere gratitude.

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Chris London	BP
Michael Kane	Procter & Gamble
Mark Ravenscroft	Shell UK
John Oldfield	Shell UK

My thanks are also especially given to Stephen Weatherley of the ECI who has reviewed the entire draft document and made a number of constructive points which have been included.

Notes for using this handbook

The handbook has been written in a number of discrete sections to facilitate reference to specific topics on an as needed basis. Cross references are made to other sections as appropriate.

There is no clear time flow for the order in which the sections have been included, as a feature of project development is that many aspects of the work occur in parallel or overlap or are revisited as development progresses. Parts of the document identify requirements, others activities and how to best execute and manage them.

Some examples are given in the text in order to help explain the points being addressed and additionally the Appendices provide further examples and user tools.

A number of sentences have been printed in bold text in order to highlight points which are considered to be of key importance.

Terminology is always a problem in documents which address business management issues, and engineering project development is no exception. It is perhaps the case that there is greater variance in terminology between different organisations than there is in the way they actually carry out project development work. This handbook has adopted use of terms with which the author is most familiar. In most cases the meaning of the term will become clear by reading the supporting text.

I have highlighted in bold text a number of statements which I consider being of importance, but which are often neglected.

Foreword

Construction, covering the process industries, infrastructure and building, is Europe's largest industry, with annual sales approaching €1,000 billion and a workforce of over 8 million. With fierce competition in an increasingly globalised market, the industry is under constant pressure. The European Commission has estimated that the cost of non-quality in construction at €80bn annually and a whole range of other indicators show that good practice is sorely needed.

ECI has been at the forefront of good practice development since 1990. Our mission is to develop and maintain industry-wide, sustainable performance-based cultures by:

- promoting co-operative, aligned practices throughout the value chain
- identifying and supporting the application of world best practice
- maintaining a powerful, relevant and user-friendly knowledge base
- networking with other competent organisations

Effective project definition is a cornerstone of good practice. Engineering and construction projects are important components of business investment processes. Unless projects are properly defined, their chances of success are slim, often posing a significant risk to the overall business.

This ECI handbook, written by Chris Fox, contains a wealth of good advice. All construction clients will be well advised to read it carefully and ensure that their own practices and procedures take its recommendations into account. The stakes are high.

Terry Lazenby
Chairman
ECI Operations Committee

1. Introduction

A project is the totality of the carrying out of a series of activities aimed at achieving defined objectives. It is time-bound in that there is start and a completion, as opposed to those types of activity which are ongoing and have no defined start or finish.

There are many different types of engineering project. These cover the whole spectrum of construction activities from greenfield to refurbishment and housing to infrastructure to manufacturing, but also many other activities such as IT systems or new product development in the automotive, aerospace and other manufacturing industries.

An inherent part of almost any manufacturing business is the requirement from time to time to carry out engineering projects with the objective of meeting changing business requirements such as maintaining or increasing production capacity, making new products or meeting regulatory obligations in a competitive environment. The effectiveness with which a company carries out such projects is likely to significantly impact upon its overall long-term ability to remain in business.

If a project is very simple, it might be appropriate to start implementation activities immediately once the objective has been established. However, for anything other than the most basic exercise, failure to carryout adequate planning, development and definition is likely to lead to unforeseen problems, delays, extra cost and possible project failure. Project definition identifies the main requirements for implementation as well as providing a benchmark against which the eventual outcome can be measured.

A key aim of development and definition work must be that the final definition package, including associated plans, strategy and estimate, is accepted by all relevant parties and that they commit to supporting the requirements to achieve effective project implementation. Equally, the strategic decisions made within the development phase will have a major influence on project outcome.

The objective of this handbook to provide advice and methodologies appropriate for the development and definition of engineering projects aimed at constructing, extending, modifying or maintaining manufacturing facilities associated with the process industries.

2. Applicability of the handbook

This handbook aims to provide insight, guidance and advice in respect of good practice in the identification of objectives, initiation of proposals, planning, development and definition of engineering projects for the construction, extension or modification of manufacturing facilities and related infrastructure in the process industries. Much of the content would also be generally applicable to major maintenance overhauls and major repairs to these manufacturing facilities.

Where an organisation is continuously or frequently engaged in the development of projects it is strongly recommended that it should have a documented development process in order to provide a clear and appropriate methodology and content for such work.

This handbook should provide guidance for development of such processes where none presently exists as well as a means of checking and enhancing where needed those that are already in use.

It must be noted that the extent and nature of the pre-planning, development and definition that are optimally required in order to achieve a good quality definition for a given engineering project is dependent upon many factors, which include:

- scale of the project
- complexity of the project (technical, commercial, regulatory etc)
- number and diversity of possible options meriting consideration
- number of stakeholders actively involved
- new site / existing site
- procurement and contracting strategy
- requirements of owners authorisation procedures
- financing requirements - internal / external (banks etc)
- regulatory requirements
- proposed project timeframe
- extent of specific technical requirements
- extent of specific project procedural requirements

This handbook aims to provide comprehensive information and guidance for all cases. **The extent to which the content is utilised must be selected and customised to meet the needs of the specific project.** It would be quite wrong to suggest that all elements of the handbook content should apply to every project. It is the role of the project development manager and their team, in conjunction with the business owner (and possibly other stakeholders), to determine the appropriate requirements and how they will be met. It is possible to carry out too much work in the definition phase leading to delay in commencement of implementation, excessive definition phase cost and the risk of wasted effort in the event that the project does not proceed. It must, however, be noted that this situation rarely arises in practice.

Whilst the handbook is not aimed at other types of engineering projects, some elements of the content may well have applicability to such projects, though there would also be other requirements not covered by the handbook.

Engineering maintenance and minor plant modification works have some similarities to engineering projects, and require appropriate pre-planning if they are to be carried out effectively. However, many parts of this handbook would only be generally applicable to major overhauls or major repair / renovation works extending over a period of several weeks or longer.

3. Phases of project development and definition - overview

Typically the development and implementation of a project will progress through a number of phases (or stages) before it is finally fully authorised for implementation.
These may be summarised as follows:

A Project development and definition

1. generation of idea, opportunity or requirement
2. concept and feasibility studies. Review of objectives, confirm fit to business objectives
3. initial development, including refining of options
4. detailed development
5. project definition
6. preparation of project execution strategy / plan (PEP) and detailed estimate
7. project financing

B Project authorisation

C Project implementation (see notes below)

8. project detailed design
9. project procurement
10. project construction
11. project handover and commissioning
12. project close-out

D Project in service

Project detailed design and other implementation tasks may in some cases be initiated within the development phase (see Section 22). Occasionally, a strategy may be adopted where essentially the whole design is executed in order to provide the highest degree of cost certainty before requesting final authorisation, however such an approach is unusual in the process industries.

The content of this handbook will address in detail only items 1 to 7 above, although reference to the implementation phase works will be made where considered appropriate.

In practice, for all but the simplest of projects the work does not entirely progress chronologically from step to step. There is often overlap, iteration and need to revise earlier work. For example, as development progresses it may be decided that it is appropriate to modify the initial objectives. Detail design may commence before all elements of the project definition are complete.

Deliberately excluded from the listing above are the various review and approval steps which are likely to be required. The position (points in the development process) of these will depend upon the requirements of the client or owner (and possibly other stakeholders) and the specific needs of the project. However, for all but simple, low cost projects it is strongly recommended that there are reviews at appropriate stages in the development prior to seeking final approval for implementation.

The management of reviews and approvals can usefully be achieved by the adoption of a 'stage-gate' process. Such a process is described in Section 16.1 (see also Appendix A). Clearly, the process will be designed to meet the client's needs, but should also be adapted to meet the specific project needs - that is it must not become a bureaucratic burden for smaller projects.

4. Idea, opportunity, requirement – business objectives

The starting point for any project is an idea, opportunity or requirement or indeed a combination of several. These may arise internally within the owner organisation or from an external source such as a customer, government regulator or even a competitor. For a proposal to be viable, the objectives must be compatible with the achievement of the owner's overall desired / required business objectives. These may be objectives which already existed or ones which arise or are modified as a result of the idea, opportunity or requirement. **The question 'why' needs to be answered and the answer must represent an important need in respect of the overall business of the owner.**

The purpose of the proposal is to fulfil the project objectives. However, an engineering project may be by no means the only way of achieving these objectives. Some will be achieved by other means, some will be modified and some will be abandoned.

It is important that all relevant parties are involved in setting project objectives so that when they are confirmed there is a consensus of support. Similarly, it is strongly preferable that there should be general support for the means achievement.

A statement of project objectives and their compatibility with business objectives should be at the core of any project proposal and should include the following components:

- identify the specific objectives, that is those aspects which, if not fulfilled, will result in the project being a failure regardless of cost, time, execution performance etc. Some background explanation of the objectives is usually helpful. These objectives should be fixed and agreed by all parties as early as is practicable
- identify any other critical success factors. If there is more than a single objective, identify the relative importance of each
- specify other essential requirements, for example absolute maximum cost, installation at a specific date (perhaps plant shutdown). Do not confuse these requirements with desirable but not essential aspects
- identify priority of the project versus other works and whether there is a conflict of available resources or finance. Does the timing of other work need to be reconsidered? This is often an issue for small projects where resources (people and money) are from a shared pool. Has the priority ranking been agreed with key stakeholders? Project portfolio management is the mechanism to resolve such issues when there are constraints imposed by limitations of staff resource or funding as a result of other projects and other business commitments
- having identified the key (primary) business objectives, assess the relative importance of project cost, schedule and quality (ability to safely and reliably manufacture product to a required specification). Ensure that the outcome of this assessment is agreed by the business management
- identify any major consequences (which are not objectives) which are likely to result from implementation. These might include, for example, the closure of another plant, likely response from competitors, relationship with regulatory authorities etc. These issues may influence a decision to proceed, selection of option, project scope and cost

- Remember **– a project which is on time and within budget, but which does not fulfil primary objectives is a failure!**

It is important to challenge the initially-stated objectives in to ensure that they are sound and fully compatible with overall business objectives. For example, expanding a manufacturing facility is not a sound objective without a high probability that the additional product can be sold profitably. This challenge should be carried out as early as is practicable but needs based upon sound data. In the example above the sales / marketing group would be expected to provide:

- a projection of future business expectations
- the basis upon which those projections have been developed
- the risks associated with the data provided
- potential action from competitors

5. Project development management

Effective management of project development is as important to the outcome of a project as implementation and in some respects presents more challenges. The project implementation strategy and project definition are the main deliverables from the development phase and provide the foundation. If they are inadequate, then the project has a high probability of encountering significant problems in its implementation.

Some of the main challenges are:

- at the outset of the development of a project it is often not clear as to exactly how the project will develop and how much work will be required to complete the development. Strong management is required to ensure that the development proceeds in an ordered manner, minimising so far as is practicable work on elements / options which are eventually discarded and avoiding delays through lack of decision making and / or lack of resource

- many of the parties who will contribute to the development process will not be core members of the development team and yet they will need to be managed to ensure that their input is both timely and of the quality required

- gaining and maintaining positive support for the project and its development from senior business management may require considerable skill and effort. A 'stage-gate' review and authorisation process (see Section 16.1 and Appendix A) can assist in this.

- where a contractor is used to carry out elements of the development work, it is most probable that they will require considerable support and supervision (possibly proportionately far greater than for project implementation work)

5.1. Project development process

The development (and indeed the implementation) of any project is a process which involves the carrying out of work, reviews and analysis, involvement of various parties and decision-making in a structured manner. All of this is the process by which the project is developed and later implemented.

To ensure that for every project the process is comprehensive, appropriate and clear to those involved, it is highly desirable to have a documented project development process. This should be used as the basis for all such work and will be a company business process approved at senior management / board level. Such a documented process is in fact a quality assurance system.

A project development process should address:

- processes for of the main activities and work steps likely to be required and the approximate sequence of each relative to others
- all reviews likely to be required, timing and information needed for such reviews and who will be responsible for the review
- stage authorisations required and documentation required supporting requests for authorisations. (see also Section 16.1 and Appendix A)
- requirements for the final project definition documentation
- project final authorisation process (see also Section 16.6)
- identify responsibilities in respect of all the above
- identify which elements of the process are mandatory and which are discretionary. It is important to provide flexibility to meet the reasonable needs of individual projects. In general, smaller, simpler projects will need a less extensive development process
- identify linkage to the project implementation process. ideally, the two processes can be fully integrated into a single project process
- a mechanism by which the project development process is updated to reflect learning from experience

The content of this handbook is intended to cover nearly all of the elements which would commonly be contained within a project development process, although it is not formatted as such.

5.2. Role of the project development manager

The role of the project development manager is to manage and coordinate all the activities, including decision making required in order to progress the development and definition of the project proposal. The nature and extent of the works involved is dependent upon the type and scale of the proposals. To a much greater extent than during project implementation, the work, information and decisions required will be from parties not directly controlled by the development manager. For larger project proposals there are likely to be numerous interfaces with external organisations. For all but the simplest of proposals the required capabilities for this role will include:

- skill related to working with and influencing others. This must include the capability to handle interfaces outside the owner's organisation
- the ability to manage a project development team, recognising that this may to a considerable extent include personnel who have other responsibilities and may not have a line (management) relationship with the project development manager
- a sound understanding of overall business objectives and how the proposal fits into these
- ensuring that the development team remain focused on meeting the agreed proposal objectives. Avoidance of drift from objectives
- the capability to prepare and manage a credible development strategy

- keeping the owner's senior business management informed and, when necessary, highlighting any problem issues and seeking agreement to proposed solutions

- understanding of the requirements of the owner's project authorisation procedures
- a sound basic appreciation of the engineering required. This is not a requirement at expert level, but an ability to interface with and manage others who are experts
- understanding of project implementation requirements and an ability to develop a project implementation strategy

Two other roles are closely linked to the project development manager. These are the project sponsor and (where applicable) the venture manager.

5.3. Project sponsor

A project sponsor should be identified for every proposal once initial development has been agreed. The sponsor should be a senior manager who has a **direct interest in the achievement of the objectives against which the proposal is being developed.** Ideally, the sponsor should be one of the business management team responsible for final project authorisation. Hence the larger the project, the more senior the sponsor should be. The role of the sponsor is to support the development manager (and later the project manager) in respect of development of overall strategy, obtaining support and getting decisions from the owner's senior management and assisting development manager in problem-solving when necessary. The sponsor should review progress of the development work on a regular basis and agree any needed remedial actions or plan revisions. A key aspect in which the sponsor can assist is in obtaining commitments for needed resources for the development work.

5.4. Venture manager

For many major project proposals, especially those which involve the development of a completely new site, the owner's business organisation will appoint an overall venture manager responsible for all aspects of the project's development and implementation. This function encompasses the overall role of the project development manager, but recognises that in such project developments many of the key aspects are no longer engineering-related but encompass most aspects of business development and are likely to require interaction with both internal management at most senior levels and with senior representatives of external organisations. Typically, the venture manager will have working for them one or more engineering project development managers responsible for the development (technical and commercial) of the engineering project elements of the overall proposal.

5.5. Selecting the project development manager

If a project proposal is to be developed in an orderly manner, it is important that someone is identified as having overall responsibility for the development work. Regardless of who is designated, it is important that the individual has not only the required skills, but also the motivation and time available to carry out the work to the required quality in the agreed

timeframe. The key capabilities for a project development manager are given in Section 5.2 above.

Whilst changing managers always involves some disruption, changing between initial development phase, detailed development phases and project implementation should not be excluded as requirements for these phases may be best met by individuals with differing capabilities. However if such changes are to be made, then there must be an orderly transition with sufficient overlap to allow the incoming manager to gain a sound understanding of the development to date and its history.

Additionally, the development work will usually require input from others and their availability is also a key to achieving quality and target development schedules.

5.6. Project development team

Other than for the very simplest of project proposals, the development and definition work will require the active involvement of a team of individuals. This may be entirely resourced by the owner or they may seek the help of consultants / contractors. Many of the requirements for an effective team are similar to those needed for the team implementing a project. There are however a number of specific issues which will need to be addressed.

In the early stages, it is likely that the 'team' will be very informal, consisting of a number of individuals from different business functions (for example engineering, operations, finance, sales technology) who have an interest in the proposal. Almost inevitably, for all those involved, the proposal will represent only a fraction of their workload and in most cases not their priority. They may be physically remote from one another. It is therefore of great importance that a proposal leader (this may be before a development manager has been formally appointed) strives to maintain interest and commitment of all involved so that the early stage work proceeds in an orderly manner against an agreed schedule, rather than simply drifting along. This person should ensure regular updates of status and identification of outstanding action items and responsibilities. If it becomes necessary to revise the development schedule, then a revised set of targets should be agreed by the team. Regular status reports are valuable provided that they are concise and focused on key issues. Such reports will also keep overall business management informed.

One of the key tasks of the early stage development is to confirm the objectives of the proposal. These are not always obvious and there may well be divergences of opinion between different functions. It is vital that the team resolve this issue and publish an agreed set of objectives for confirmation by the business. Once fully agreed, it is important that the development team remain focused on fulfilling these objectives.

A key requirement for a development team is provision of specific knowledge covering elements such as commercial needs, technology or knowledge of existing plant. It may be a key determinant of who are preferred as team members. If the team utilises people without the required knowledge, then no matter how skilled and experienced they may be, they will spend considerable time in gaining the required information, largely through briefings supplied by others. However, it must be recognised that the preferred individuals may well be in positions where it is difficult to gain release to the project development team and compromises may be needed.

Throughout the development process, team members will be involved on a part-time basis. If the work is to proceed to a clear schedule, then team members must be available to carry out work as required by the schedule. There is therefore great merit in ensuring that the schedule is developed and agreed by the team. If it appears that an acceptable schedule cannot be agreed due to other commitments, then business management must be asked either to change team members' priorities or to accept a longer development. Even with an agreed programme it is almost inevitable that changed or conflicting work requirements will arise either related to the proposed project and / or in respect of team members' other work. It is therefore vital that when this arises it is immediately highlighted and the project development manager identifies necessary remedial action. Given that many team members are part-time it is essential that a clear commitment is obtained from the line manager of each tem member to the time and priority required for the team member to carry out their duties.

It is not uncommon for the development phase of a project to be much longer than the implementation phase. Even the development of small projects may take 2 or 3 years and for large projects the development time may exceed 10 years. In general, development schedules are highly vulnerable to slippage for many reasons, most of which are largely outside the control of the development team. With extended development phases it is almost inevitable that there will be periods when very little development work is proceeding. In such cases, it is important that the development manager maintains the interest of the team. This can be achieved with the issue of information notes or newsletters and occasional short meetings. The project team must also be kept informed about potential changes in the availability of members.

The intermittent nature of development work presents a particular problem when a consultant or contractor is used and it is of great importance that this issue is openly addressed prior to the engagement. See also Section 5.7 and Section 11.

Due to extended development schedules there is a significant risk of unavoidable change in team membership. Where change occurs due to project development skill or knowledge requirements, then there is no significant problem provided there is an orderly handover: indeed it may well assist in fulfilling the requirements of the development work. However, it is a far greater problem when a valued team member leaves for reasons not related to the project development needs and especially if this is unforeseen. If this does occur, it is likely to be disruptive to the development work and proactive steps must be taken to mitigate the impact. These may include the following actions:

- identify the impact and if sufficiently serious aim to reverse the decision
- negotiate a deferment until a point in the programme which would cause less disruption. This would also allow for better handover to a successor
- identify skills and knowledge requirements for successor(s). These should look to future needs, addressing issues beyond those caused by an individual leaving
- consider possibilities for reallocation of future work to other team members
- ensure that all relevant work and information held by the person leaving is properly filed and accessible. This should include background data as well as direct development work
- carry out a handover meeting involving all those in the team with whom the person leaving has a significant interface. This should review the status of work of the person leaving and focus on outstanding issues
- if possible, agree the possibility of future contact with person leaving to allow any needed clarifications

5.7. Utilising a contractor or consultant for management of project development

It is not normally practicable to utilise a contractor to manage initial development work on a proposal. Requirements for specific knowledge and the number of required interfaces within the owner's organisation would make the task near-impossible. Where the owner employs a site-based contractor on a long-term alliance basis, it may be feasible in relation to small and medium-sized proposals for the contractor to carry out certain elements of early development. In such cases, the relevant contractor's site-based project managers may have gained sufficient specific knowledge and relationships with the owner's staff to make this possible. The contractor will always require overview supervision, which can be provided by a combination of the project sponsor (which must be an owner's manager) and the owner's alliance manager.

Once the basic parameters of the project proposal have been identified and agreed, the work moves on to detailed development and definition. From then on, it is entirely feasible to utilise a contractor / consultant to carry out and manage most of the work. Again, it will be necessary for the owner to provide overview monitoring and supervision, to give necessary guidance and to participate in and give approvals for key decisions. If a contractor / consultant is to be used in such a manner, then it is vital that the owner provides a clear statement (mandate) of what is required and how it should be provided.

See also Section 11 – Use of consultants and contractors for project development and definition.

6. Initiation and early development

6.1. Concept and feasibility studies

This initial stage of a major project proposal is usually driven by the business.
The fundamental issue is to identify whether, in principle, there is a venture proposal which has the potential to be sufficiently profitable (and / or meet other important objectives) and fit into the overall business strategy of the company. If, as is often the case, there are a number of options, then a comparative assessment to select preferred option will be needed. For smaller projects, the principles are the same, although the party driving it will be the more local beneficiary such as site management, plant operations or maintenance.

In addition to the business / financial / market development issues, there are a number of other issues which will need to be addressed at this stage.

1. having identified the fundamental 'why?' for the proposal being considered, categorise the objectives into those which are core to achieving the business needs and those which are merely desirable. For the latter, it is useful also to identify the negative impact of non-fulfilment. If this is shown to be severe then that objective may well be core to the business
2. what are the main merits and demerits of the various options? If possible, aim to rank their importance
3. what is the foreseen priority and hence timing for the proposed project? Are these likely to be significantly different for the various options?
4. develop first-pass order of magnitude estimates for each of the main options. These will not be high accuracy, no better than ±30% and often ±50%, but are suitable for comparative purposes including testing of project return on investment sensitivity to different cost figures and options
5. prepare an initial estimate of funding foreseen to be needed for project development and identify the source(s) of this. Initiate steps needed to ensure this funding will be available when required
6. **identify and assess any issues which may be 'project killers'**, such as:
    a. any significant doubt about the likelihood of sales and price levels achieving acceptable profitability within a reasonable timeframe
    b. the availability of reliable and economic feedstocks
    c. the availability of land for the project
    d. availability of required utilities
    e. any major regulatory issues
    f. any incompatibility with overall business objectives
    g. possible action by competitors
    h. an unstable political environment

7. Identify and roughly evaluate any other items which could significantly impact on project costs such as:
    a. financing costs (especially if external)
    b. process licence costs
    c. need for new buildings
    d. costs associated with product handling and logistics
    e. utility and feedstock upgrading and connections
    f. land upgrading, including building new roads, and general infrastructure upgrading
    g. staff recruitment and training

6.2. Initial development

The purpose of this phase is to study the proposal in order to further assess viability, identify the basic scopes, identify and assess options and other parameters. In particular, the following tasks must be addressed:

- revalidate the merit of the idea, opportunity or requirement. Confirm the objectives and the fit with overall business objectives
- evaluate the options in respect of their potential to fulfil the objectives
- identify any major risks which apply to any or all of the options. These are risks which may fundamentally affect option selection and / or the decision to proceed unless there is a clear possibility of eliminating or mitigating them
- develop order of magnitude estimates. **The limitations of such estimates should always be highlighted to all parties, in particular business management** who will later be asked to authorise the project against a more definitive estimate
- identify key issues, including those covering safety, health and the environment (SHE) and personnel issues
- determine a preferred option and evaluate its basic technical and economic validity. It may not always be possible to achieve a single preferred option at this stage, but at least a short list for further development should be identified and agreed. A summary reasoning for selections should be provided
- prepare a strategy and outline scope of work for the further development and definition of the project (see Section 8)
- initiate development of the project implementation strategy
- develop an initial outline project development and implementation time plan
- identify resources and funding needed for the next phase
- identify approx requirements for any significant off-plot facilities
- if the strategy for next phase includes use of external resource, initiate the identification of suitable consultants / contractors and develop of terms of engagement
- identify the priority of the project development within the overall programme of projects. If it merits a high priority, this may require deferment of other works. Priority will need agreement with the project sponsor and possibly also with senior business management

- identify likely required process licences, initiate negotiations with licensor(s)
- for projects of significant cost, provide a 'first view' indication of possible cash flow requirements
- ensure business support where applicable
- an additional aim of this initial phase should be to cull those numerous proposals which do not have sufficient justification to be implemented. Too often, this does not happen and they linger on (sometimes for years) with occasional further work consuming resources and money

This phase should not normally progress beyond the above without further authorisation, in order to avoid additional work on items which may subsequently not be supported for further development.

6.3. Selection of best solution to achieve business objectives

Selection of the best solution to meet business objectives is a vital element of the early development phase of projects. Adoption of the best solution may yield huge benefits in terms of time, cost and other factors versus other solutions and hence maximise benefit to the business. It is not a sin to have second thoughts in the project development phase. It is entirely sensible at this time to review any and all proposed possible projects to check thoroughly that they constitute the best option for the business both technically and commercially. The costs and other impacts of making changes at this stage are far less than doing so later on. A rough 'rule of thumb' suggests that:

- if the cost of making a change during development = 1
- the cost for the same change initiated during detailed design = 3 to 5
- the cost for the same change initiated after start of construction = 10 to 30

It is therefore essential to achieve a firm scope and strategy as key objective of project development

The review process needed to identify the best solution should include all relevant parties and may well be iterative. A diverse team to identify and consider options is more likely to identify the best overall solution for the business. The diversity of options will naturally depend upon the nature of the objectives. A project aimed at improving plant reliability is unlikely to require input from marketing, whereas one which is intended to deliver an enhanced product certainly will. An objective such as reliability improvement may be achieved in some cases by improved operation, monitoring or maintenance as opposed to a capital project: such options should be analysed as part of a best option assessment.

Option evaluation should be carried out as soon as there is sufficient information available to allow a reasonable assessment. Reasons for option selection should be recorded. Requirements are likely to include:

- identification of all possible means of achieving the objectives. This should include non-project solutions where appropriate
- challenging the proposal

- challenging the need for an engineering project. It may be possible to achieve the objective by other means: for example, giving employees enhanced skills may avoid the requirement for expensive automation
- in some cases a solution which meets modified objectives will yield the maximum business benefit. For example, it may be possible to expand capacity by 80% of an original objective for only 30% of the indicated expenditure needed fully to meet the objective. This could be a very attractive option
- carrying out 'order of magnitude' estimates for options. Even though these estimates will not be precise, they will allow broad cost comparison of options
- identifying 'order of magnitude' operating costs for the options as input data to economic evaluations
- identifying the importance of completion by a given date. What are the key dates and can the different options meet them? What are the implications of earlier or later completion? What are the financial risks associated with failure to meet dates
- identifying and evaluating technology risks. What is the risk of the chosen option not being capable of achieving objectives? If there is significant risk, what would be the required remedy?

Selection of the best option should be carried out as early in the development phase of a project as is practicable and should only include that work needed for a sound selection. Allowing consideration of multiple options for longer than is strictly necessary is likely to delay a project as well as adding to the cost, so there needs to be a balance between early selection and ensuring, so far as is practicable, selection of the best option. This may well involve progressive whittling of the number of options being considered.

The time requirement for option selection will vary. For some projects (usually large ones and those which involve joint ventures), the time required may be influenced by the ability to obtain decisions from other parties such as government, partners and potential customers. The following should be addressed:

- for smaller projects with an immediate business benefit (including regulatory obligations) a decision on preferred option should, wherever practicable, be made quickly. Provided the chosen route is a no risk or low risk option and is also not unduly costly, early completion will often outweigh any benefit from spending an inordinate time trying to finesse best option
- for some projects, one option is easily identified as being clearly the best. In such cases it should be rapidly be confirmed as the way forward and no further effort wasted on other options. **Work on 'no hope' options, and indeed 'no hope' proposals, is a major waste of resource, time and money**
- for some objectives, there may be diverse options and indeed these may require considerable work over an extended time frame to resolve. In such cases, initially it may not be clear which option provides the maximum business benefit and the different issues to be addressed may be many and complex.
  Appendix B provides two example

- be willing where appropriate to recommend the ‘do nothing’ option. If the proposal does not have sufficient merit and / or none of the options provide a satisfactory solution, then a decision to do nothing should not be shirked. Very often this decision is made far later than it could have been and much valuable resource time has been wasted. However, it must be noted that the ‘do nothing’ option is not necessarily a ‘no cost’ option! Doing nothing may well forfeit the benefits accruing from a project and result in higher business costs and / or loss of potential revenues
- there are occasions when the do nothing option is not acceptable, such as regulatory obligations or situations which result in significant commercial impairment. If none of the proposed options is considered satisfactory, then further work to develop an acceptable solution must continue and may need to involve external specialists to provide expert advice
- ensure the resources needed to carry out option development and selection have been identified and will be made available as required to meet the agreed work and evaluation schedule

Note:
Option selection has similar characteristics in principle to value engineering and analysis. It should, however, not be confused with the more detailed value engineering exercise which should be carried out later in the project definition work phase. The latter is aimed at refining (optimising) an already agreed overall choice of solution.

7. Identification and engagement of stakeholders

Every idea, opportunity or requirement and any subsequently-arising project proposal will have a number of parties, who for a variety of reasons have an interest in the development. These are usually referred to as 'stakeholders'. The reasons for the interest of different stakeholders will vary and in some cases may be incompatible with one another. Occasionally a stakeholder's interest may be negative, in that they do not wish the proposal to proceed and may actively try to frustrate progress. Some stakeholders will be overtly interested and involved in the development, others may only become active as development progresses and some may remain passive.

It is incumbent on those responsible for the development of the project proposal, principally the project development manager, to identify the stakeholders and their interests. In respect of key stakeholders, who have some power to affect the progression of the project proposal, it is important to ensure that they are properly informed, consulted and persuaded that the proposal is fulfilling their interests or at least they accept it as the best practical solution to their identified core needs and objectives. In respect of some controversial project proposals this may not always be achieved and other steps will be required to allow the project to proceed.

Most large projects and many smaller ones will require a permit from the local government regulatory body to allow construction and use. Hence the regulatory body is a key stakeholder. Additionally they are subject to influence from other stakeholders such as local community, SHE regulatory bodies, highway authority and special interest groups, who are therefore also stakeholders.

A listing of the more common stakeholders is provided in Appendix C.

8. Project development strategy and plans

Project development strategy and plans are needed to identify how, in terms of methodologies, resources, timings and the like, the development processes, information requirements and deliverables will be achieved. The development and definition phase of a project may, dependent on scale, complexity and other issues, require in itself considerable work, the use of skilled resources and significant funding. Hence, this early part of a project needs to be planned and controlled if it is to be managed effectively to meet the needs of the business. However, at the start there is almost inevitably a lack of clarity in respect of both the scope and strategy for the project which is only progressively resolved as the development and definition phase progresses to completion. It is therefore likely that the plan for project development will initially be 'broad brush' only, requiring to be updated and revised as the work progresses.

Good practice dictates that, as soon as possible after development work has been initiated, a 'first pass' plan should be prepared outlining foreseen requirements for resources, funding and the overall development and definition timeframe. This should then be progressively refined. In particular as each 'stage-gate' is reached the plan for the next phase of work should be provided in sufficient detail to allow those authorising progression to have a clear understanding of what is work is intended and the strategy for it.

The development and definition phase for a project may well have a longer duration than the implementation phase. Additionally, often at the beginning of development there is a target or aspiration for project completion, but the development and definition may take much longer, for good reasons and bad, than initially anticipated. Except where achievement of a specific completion date is a key business objective, then extended time for development and definition is almost always preferable to inadequate development and definition.

Generally, the work content of the development phase will be, as a proportion of the project total, greater the smaller the project. For small projects (say <€1.0M) it is not uncommon for development cost to exceed 5% of the total, whereas for a major new complex (say >€1.0bn), it is unlikely that development cost will exceed 2% and in many cases will be significantly less.

Note:
These percentage figures exclude any initiation of detailed design, purchase of land, pre-ordering of materials or preparatory construction works which are sometimes carried out prior to full project authorisation.

8.1. Overall project development strategy and plan content

The plan should include:

- identification of the proposal objectives against which the strategy applies
- indication of the boundaries, in terms of objectives, and physical, commercial and financial constraints
- initial outline schedule for overall project development and implementation. Identification of any key dates if applicable

- outlining the proposed deliverables at completion of the development and definition phase
- identification of any key intermediate decisions (and related target dates)
- identification of the 'stage-gate' process or other review method to be used if applicable
- outline of the overall strategy for the development and definition phase works
- identification of the project development manager who will lead the initial phase of the development
- indication of the key people needed for the work, including specific skill / knowledge requirements. If the use of external resources is foreseen, identify how will these be engaged?
- identification of the foreseen funding requirement for the work. This statement of funding required may well need to carry a strong warning that, by the very nature of development work, it is often difficult accurately to assess the work requirement and hence cost until the work has substantially progressed. As a result there is a significant uncertainty as to any requirement for additional funding
- identification of all the internal and external parties to be consulted during the development phase
- if there will be significant interaction between different organisations during the development phase, especially if a contractor is supporting development works, then the requirement for a communication and documentation strategy should be addressed at this time, rather than later in the execution strategy.
  See also Section 12.10

8.2. Project authorisation strategy

See also Section 16.

A key part of the development strategy will be to identify the authorisations to be sought during the development phase and the basis upon which final authorisation will be requested. If the owner has established authorisation procedures, these should be adopted or a specific deviation agreed. Optimal project development and approval will best be achieved by addressing the particular needs of the proposed project, including the business context against which it is being developed and adapting or modifying procedures to fit those needs. Blind adherence to proscriptive procedures could hinder development and delay implementation for no material benefit.

Delay to initially-targeted authorisation timing is a common feature of project development. Whilst such delays may be acceptable for many projects, for those which are particularly time sensitive the implications can be seriously detrimental and will almost inevitably lead to cost escalation.

The authorisation strategy should identify:

- the funding required for the different stages of development
- other aspects for which approval will be requested, for example confirmation of option selection
- the realistically desired timings for authorisations

- the information required to support authorisation requests
- the quality of estimates needed for intermediate authorisations. There is an absolute need to be realistic. The amount of detailing required increases dramatically for higher-quality estimates, and in many cases may simply not be available
- the quality of estimate needed for final authorisation. Again, if a high-quality, low-risk estimate is needed then the work to provide detailed information and prepare the estimate will be extensive and is likely to be the critical path in preparation for authorisation

The need for so-called 10% estimates for project authorisation should be challenged. They often require extensive work and delay the overall schedule. If a project is so sensitive to cost, then it must be highly questionable as to whether it is genuinely an attractive investment. A 20% or even 30% estimate with appraisal including sensitivity to cost overrun should provide sufficient information for approval. All or part of contingency monies can retained by the business in order to limit any perceived risk of the project manager applying inadequate cost control. It must, however, be acknowledged that the more accurate an authorisation estimate the lower is the risk of exceeding the budget: if budget constraints are a key issue then the additional time and effort needed to produce the higher accuracy estimate may be considered worthwhile.

The comment about 10% estimates is less valid for complete new build process plant projects, at least in respect of the core process units, in the case where the plant adopts essentially the same process and similar scale as others recently constructed. In such cases, a good (10% or even better) estimate can be derived from the known actual cost of the already-constructed plant.

8.3. Project development stage plans

The initial overall project development plan is of necessity a ‘broad brush’ overview. However, as the work progresses it is sensible, and may be required by a stage-gate approval process, to provide more detailed planning for the next stage of work within the overall development and definition. The requirements are as for the overall plan but with additional detail.

The plan is the means by which the work is tracked and managed by all those involved. It is probable that as development work proceeds, some elements of the original plans will cease to be valid and hence updating will be required. Whist it is impracticable to update to reflect every small change, the requirement for updating to retain a broadly valid development plan should not be ignored.

8.4. Development plan – some key issues

The following are the more common specific aspects which may significantly compromise the progress and successful completion of project development and definition. It is important to ensure that they are adequately addressed early in the development and revisited as needed at later stages.

1. **Agreeing the project objectives and priorities**
   The requirement for a project arises from an idea, opportunity or requirement compatible with overall business objectives. However, project objective creep often occurs. Almost all projects have multiple stakeholders, within and outside the owner's business, who wish the project's objectives to be adjusted to best meet their individual desires. At the beginning of the project development phase it is perfectly reasonable, indeed desirable, to obtain the views of the various stakeholders in order to agree a definitive set of clearly-stated objectives for the project. However, having arrived at a firm set of objectives, it is essential to avoid their being revisited and revised unless there is a compelling reason to do so. Objective creep / revision is extremely debilitating to effective and efficient progressing of development, typically resulting in additional, wasted work and delays to progress.

   If the fundamental reasons for the project become significantly altered or overall business requirements change, then revisiting objectives and indeed the overall requirement cannot and should not be avoided.

2. **Resurrecting project options previously discarded**
   This leads to additional work and delay. Ensure that sufficient, but not excessive work is carried out to select the preferred options. Aim to consult all relevant stakeholders in option selection. Record the reasoning for selection. Ensure that all involved in the project development are then focused on developing the chosen option.

3. **Provision of resources with the relevant skills and knowledge at the times required**
   Non-availability leads to delay, disruption and possible failure to carry out work to the required quality. Resource availability is one of the most common challenges to project development.

   Where internal resources are to be used, it is essential to get commitment to their availability, especially for those who are not full time members of the development team.

   Where external resources, such as consultants and contractors, are to be used, there is a need to identify how these will be selected and on what basis they will be engaged. It is important to engage those able to do the work required (as opposed to lowest cost) as this will have a significant influence on overall project outcome.
   See also Appendix D.

4. **Limiting the funding available for development and definition**
   Whilst it is sensible to avoid unfettered expenditure, inadequate project definition is likely to result in additional costs or late discovery of the true cost to the owner far in excess of the additional funding needed for a good definition. Additional cost will manifest itself in terms of higher project direct costs, delays in project implementation and potential failure to meet objectives. A stage-gate process provides for progressive release of funding as the development work progresses and the desire of the business owner to proceed with the project is reconfirmed.

5. **Setting and agreeing realistic timings and requirements for approvals**
   It is essential to identify what information will be required for each (stage-gate) approval, how and who will provide this information and how much time and work is needed to obtain it. Almost always some of this information will be from parties

outside the core project development group and it is therefore essential to get specific commitments to the timing and detail of its provision.

8.5. Risk management

For most proposals and projects there is need to identify and manage associated risks. The extent and nature of these risks and how serious a threat they represent is specific to the project and the circumstances under which it is undertaken. Typically, risks present themselves at all stages from early development right through to in-service operation. Most risks are foreseeable well in advance, although some will evolve in their detail and the extent of the threat may change significantly as the project progresses. Risk management should therefore be a continuing element of overall project management.

Many of the risks generally applicable to engineering projects are managed simply by effective overall project management, not least by ensuring that development and definition are sufficient both in detail and quality. The risk management plan can then focus on risks which are specific to the project.

A plan for risk management should be initially formulated early in the development phase of the project and should identify:

- significant risks that would prevent the proposal fulfilling the project objectives. such risks are likely to be unacceptable unless they can be eliminated or significantly mitigated prior to project authorisation
- significant risks associated with an option and which may determine whether or not that option is selected
- other risks which must be resolved or mitigated within the project development phase

Typically a risk management strategy will:

- identify the proposed timings of formal risk reviews and indicate what will be addressed at such reviews, for example business risks, project technical risks, project schedule risks, project cost risks, other risks
- identify a methodology for assessing risks. Appendix K provides a matrix for assessment of SHE and other business risks
- indicate foreseen participation in risk reviews
- confirm how SHE risks will be managed. Normally this is an integral part of SHE management processes and is therefore substantially separate from other risk management
- set out the owner's basic approach to risk management. What is the owner's attitude to acceptance of risks?
    - is the owner highly risk averse or are they willing to accept some risk provided there is management in place to mitigate the consequences?
    - is the aim to place most risk onto contractors or to share risks? The answer will influence forms of contract to be adopted and relationships with contractors
    - is schedule critical? If so, schedule risks may be the most important
    - is new technology involved? If so technology risks will need to be addressed
    - is it intended to provide specific contingency for identified major cost risk items?

- are there risks which may have a significant impact on overall schedule?
  If so, it is almost inevitable that there will also be significant associated cost risk

Typically, an extensive risk review is carried out towards the end of the project development phase, aimed at identifying all significant risks and agreeing strategies for handling them. Such a review should involve not only the project team but also other key stakeholders. Identification is done by brainstorming and all are entered onto a risk register.

It is important to agree a philosophy in respect of management of risks:

- even for relatively small projects, it is possible to identify many potential risks. The list will be far longer than is practicable to manage. It is therefore essential to have a system (typically a matrix of severity / probability) for categorising identified risks. Only those which pose a significant threat will be actively managed
- focus on those significant risks which have a reasonable probability of occurrence. Risks which have high severity of impact but very low probability should be noted, but generally no action taken unless that action is simple
- take care in assessing probability of occurrence. If there is published historic data relating to the probability of the risk, use it, but very often there is none. Cross-check opinions on probability with other professionals with relevant experience to gain additional confidence in the assessment
- identify linkages between different risks. In some cases, the occurrence of one may make another either more or less probable or modify its impact
- do not remove those identified risks marked 'no action required' from the risk register. Such items should be revisited at future reviews as there is a real possibility of change to probability and / or severity. Items should only be removed when it is clear that they are no longer credible or relevant

A risk register is usually developed as a management tool. Each identified risk is listed together with additional information. New risks are added as they arise. Typical content of the register is for every risk:

- an allocated risk number
- a brief description
- a risk ranking (score of probability x severity)
- proposed management of risk (which may be 'no action')
- party responsible for management of the risk
- linkage to other identified risks
- additional relevant notes / comment

8.6. Portfolio of projects

Many client organisations will have a number of projects at the stages of proposal, development and implementation at any one time. Indeed this situation may well apply to a single location within an organisation. In most such cases it is appropriate for management of the business to consider all such items in order to assess the practicability of concurrent working on multiple items in terms of resources required and other constraints. This is commonly known as project portfolio management.

It is important that as soon as a project proposal is approved for initial development, or possibly as a part of its approval, that it is entered into the portfolio list together with initial data covering:

- foreseen total cost
- phasing of expenditure
- people resources needed, including details of specific skills and knowledge requirements
- initial view on priority, with reasons for this
- any other specifics, such as need to install at plant shutdown, legislative obligations etc
- any other significant issues which may change priority or schedule

Portfolios will include a range of projects, including engineering, major maintenance and other types of projects where common resource requirements may apply.

Inclusion of a new proposal, especially if it is of a significant size, may call for an extensive review of the whole portfolio. In turn, this may well result in a requirement to change the priority and timing of the development and implementation of the project and / or result in changes to other projects within the portfolio. However, deliberately delaying progress of projects already in the implementation phase is an extreme step which is likely to have a disproportionate impact upon the cost and progress of the project concerned.

A project portfolio management review may lead to modification of the original project development strategy. This is most likely to be a change in the schedule for development as a result of limitations on resources and / or finance.

Equally, the schedule, work and resource requirements for the development of a project are highly vulnerable to change during the course of the development work. This usually has a consequential impact upon anticipated costs and schedule. Whenever a change of significance occurs it is vital that the project manager ensures that this is promptly entered into the project portfolio data base and that relevant management are informed so that they can assess impact on resourcing and financing of the overall portfolio.

Engineering contractors should operate a portfolio management system in order to assess the impact of actual or potential projects. However whilst this is an important management issue for the contractor, it is not directly a project development and definition topic and is therefore outside the scope of this handbook.

9. Detailed development and definition

The aim of this phase is to carry out all necessary work in order to:

1. define the physical scope of the project and project deliverables (project definition)
2. confirm the technical, regulatory and business parameters against which it is proposed to implement the project
3. authorise the project and release the required funds
4. allow implementation of the project efficiently and expeditiously

The work, time and resources needed to provide the appropriate development and the final definition package will vary according to the scale and complexity of the project and also according to the chosen project implementation strategy.

The following items are typically included in this stage:

1. Confirm the performance criteria for the facility / plant – capacity, product specifications, on-stream factor, efficiencies, grade capabilities, waste product handling, functional requirements for buildings etc
2. Where needed, negotiate and sign licence agreement for process. Include other support from licensor, such as:

    - process engineering support to vet the engineering contractor's work and participate in design and safety reviews
    - agreement of plant layout
    - support engineering specification of key equipment
    - support in development of plant operating manual
    - operator training
    - commissioning support

3. Obtain and review licence design package for inclusion in project technical specification
4. Where no process license is involved, develop process engineering using own / support contractor's expertise
5. Develop process control and safeguarding philosophy as needed
6. Carry out initial process safety reviews
7. Confirm owner's 'in-house' requirements for project management in implementation and commissioning phases and initiate actions to make available
8. Collate relevant 'existing data'. Assess and note accuracy of this data
9. Finalise project implementation strategy
10. Based on the project strategy, prepare definitive project execution plan
11. Award contract for project definition phase works if required and not already done
12. Develop overall plot plans and basic layouts for process units

13. Carry out ground studies. If ground improvement is needed prepare contract for this
14. Develop process scope and routeings for utilities, feedstocks and products
15. Firm up scope for product storage and handling and for packaging facilities. This will require considerable input from both marketing and plant operations as requirements are sensitive to grade range, packaging types, market requirements and operating modes
16. Confirm and specify other items in scope of project, including off-plot items
    - building specifications including their internal utilities and fitting out requirements
    - off-plot interconnections (pipelines, power lines, drainage systems)
    - new roads, paved areas, fencing
    - construction temporary facilities
17. Develop a listing of standards and specifications required for inclusion in the project technical specification
18. Where standards and specifications are project-specific, carry out their preparation.
19. Develop and agree contracting strategy for project implementation.
20. If the implementation phase of the project is to be substantially handled by a single main (EPC) contractor (see also Section 21) then:
    - identify the scope of the EPC contractor's work
    - develop terms and conditions for the EPC contract
    - identify and agree bidders for EPC
    - tender EPC
    - evaluate / negotiate EPC
21. Identify work within the project scope, but outside the EPC contract. Identify responsibilities.
22. Develop and set up contracts for work outside EPC as needed.
23. Complete full project specification documentation.
24. Carry out project authorisation estimate.
25. If needed, progress project external financing.
26. Develop a more detailed overall schedule. Identify critical activity chains.
27. Carry out project commercial and technical appraisal in the detail needed for authorisation.
28. Assess the need for procurement of any 'long lead' items prior to main contract award.
29. Carry out an initial project safety review (prelim HAZOP or other).
30. Carry out scope value analysis.
31. Carry out initial detailed project risk assessment.
32. Agree spare parts philosophy.
33. Develop and submit an application for regulatory planning permission.

34. Develop initial SHE plans related to construction, in line with statutory requirements.
35. Identify requirements for project final documentation.
36. Set up a project accounting system.
37. Set up project authorities.
38. Agree an internal change control process.
39. Carry out an assessment of quality of project definition (front end loading).
40. Prepare and submit project authorisation documentation. If possible, include a recommendation for EPC contract award.
41. Identify and agree action plans for other issues:

    - requirements for operations and maintenance manpower, including recruitment
    - local customs / requirements which may influence the project implementation strategy. These might include the need for a formal project dedication ceremony at start of construction, local religious requirements etc
    - operations / maintenance input to project design, construction and commissioning
    - interfaces with business accounting systems
    - requirements for data input to maintenance management systems
    - identification of additional maintenance facilities required
    - operator / maintenance training
    - set up logistics contracts (for product, other materials)
    - arrange for supply of additives, packaging materials etc
    - identify requirements for safety case, procedures and documentation, IPPC requirements ATEX etc. Identify responsibilities for preparation of submissions
    - development of plant operating manual
    - identification of requirements for updating of existing site documentation

10. Appraisal of project proposals

Appraisal of proposals should take place on a number of occasions during the development of a project: typically this will be as a part of the stage-gate approval process. It makes no sense, even for the smallest proposal, to proceed all the way to the request for final authorisation having carried out no preliminary appraisal to check its 'in principle' attractiveness.

10.1. Commercial appraisal

Many project proposals are aimed at generating commercial benefit for the business. Commonly, this is to enable manufacture of product(s) on a profitable basis over an extended period. This may be through a new manufacturing plant, upgrading an existing one for improved quality and / or efficiency or the provision of utilities and feedstocks at improved input prices. Occasionally, it may be the manufacture of a product in order to deter a competitor from entering the market or to gain market share. Assessing a competitor's position and likely response to a proposal may be an important element of a commercial appraisal.

It is useful for a commercial requirements specification (CRS) to be developed for the proposal and that appraisal is carried out against it. The CRS must of course fully reflect the stated objectives for the proposal, which in turn should have been checked for conformity with overall business objectives and priorities.

Long-term projections for product selling prices and feedstock and utilities costs have significant potential for error. Company marketing departments tend to be over-confident in predicting future market demand and selling margins. It is therefore vital that those techniques adopted for economic appraisal include scenarios less favourable than the base case. Which less favourable scenarios are considered needs to be carefully considered by the owner's business management: they should reflect credible cases rather than doomsday scenarios, but care should be taken to identify those which are likely to occur concurrently, for example plant under-loaded coupled with weak market price.

In the early stages of project development, the economic appraisals are likely to include figures with large margins of error. Therefore, it is sensible to test economics against significant deviations from the base line figures. This is not the same issue as the less favourable scenarios referred to above, though in practice they may well yield similar results. For an estimate which is 'order of magnitude' only, the owner should require the project to remain robust using at least a +30% cost figure. If the project fails such a hurdle, it should be further critically appraised.

If a project proposal is to secure business support, it should demonstrate acceptable business economics for each of the less favourable scenarios considered. If this is not the case then the business management has the following options:

- to require steps to improve the economics of the proposal
- to determine that the risk of the non-acceptable scenarios is sufficiently remote to be acceptable
- to discontinue the proposal

Economic appraisals should also address the consequences of project completion delay. Most projects are completed later than hoped at the start of development. In some cases, and fairly commonly, this later completion is measured in years rather than months. The impact of delay upon economic viability varies tremendously from project to project. In many cases, delay in the development phase does not have a major impact other than that benefit from the completed project is delayed. Some projects, however, are much more time-sensitive. Delay in the implementation phase is much more likely to have a serious economic impact as far more expenditure has occurred and hence capital is tied up, and firmer plans and commitments will have been made in respect of performance.

If a project is highly time-sensitive, then a fast track approach may be appropriate. However, such an approach carries its own risks, in particular as implementation may commence with a level of project definition somewhat less than optimal. The most common risks are:

- re-engineering required resulting from inadequate definition
- failure achieve meet the target schedule
- expenditure in excess of budget in attempting to achieve target schedule

Where the object of a project is to produce a new or improved specification product or a significant increase in capacity, the commercial appraisal must additionally address the issue of market acceptance. This may well include the requirement for additional marketing effort and for financial incentives to promote the product which will have a cost and hence an impact upon return on investment. For an entirely new product there is the risk of market failure, which is one of the reasons why small market development plants are constructed. Appraisal of such a project proposal would focus on the probability of establishing viable demand.

Significant infrastructure upgrading projects often combine a commercial benefit with other, non commercial objectives. Commercial appraisal will focus on savings for the business rather than creation of income. Examples are:

- an upgraded cooling water system may have lower running costs. Improved water quality may result in less corrosion and better heat transfer and hence improved efficiency on process units. Such items can be valued
- renovation of a feedstock supply line where there is an identified risk of failure can be assessed in terms of lost business from the process unit
- complete resurfacing of roadways can be assessed against the cost of repeated minor maintenance

10.2. Technical appraisal

Technical appraisal is important for all projects, for varying reasons. One or more of the following will apply. As for commercial appraisal it is useful to have a clear user requirement specification (URS) against which the appraisal can be conducted. This can, where appropriate, be subdivided into those elements which are vital for success and those which are highly desirable, but which may allow some limited degree of non-compliance. Aspects which are merely desirable should not be included in the URS. Equally, the URS should not normally dictate how the requirement should be fulfilled, except when the owner

has a specific reason for requiring a particular approach, for example where control system compatibility with existing requirement leads the owner to require the use of a common vendor to avoid risks and costs associated with hardware and software from different vendors. Clearly the URS must be fully compatible with any associated CRS.

Commercial projects / proven technology
Appraisal will focus on ensuring that the specification meets the URS, serving the objectives, including performance criteria, without incurring additional costs of over-specification. In particular, appraisal should look at any elements of the project which are new or different from the norm and consider risks / benefits. Even for proven technology, it would be sensible to look at the impact of limited deviations from performance specification. For example a 1% loss of efficiency for a power station would have a significant impact on whole life return on investment.

New technology / significantly upgraded technology
Appraisal should assess the risks of the technology not performing as intended and, if so, the likely consequences and any remedial work needed. If the new technology is related to a commercial plant, then its failure to function could have a major business impact.

Regulatory projects (including all SHE projects)
The whole purpose of such projects is to meet regulatory obligations and / or company SHE standards. This means that the technical assessment of the project's ability to meet its objectives will be the overriding appraisal issue.

General projects – regulatory requirements
Virtually all projects will have a need to comply with regulatory requirements and some may impact on the owner's overall regulatory obligations such as total output of waste. All such projects should be checked to ensure regulatory compliance and, where applicable, to identify any further requirement for regulatory approvals and / or work to update regulatory documentation.

Research / development / product testing facility projects
This section addresses project proposals aimed at the construction of facilities to be utilised for research, development and product testing. It does not address those categories of projects which are focused on carrying out research and development itself. This latter class typically does not comprise engineering projects per se, but may well require the construction of facilities to enable the R&D work to be carried out.

Projects developed to provide facilities for research and development of products and processes are unlikely to achieve a return on investment in the conventional sense, yet are important to the overall future of the business. Technical appraisal will need to address the required functionality of the completed project such that it will be able to meet its objectives. Functionality may be divided into vital requirements and additional, desirable items. Inevitably in research and development, work requirements arise which were not entirely foreseen at the outset; hence the flexibility of a facility may be a significant aspect of a technical appraisal. In addressing flexibility, it is important to achieve the right balance between great flexibility with a greater scope / higher specification and lower flexibility which may not be able to meet arising requirements. In some cases, building in capability for ease of future modification / extension may provide the optimal approach.

10.3. Value analysis

Value analysis is a technique for reviewing the engineering scope and specification of a project against the its objectives, including performance specifications. The aim is to optimise the scope the best to achieve the objectives whilst avoiding extra costs related to non-essential items or over-specification. This exercise should carried out by a multi-disciplinary team including the plant / facility operator and, if practicable, the engineering contractor who will carry out the detailed design. Ideally, it is carried out when the design scope is reasonably well detailed: this is usually immediately prior to finalising the scope within the project definition package, towards the end of the development phase. For large projects, it is often worthwhile to carry out an initial review somewhat earlier in the development phase as a part of overall initial scoping.

Whilst the aim is to yield significant cost savings it must not be seen simply as a cost cutting exercise and every proposed change must be checked to ensure that it does not compromise the achievement of project objectives and / or the URS. If plant / facility reliability, operability or other performance capability is compromised then any cost saving may be trivial compared with subsequent cost to the business. **It is vital that any value analysis considers the whole life value of any proposal.**

Proposals which may involve some additional cost but which will yield significant whole life benefit should also be considered. However, in doing so it must be confirmed that the benefit will be of real value to the business. For example, additional or higher specification product must be capable of being sold profitably. If the increased project cost is more than marginal, then firm support from the project sponsor and authorisation must be obtained before proceeding.

If value analysis is to be an effective and valid tool, it is important that sound data is available to address the cost implications of any proposal together with an assessment of the impact on operating and maintenance costs and revenue. If the proposal compromises any aspect of the URS then this must also be assessed. It is usually relatively straightforward to develop a cost estimate for a proposed change in scope (at say ±30%), but accurately identifying the extent of future cost impact is likely to be much more difficult. It is therefore useful to identify the range of possible outcomes, assign probabilities and use this as a means of assessing the value of the proposed change. Clearly, obtaining such data will require the involvement of those responsible for managing the costs in question, including managers of operations and maintenance.

In order to limit the time required for such an analysis, normal practice is initially to carry out a rapid brainstorming in order to identify those items which may yield significant saving, of say >€50,000 or >5% of project cost for small projects. After this initial screening it will be necessary to carry out additional work on scope, costs etc leading to a more detailed review to judge their practicality and validity.

Whilst it is preferable to carry out value engineering and analysis during the project development phase, the possibility that opportunities will be identified in the detailed design phase should not be discounted nor ignored if its potential benefit is sufficiently attractive. However it is inevitable that the later any change is made, the greater will be the potential for disruption, delay and additional cost.

The table below is a possible format for decision-making in respect of proposed value improvement items.

Table 10.3 Rating criteria for value analysis

A	B	C	D	E	F
Rating	**Capital cost saving (Net)**	**Impact on project schedule**	**Operating cost savings**	**Other operational impact (capacity, product specification, reliability etc)**	**Overall assessment**
1	<€50,000	Significant delay	Minor negative	Minor negative	Do not consider
2	€50k - €250k	Minor delay	€0 - €20k/year	None	Further consideration to refine assessment
3	€250k - €1.0M	None	€20k - €100k/year	Minor gain	Probably worthwhile
4	>€1.0M	Shorten	>€100k/year	Significant gain	Must proceed

Notes for use of table

- for every proposed item, it is important to consider each of the four impacts before arriving at an overall assessment
- it is not valid to add the scores in each column in order to arrive at an overall assessment. Overall score is a judgement to be made by the project manager after liaison with other management
- Items which require additional capital cost should only be considered if scoring 4 in columns D or E. or assist in achievement of project schedule for fast track projects
- capital cost savings assessed must be the net cost after deduction of any costs associated with making the necessary changes
- anything which has a major negative impact upon operational performance is likely to be unacceptable even if significant capital cost savings are available. Such an impact is most probably represents a severe compromising of the primary project objectives
- operating costs will include maintenance cost, and change in cost of utilities, feedstocks, waste disposal costs etc
- other operational impact must address any impact upon the potential revenue stream resulting from the project

11. Use of consultants and contractors for project development and definition

Unlike the implementation phase, where it is common practise to delegate most of the management of the project to a consultant or contractor; the core management and key decision-making in the development phase must, with a few exceptions, remain with the owner. This does not exclude the use of consultants and contractors to carry out many parts of the work involved and this may include elements of development management.

There are a number of reasons why an owner would wish to utilise consultants and contractors in the development and definition of a project. These include:

- provision of specialist skills and knowledge
- provision of the required quantity and quality of resource which may be far greater than the owner(s) could provide
- provision of proprietary design packages (licences)

As a part of the project development strategy the owner will need to identify the activities they foresees as needed to develop and define the project and then determine for which of those they will utilise (or partly utilise) an external resource. They will also need to address:

- how to identify the best consultant / contractor to carry out various elements of the work
- the contractual basis upon which they will be engaged

If the owner is inexperienced in development work, they can obtain support from the consultant / contractor to advise on requirements before proceeding with the development programme of work. The problem with such an approach is that the consultant / contractor may have an interest in maximising their work beyond that which is legitimately optimal for the project development.

11.1. Specialist consultants / contractors

These are consultants / contractors who provide advice / services in a relatively narrow field where they have a high level of specific expertise. They include:

- public / government relations consultants
- environment impact consultants
- ground condition surveyors
- architects / specialist consulting engineers
- secondment of specialists to the owner's development team
- hv electric system specialists

11.2. Project management consultant (PMC)

A PMC carries out most of the development and definition works for the owner and often this includes elements of management. A PMC may also continue to act as the owner's agent in managing the work through project implementation. It is, of course, necessary to provide the PMC with guidance as to the broad project parameters and requirements together with a listing of what they are expected to deliver. This will be in the form of s an indicative scope of work and deliverables.

There are three categories of PMC:

1. **Specialist consultants** These are consultants who have extensive knowledge the requirements for specific types of projects, for example electric power generation projects. They can work with the owner initially to find the optimal solution to meet objectives and then to define the scope and assist with tendering for implementation.

2. **General project management consultants** These do not engage in the detailed engineering and procurement for projects but offer their services purely to manage on behalf of the owner. In many cases they have there origins in quantity surveying and contract management and have broadened their capabilities. They may in some cases not have great depth of expertise in respect of the technical issues which may arise during project development and implementation.

3. **Design and management (D&M) contractor** These are contractors whose main business is in the overall implementation of engineering projects. They can also be used to carry out PMC work. However, usually it is difficult effectively to engage them until the initial development phase is complete. Initial development including identification of the broad parameters of the proposed project provides a basis for the D&M contractor to carry out the further development and definition work. If the D&M contractor does not have all the specific skills they will subcontract and manage the subcontractor. Possible conflict of interest must be addressed in respect of relationship to those parties who may be invited to bid for implementation works.

Notwithstanding the three distinct categories listed above, amalgamations and capability development within the contracting business has led to the emergence of organisations which can fairly claim to have capability covering all three areas. The true extent of their expertise would naturally require to be verified.

11.3. General design and management contractor

These are the type of contractor whose main business is to provide overall services for design and management of engineering projects, typically on an engineer-procure-construct-manage (EPCM) basis. Given the breadth of their capabilities they can also support project development work. This type of contractor can:

- act as PMC (see Section 11.2 above), provided that they do not tender for the project implementation works
- provide more limited services on an as-required basis. The services of the contractor are retained, based on agreed rates and terms and are used as the need arises

- second staff to the owner's development team. Where the owner wishes to maintain full management control and has most of the capability to carry out the work, they may supplement their team with staff from either agencies or from engineering contractor

11.4. Process licensor

Where a proprietary design owned by another party is to be used, a licence agreement will be required. Unless it is intended that the licensor will supply the complete project, it will be necessary for him to provide a design package which will form a core element of the project definition package. This is commonly arranged via an interim agreement which can be terminated if the project does not proceed. The licensor will typically provide the following as a part of the licence design package:

- a design basis upon which detailed design and engineering will be based. This will normally include a comprehensive set of engineering flowschemes for the core process
- any specific design and engineering requirements
- information regarding process control and safeguarding requirements
- advice about preferred vendors for special equipment
- advice about plant layout, participate in layout reviews
- participation in design reviews, safety, operability, maintainability etc
- confirmation of utility requirements
- advice about requirements for product testing including lab equipment requirements

11.5. Alliance contractor

Where the owner already has an alliance-type contract in place with a design and management contractor, there are considerable merits in involving them in project development type work. This will provide an excellent basis for the alliance contractor to provide efficiently work and services for implementation. The extent of involvement can be tailored to the needs of each project.

The terms of the alliance contract will need to provide for this type of work. As indicated elsewhere in this document, it is difficult to reconcile fixed manhour budgets to development work, so such work may need to be excluded from any manhour efficiency targets which may be included in an alliance contract.

11.6. Conditions of contract for consultants and contractors in the development and definition phase

The importance of achieving the desired quality and completeness of project development and definition is highlighted numerous times within this document. When engaging consultants and contractors for such work, achieving these objectives should always be the paramount consideration. It is, of course, important to control the cost and progress of the consultant / contractor, but it would be foolish to prejudice the overall project outcome in order to achieve what would inevitably be small, and probably illusory, savings.

For most development works the detailed scope and content of the work is, almost by definition, not accurately known at the outset and it is therefore unrealistic to aim for a lump sum type agreement. This does not mean that payment must necessarily be on a purely man-hour basis. Provided there is some reasonable definition of the scope of work required, it may be possible to agree a 'target cost' type contract where there is a sharing of an under / over run. Obviously, if there is only a very limited definition of the work required, and this is often the case, then fully reimbursable is the only sensible option.

There are cases where a lump sum may be appropriate, but provisions for how additional works will be reimbursed should always be included. Examples include:

- a specialist carrying out a well-defined specific task, for example execution of a ground survey and associated analysis
- a D&M contractor providing a project specification for a project essentially similar to one they have previously engineered

Appendix D provides guidance in the form of a checklist for engaging a contractor / consultant to manage and execute project development works.

The terms of licence agreements are often largely dictated by the licensor. However, it is important to ensure that:

- the licence package has sufficient detail and is provided to meet the requirements of the overall development plan and subsequent detailed design work
- that the licensor will provide appropriate support in to overall project development and detailed engineering beyond the licence package
- that there are no unreasonable penalties in the event that the project does not gain approval
- that the licensor will provide support to training of owner's staff and plant commissioning

12. Project implementation strategy and project execution plan

A key activity in the project development phase is to develop and agree the strategy for project implementation. This should commence fairly early in the project development phase as a continuum from the development strategy. Initially, it is likely to be a review of the broad options, which are then progressively refined and detailed. It is essential that the project development strategy is compatible with the implementation strategy and either or both may need to be adjusted to achieve this. The implementation strategy must be essentially complete before the project definition package can be finalised and before the tendering for main implementation works can commence.

The strategy should include:

- the background to the project and the agreed prime objectives
- critical success factors
- the relative importance of cost, quality, time, performance of finished project. Simply stating all are important, fails to address the issue
- how overall project implementation will be managed
- clear identification of staff numbers and capabilities and other labour resources needed to implement the works and who will provide such staff and labour
- requirements for quality management including any specific non standard requirements
- any other key issues, which may significantly influence outcome, including any major risks and how these risks will be managed
- how project costs will be managed, including change control. This should include Identification of any significant specific cost risks and how they will be managed
- identification of the proposed overall schedule for implementation together with key intermediate dates. Any significant time-related risks should be indicated
- the proposed technical approach - to what extent will the technical requirements need to be defined? (see Section 13 – project specification)
- the proposed commercial approach. What contracts are foreseen? How will bidders be selected? What type of contracts will be used?
- any key SHE issues, any outstanding regulatory issues and how they will be managed
- how the project will be precommissioned and commissioned
- proposed project reporting

This strategy should be summarised in a presentation document for submission as one of the authorisation documents. It, or parts of it, may also be required by other key stakeholders such as finance providers or regulatory authorities.

The importance of a clear project strategy, even for a relatively small project, must not be underestimated. Projects without a strategy which progress on an *ad hoc* basis and without a common understanding of the way forward by all involved are highly likely to encounter delays, additional costs and possibly failure to meet objectives and project failure.

The project execution, or implementation, plan (PEP) provides further detailing to identify how it is intended to achieve the aims of the strategy.

For small or simple projects, the PEP may only require a few pages. A template for the suggested content for such a project PEP is provided in Appendix E.

12.1. Development of the project implementation strategy / plan

The project implementation strategy aims to provide a coherent outline plan of how it is proposed to implement the project in a manner that will most effectively achieve its objectives. It is vital that the objectives and the associated critical success factors and deliverables are clearly stated as an introduction.

The strategy will contain a number of inter-related elements and it is essential that these are mutually compatible. Where a fully discrete strategy is to be developed, work on the outline should commence early in the detailed development phase. The strategy should be presented to senior management, ideally those who will later authorise the project, to verify that it is acceptable in principle. For significant projects, the strategy may go through a number of revisions as development proceeds and requirements are better identified.

For companies that generate a regular stream of projects, it is sensible to have a standardised overall strategy at least for small and medium sized projects. This will save time and effort and will utilise previous experience. The specific needs of each project should be checked against the standard strategy and, where appropriate, modifications adopted. Clearly, projects of a very different nature from the usual would still require a discrete project strategy to be developed.

12.2. Project schedule strategy

In order to develop the final schedule strategy it is necessary to identify:

- the optimal schedule for implementation if there are no constraints or imperatives - that is, key objectives are not significantly time-related and nothing inhibits orderly progress
- for the optimal schedule, what are the critical and near-critical chains of activities? These should be reviewed to verify, so far as is practicable, that indicated durations and linkages are realistic
- what are the business and other constraints and schedule drivers? Do these indicate the need for an accelerated (fast track) approach? Examples might be, funding availability, people resources, regulatory authorisations, plant shutdown dates and durations, product market and customer commitments
- are there other key issues which may impact on the optimal schedule such as funding and / or resource availability or timing of required plant outages (shutdowns)?

If there are sufficient business or other reasons seriously to consider a fast track (targeting to complete in a period significantly shorter than the optimal schedule), then the following must apply:

- acknowledgement by the business including senior management that achievement of the shortened schedule is an overriding project objective. This is not merely a desire to see the project completed sooner rather than later which legitimately applies to most projects
- the need to achieve a fast track schedule should always be challenged and alternatives considered
- acceptance that shortening the schedule brings additional risks, particularly of additional cost and failing to achieve the schedule
- targeting an earlier start to detailed engineering and long lead ordering, either by release of advanced funding or acceptance of lower accuracy estimate for full authorisation

Acceptance that use of non-standard project processes and rapid decision making is essential. Only very limited gains are possible from simply trying to do the same tasks in the same order but faster. It will be necessary to take decisions based on incomplete information, to overlap tasks normally done sequentially (for example ordering long lead equipment based on a preliminary specification), to eliminate certain tasks, for example competitive tendering, to use already available designs rather than developing project specific.

If significant construction work must be done during a plant shutdown, the duration will often depend on the volume of work to be carried out in a limited area and may partly be addressed by working extended hours, but with a resultant loss of productivity and additional cost. Efficient shutdown work will require a high degree of pre-planning and intensive supervision. Hence review should always be carried out to validate the required duration and to determine needed resources.

12.3. Resourcing strategy

Successful project execution requires the provision of sufficient people with the skills to carry out the needed tasks at the appropriate times. Other than for very small projects it is unlikely that the owner will have on their staff the appropriate resources to carry out most aspects of project implementation. It is therefore almost inevitable that the owner's strategy will be to utilise contractor(s) for much of the work including detailed management.

If the project owner still has significant project engineering and management capability they may choose to retain some elements of the implementation for small and medium sized projects. Such an approach can be cost-effective, at least in terms of direct capital cost. What is retained will depend on the scale and nature of the work and the owner's in house resources. Typically, this may include any of the following:

- detailed design and engineering work or specific elements of it. This is especially beneficial for retrofit projects where specific plant knowledge is a key issue
- procurement of materials and contracts or partly for key items
- overall management of construction, utilising individual discipline contractors

- management of handover and precommissioning
- overall project management and co-ordination

Any directly engaged contractor will require technical and commercial management by the owner, which will in turn call for skilled resource. This applies even where the whole of the project including its detailed management is contracted out on a single engineering, procure, construct, manage (EPCM) basis.

For those activities to be carried out by the owner, the total resource requirement should be identified by discipline, by volume and by timing of the requirement. Having done this, steps must be taken to ensure the availability of the required people. In some cases, this may be a named single individual who has the required specific knowledge. Non-availability of key individuals is a common cause of delay to project development

For example, the requirements for a plant process engineer might encompass the following:

- 40% of 1 person for 3 months in development period up to authorisation
- 60% of 1 person for 4months following authorisation
- 20% of 1 person for the balance of the project

For activities to be carried out by contractors, it is necessary to identify resources by discipline likely to be needed and, as apart of contractor evaluation, to check availability in terms of both capacity and skills. Where certain high-level skills are required and individuals with those skills have been identified, the owner may ask the contractor to guarantee inclusion of those people in the project team.

12.4. Project specification strategy

The project owner must decide on the extent to which they wish to specify the detail of the work and services needed to meet objectives and deliverables. Where they have specific requirements (performance, quantity, quality, testing, type requirement, layout, appearance, documentation etc), it is essential that these are detailed in the project specification. If the owner fails to do this and later requires such compliance or changes the requirements, then it is likely to cause disruption and claims for additional costs.

For some projects, especially where the proposed main contractor has the specific technical knowledge and expertise (and is often the supplier of the process licence and / or key hardware components), a possible strategy is to provide a minimum technical specification. This will cover the key performance requirements and a few other owner-specific needs, leaving most technical detail to the contractor. This can save considerable time in specification preparation and in fast, cost-effective achievement of project objectives. The owner must, however, accept the contractor's technical interpretation of how to achieve the performance requirements. This approach is commonly applied to electric power generation facilities and some semi-standard facilities such as air separation units or small waste water treatment units.

See also Section 13 – Project specification.

12.5. Procurement / contracting strategy

The proposed contracting strategy is an integral part of the overall project strategy and has a major influence on other elements. This strategy should include:

- identification of the work and responsibilities intended to be contracted out. Identification of how contracted work will be allocated – number and scope of contracts and relationships one to another. The scope must address not only work required and deliverables but also responsibilities. In particular, will a single managing contractor be appointed for the whole (or at least most) of the implementation works or does the owner, possibly via a PMC, propose to manage the works and let multiple contracts?
- identification of those works and responsibilities the client intends to retain or carry out themselves
- identification of forms of contract to be adopted. In particular, this needs to reflect the quality of the information to be provided to the contractor and the risks they will be responsible for managing. Appendix F identifies the more common forms of contract used
- where a contractor has provided support in project definition work, will they be allowed to tender for implementation work, or to negotiate on a single tender basis? Alternatively will they continue in a PMC type role acting on behalf of the owner?
- if a management-type contract is to be employed, does the owner wish to influence how sub-contracts are let?
- should specific incentives be included in contracts? If that is the case, the owner must consider which aspects of the project to be of particular importance: the incentive will encourage the contractor to focus on achieving the incentive, possibly at the expense of other aspects. See also Appendix F
- development of a schedule of activities for tender preparation, tendering, bid evaluation and contract award. Alternatively, identification of the use of existing term / alliance contractors and the timings for scope preparation and agreement of job specific terms for the work
- identification of the criteria and process by which tenders will be evaluated, especially for major contracts and major procurement items
- identification of key interfaces between owner and contractor and between any management contractor and other contractors
- identification of key skills / resources needed from contractors for the project
- identification of contracting companies likely to be considered for the various packages of work
- identification of foreseen extent of use of suppliers / contractors with which the owner (or main contractor) has existing long-term agreements or relationships
- particularly for remote locations, the availability of suitable contractors, labour and supervision, means of getting materials to the work site and their security once delivered
- any requirement to commence contracted-out implementation works prior to final project approval. If this is to be done, how and by whom will this be carried out?
- any requirements for local procurement, imposed by central or local government, and how this will impact upon overall strategy

- inclusion of any incentives and / or penalties into the conditions of contract. Avoid penalty terms that can amount to a significant portion of the contract price even though the contractor is generally performing satisfactorily. This may make the contractor focus on avoiding the penalties, rather than meeting the quality and other aspirations of the owner. This comment does not apply to the case where the contractor substantially fails to perform
- identification of critical materials and how they will be procured. Criticality may be as a result of schedule constraints and / or technical requirements

12.6. Technical quality assurance strategy

Note: this section addresses the requirements for technical quality of the physical project. It does not address the overall project implementation process, which may be considered to be a business management quality system.

Technical quality requirements can be expressed as:

- functional specifications, such as capability to perform at a certain level, availability, reliability, efficiency
- compliance with specific standards and technical specifications, including technical procedures such as testing and inspections

In practice, the requirements for almost all engineering projects are a combination of both of these categories.

Functional requirements must be linked to the project objectives. They set the essential minimum capabilities for the completed project. Functional requirements may relate to the overall project, for example plant capacity, on-stream factor, efficiency; or to specific parts of the project, for example facilities for a certain number of operators in the control building, the functionality of a process safeguarding system or the capability for a product analyser.

Standards and specifications are not necessarily specific to the project, but are considered by those responsible for definition to help set minimum technical requirements for the completed facility. These standards and specifications may be international, national, industry; owners or contractors in origin and may sometimes be customised for the specific project. Typically they have been developed as a result of experience within industry in order to improve safety, reliability, performance and to provide a degree of standardisation. The basis for inclusion is the belief that they are needed to ensure a level of technical quality that will meet the owner's needs, including those related to:

- functional performance of the completed facilities, both short term and long term
- compliance with regulators' and owners' SHE requirements
- owner's desire to utilise standardised components within their facilities
- demonstrating conformance to standards and specifications

One problem with standards and specifications, especially those of owners and contractors, is that they were usually been developed when there was a clear need, but may not have been regularly reviewed subsequently. The development of national and international standards and specifications and the generally improved specification and performance of

suppliers' standard materials and equipment has rendered many owner / contractor standards superfluous. As a result, many project specifications include an excess of standards and specifications which are not needed to achieve the 'fit for purpose' requirements for the project. 'Fit for purpose' should always be the criterion by which the technical requirements and hence standards and specifications for a project are included. To achieve this, the proposed inclusion of standards and specifications should be critically reviewed, ideally jointly by the owner and engineering contractor, to test the need for their use.

Standardisation may be considered a legitimate contributor to fitness for purpose, although this should be tested in a value engineering review if the additional capital cost of standardisation is significant.

Having included functional requirements and specific standards and specifications in the project requirement, there is then a need to devise the quality assurance strategy: this should detail how will the owner satisfy themselves that the requirements have been complied with. The owner, or a PMC or management contractor appointed by the owner cannot possibly check every single element which contributes to overall project quality. It is therefore necessary to prepare a quality plan which should:

- identify all the measures which will be taken to provide assurance
- who is responsible for each of the measures?
- when will the checks / reviews be carried out?
- what reporting is required?
- what actions are required in the case of non-conformance?

Functional requirements are of key importance as they are almost certain to impact upon the performance of the project over its whole service life. In many cases, deviations from the specified functional requirement are unlikely to be identified until the project is complete and has been taken into service. Whilst design and other reviews may pick up major non-compliances, they are not likely to identify smaller deviations and even less so those which may appear only some time after commissioning. For this reason, functional requirements are often addressed by means of performance guarantees written into contracts. Typically these will:

- impose a penalty proportionate to the degree of non-conformance, and / or
- require remedial work to achieve conformance

Specific inspection, testing and certification requirements should always be identified in the project specification. It is good practice to require the managing contractor to interpret these requirements into a consolidated quality assurance schedule which shows:

- every category of inspection, test and certificate required
- where it applies
- who is responsible for its execution?
- who is responsible for its verification / approval
- timing
- whether the related documents are required as a part of project final documentation

For design and engineering documents (drawings, requisitions, specifications etc), the owner must identify their requirements for review by document category. Additionally, a listing of all applicable design / design safety reviews should be prepared and included in the project specification which will also identify requirements for owner's participation. The owner will also usually require the managing contractor to detail in their tender how they will ensue designs are in conformance with project standards and specifications.

12.7. SHE management strategy

The specification of engineering projects needs to address two distinct issues:

- ensuring that the design and construction will result in a facility which meets all applicable SHE regulations and owner's standards in respect of its future operation and maintenance
- ensuring that construction at site meets all applicable SHE regulations and owner's standards

The owner has a legal obligation, in most developed countries, to take all reasonable steps to ensure that all parties involved have the knowledge, skills and capacity to comply with SHE regulations. There is also an obligation to advise any SHE issues which are project-specific. In most cases, the owner will wish to have a somewhat more detailed involvement in SHE management and this requirement should be indicated in the controls and procedures part of the project specification.

Typically, the owner will specify:

- applicable owner's standards and procedures related to SHE for design and construction
- foreseen SHE related permits required and responsibilities for obtaining them
- requirements for and owner's participation in design safety reviews
- testing requirements for safety-related equipment
- minimum requirements for installation of safety-related items, such as secondary means of egress, fire fighting systems, safety showers, breathing equipment
- process safeguarding philosophy
- minimum requirements and owner's involvement in site SHE management
- requirement to approve the main contractor's site SHE management strategy
- site-specific safety requirements, including need for safety inductions
- minimum requirements for labour workplace hygiene
- minimum requirements for personnel protection
- safe work permit requirements and responsibilities for preparation and obtaining them
- requirements for disposal of waste materials

12.8. Project control strategy

All projects must be controlled through their implementation in order to achieve, or at least strive to achieve, conformance with project objectives, SHE requirements, project technical specifications, cost and schedule obligations.

In order to control, the following should apply:

- provision of targets against which performance will be measured
- a process for monitoring and measuring performance
- a process for implementing actions as needed to bring actual performance to meet, or get closer to, targets
- clarity as to who is responsible for monitoring and measurement and for implementing any needed actions

If control, rather than simply monitoring, is to be effective, then monitoring data must be available in sufficient detail and as up-to-date as is practicable, allowing rapid analysis and remedial action. **The amount of data and work required in carrying out effective monitoring and control even for modest-sized project should not be underestimated.**

Where a management-type contract is in place, the managing contractor should have prime responsibility for project controls. They may further delegate the detailed work to sub-contractors. The owner will, however, normally wish to:

- ensure that contractor has proper processes for project controls
- allocate sufficient skilled resources to manage project controls
- require regular reporting and review of performance versus targets
- audit actual performance data

The owner will also need to control any aspects of the project implementation which are not within the contractor's responsibilities.

A number of key points should be noted for strategies.

Cost control

- identify / agree the base line target. The starting base target is usually the authorisation budget, excluding certain contingencies, but as the project progresses it will often be appropriate to carry out a detailed reappraisal of forecast cost, especially if it is believed that there may be a significant deviation form the original budget
- identify / agree the amount of detail required. Typically, a multi-discipline project of the value of €10M might have 500 to 1000 items within the budget against which monitoring and control would be carried out. The estimate breakdown structure should match, so far as is practicable the work breakdown structure used for progress evaluation. This approach can be of considerable assistance in forecasting cost trend versus progress, which is an extremely useful project management tool
- identify / agree the frequency of reviews. This should be at least once per month, but some may require more frequent review

- specify points where the owner must be consulted or provide approval before commitments are made. This will depend upon forms of contract
- outline procedures for change orders
- if the project is being managed on a 'turnkey' or similar basis, where the contractor has taken responsibility for the cost risk, at least for the identified scope within their contract, then the detailed cost control process will be an internal issue for the contractor. The owner will still need to have a cost control system but the cost of the turnkey contract will usually be represented as a single item

Schedule Control

- identify / agree the base line target schedule. Overall completion date and key intermediate milestone targets will probably be based upon the schedule presented as a part of project authorisation. The managing contractor, or other managing party, will develop more detailed schedules for progress monitoring purposes
- the project specification documents should indicate the owner's minimum requirements for schedule control. This should include:
  - the level of detail expected for schedules. This may be different for different parts of the project
  - the requirements for measuring progress. Having a measurement system that accurately reflects real progress is essential
    - development of a work breakdown structure to divide the project into measurable elements
    - considerable effort is necessary to provide weightings for the different elements of the project based upon their real contribution to overall progress
    - agreement as to how the progress of each element will be evaluated. This requires objectively measurable physical achievements, for example the number of piping drawings issued for construction as a percentage of total forecast drawings. Expended man-hours against budget man-hours is not a valid measure
    - frequency of reviews
  - a process for identifying the need for and agreeing remedial actions
- fast track projects will require a high degree of schedule monitoring and control
- the extent of involvement of the owner in schedule control will depend on the form of contract(s). With a lump sum turnkey contract, the owner's involvement will be very limited, although the contract will most probably include damages for delay. With a reimbursable contract or where the owner is managing the project themselves, involvement will be much greater

Quality control

See Section 12.6 above

12.9. Risk management strategy

The risk management strategy for the implementation of the project should be a natural continuation of the strategy already adopted in the development phase. See Section 8.5 above.

Before commencing the implementation phase the following should be addressed:

- revisit the risk register and review to identify any new or increased risks
- identify those risks which will become (at least in part) the responsibility of contractors
- develop a strategy to ensure that contractors understand their responsibilities in respect of risk management. In particular, if a managing contractor is to be employed they will become the main manager of the overall project risk management initiative
- identify intended further formal risk reviews and the foreseen participation by the owner's project management and others such as plant operations. It may become appropriate to split the risk management into two:
    - the core engineering project where the managing contractor will have responsibility
    - the many peripheral (but still important) issues where the owner retains responsibility

12.10. Project information management and communication strategy

Engineering projects generate large amounts of information, much of which is required beyond physical completion. Effective management of information will improve communications and generally facilitate more efficient implementation. It is essential that there is a clear understanding by all those actively involved in the project as to how information will be managed. To this end, a clearly stated strategy should be developed.

For larger projects, particularly where a contractor is engaged to assist in development works, the main elements of the strategy will need to be in place to cover the development phase. For small projects where the owner will retain all the main management responsibilities, it is likely that already-established information management and communications processes will suffice, though a review should still be undertaken to identify specific needs. Where an ongoing alliance relationship exists and will be utilised for the project, so far as is practicable those processes established for the alliance should be maintained.

In most cases, it makes sense to build upon processes utilised for previous projects, taking into account identified deficiencies, differing needs and the capability of electronic data systems.

The following will require to be addressed:

- how will the basic data be provided? This is usually given in the project specification and documents annexed to it such as process design package. However, there may be an outstanding requirement for further discovery to be carried out by the design contractor. If there is such a requirement, this must be clearly identified in the contractor's scope of work
- where and how all the project basic data will be held (specifications, contract documents, purchase orders, reports etc)?
- the owner's project documentation requirements must be identified. This needs to identify required formats as well as content and who is responsible for preparation. The following categories will usually require to be addressed:
    - documents required by the owner during implementation for technical review, quality assurance, project control, operator training etc
    - documents required to allow plant operations / maintenance take over and commission the plant / facility
    - use of and requirements for updating of existing documents
    - project reporting requirements
    - project final documentation

- The extent of use of electronic data systems and transmission. This often cannot be finalised until all the main user parties are identified and are able to confirm their ability to use the system. This will need to address:
    - software to be utilised, in particular cad tools
    - providing accessibility to all relevant parties, yet fulfilling security requirements
    - use of standard formats / templates
    - ensuring full compatibility between systems of the various parties
    - whether project-specific systems are to be set up (for example project website). this may well be appropriate for large projects
    - a process for electronic review / comment on documents
    - electronic filing systems and responsibilities

- list who needs to receive each category of information. It is important that every party receive the information they reasonably need for their role in the project, but are not burdened with irrelevant information
- list what routine meetings will be required, their anticipated frequency and responsibilities for note taking
- identify who should normally be present at meetings
- a process for formal notices and approvals
- specific requirements for the intensive multi-party communications needed during the project handover and commissioning phase. Often these are not detailed until later in the implementation phase of a project, but the basic need should be identified as apart of the strategy

For each category of document, the party responsible for preparation should be identified and a statement of the required document status given. In some cases, for example

operating / maintenance manuals, the party responsible for overall preparation may require input from others: this requirement should be identified.

12.11. Project handover, precommissioning and commissioning strategy

A key step, which occurs at the end of project construction, is the requirement to hand over the constructed facilities and then to precommission and commission them. For small, simple projects this may be a fairly straightforward set of activities, wholly managed by the owner. However, as the size and complexity of a project increases, then the requirements in this phase rapidly become more extensive and complex, with consequent need for substantial preplanning and vigorous management. In particular, it is probable that there will be significant overlap of activities with construction finalisation, handovers, precommissioning and possibly commissioning all occurring at the same time.

The strategy for this phase must be identified as a part of the overall implementation strategy. As a minimum the following should be addressed:

- the required processes (at overview level) for handover, precommissioning and commissioning
- identification of a preliminary time line for these activities, detailing at what stage of construction completion is handover expected to commence (for example 90% completion of mechanical works). It should include the expected duration for handovers and precommissioning
- identification of prime responsibilities for managing and for executing works
- required timing and responsibilities for preparation of detailed work requirements for this phase (for example, 12 months before first system handover)
- required timing and responsibilities for preparation of detailed scheduling for this phase
- the extent of the owner's involvement in the above

All of the above must be clearly spelled out in specifications / contract documents relating to all of the contractors who will be involved in such works.

12.12. Training strategy

Many projects will result in the need for training of the owner's new staff and / or retraining of existing staff. The strategy should identify:

- training requirements, including any non-technical training such as the use of new IT system
- parties who will provide the training
- preparatory work needed to facilitate training, for example preparation of operating manuals, setting up arrangements with training providers
- approximate timings for training
- who is responsible for managing the training
- how the training will be funded - from the project budget or from elsewhere
- any requirements for temporary staffing to facilitate training of others

- the location of training where this will be remote from the facility, especially if overseas

Within the project team itself, there may be a requirement to provide training to individuals for them to be better able to fulfil their responsibilities. Where possible, such requirements should be identified in the training plan, but as a minimum a 'training needs review' should be identified.

Where a project is to be located at a new site, the extent of training requirements is likely to be far more extensive and include requirements for all the foreseen permanent employees at the site.

A contractor may wish to train of members of their team as the project proceeds. This may be general professional development or specific skill training. This is not unreasonable provided that they ensure that this does not damage the project due to non-availability of resource at critical times or a lack of required skills. The contractor should be open about their intentions and reassure the client that this will not impose any additional burden on the project.

12.13. New site issues

Where the proposed project is to be implemented at a new site, remote from owner's existing locations, a number of additional issues will often need to be addressed as a part of the project strategy. Some of these may be of key importance and require considerable work and resolution before a final commitment to the site is made. A listing of some such issues is provided in Section 18.

13. Project specification

The project specification is the documentation which defines the physical extent, technical requirements (performance requirements, standards and specifications) and project management and control procedures for the project. This can only be finalised towards the end of the development phase as it must reflect the agreed technical basis for the project. The project specification normally forms the core of the overall definition data. Its format and content will depend upon requirements arising from the finalised project implementation strategy, in particular the proposed contracting strategy.

The following will usually apply:

- where a process licence forms the basis for design of the plant, then the licence package will be a key element of the project specification
- the extent of technical specifications included will depend upon the approach in respect of using functional requirements and / or detailed technical specifications (Note. This is not an either / or issue but a continuum, see below)
- where the project implementation is to be awarded to a single EPC contractor, the project specification will probably form the technical part of the contract documents
- where the project implementation will be contracted as several separate parts, then the project specification will be the basis for development of technical requirements for each contract
- in almost all cases, it is useful to identify the scope of the overall project and then for each prime contract the scope and requirements for that contract, together with a listing of other works and provisions excluded from the contract (but within the overall scope of the project)
- for small projects where the owner will implement the project themselves, possibly utilising local construction contractors, the extent of the project specification may be limited to a scope of work as the owner will control the other technical aspects using their existing standards and procedures as the work progresses

13.1. Type of project specification

Different levels of technical and procedural specification will be required, depending on the project implementation strategy. An index for possible content of a project specification is provided in Appendix G. It provides a generic index which does not address any additional project-specific issues.

Functional specification
The owner only specifies the minimum performance requirements for the completed facility. Such an approach is appropriate when the proposed contractor has extensive specific experience and knowledge of virtually all the design, engineering and operational aspects related to the proposed facility / plant. An example of this would be a new boiler or electricity generation unit.

A fully detailed technical specification
This includes extensive detailing of all significant components together with a set of applicable standards and specifications. This is appropriate when the specific design and engineering knowledge rests with the owner (client) or their nominated licensor. The contractor is engaged for their general (rather than specific) project management and engineering capability, and the owner will wish to ensure that they comply with the specifications provided.

In practice, most technical specifications will fall somewhere between the two cases stated above with the owner wishing to specify certain elements and leave others to the technical judgement, within overall project parameters, of the designing contractor. The owner must provide a specification for all those aspects where they wish to control the detailed requirements. This is not necessary where the owner is willing to accept the contractor's or vendor's means of achieving the overall project deliverables. Any omissions or inaccuracies in the technical specification which the owner later wishes to correct or otherwise influence are likely to lead to delay and extra cost.

Controls and procedures specification
All projects require controls and procedures by which they will be managed. The extent to which these need to be formally detailed in the project specification will depend upon the contracting strategy and the extent to which the owner wishes to be involved in management and control. Even for projects where all detailed management has been delegated to a main contractor, the owner will still require some involvement to verify that contractor is fulfilling their obligations. This typically will include at least the following:

- means of formal communication between owner and contractor, including requirement for meetings
- progress reporting against the agreed project schedule
- methodology for making stage payments
- procedures for change requests
- requirements for design auditing and review
- requirements for demonstrating quality assurance (see also below)
- minimum requirements for site she management
- requirements for relations with external bodies (government, regulatory authorities etc)
- requirements for project physical handover
- requirements for project final technical documentation
- procedures for project close out

For contracts where the owner retains financial risk (reimbursable, target cost etc), the following will also be needed:

- detailed cost status and forecast reporting against budget
- procedures for evaluation of tenders for materials and services
- procedures for authorisation of purchase orders and sub-contracts
- procedures for authorisation of and making payments to suppliers and sub-contractors

In many cases, the measures described above may, by agreement, be achieved by utilisation of the contractor's standard procedures. However, this does not obviate the need for the owner to specify their minimum requirements.

Where the owner retains responsibility for project management, they may well adopt their standard procedures for project management and control, in which case the need for a discrete set for the project will not arise.

13.2. Scope of the project / scope of work

Any specification must identify the scope of the project in sufficient detail to allow the various parties involved in implementation to have clear understanding of:

- the overall physical and performance parameters of the project
- the basis on which to proceed with their work
- the responsibilities for the execution of the project
- the required deliverables for the project

The extent of detailing of the project scope and the related scope for contractors will depend upon project complexity and the technical and contractual obligations imposed upon the parties.

Where project implementation is to be handled by a managing contractor on an EPCM or turnkey basis, then it is likely that the contractor's scope of work will encompass most of the overall scope of the project. It is important in such cases specifically to identify activities, deliverables and responsibilities excluded from the contractor's scope of work. Appendix H lists some of the more common items sometimes excluded from the main EPCM / turnkey contract.

14. Estimating

In almost all cases the development and definition of an engineering project will require cost estimates to be produced. Estimates may be required to evaluate different options, to assist in assessing economic viability, to identify cash flow requirements, to obtain funding for next stages of the work and to seek final approval to implement the project. Whilst this handbook does not purport to provide an exhaustive treatise on the subject of cost estimating, it is appropriate to provide an extensive overview of the key aspects and issues. All those parties who will utilise the output data from the estimates must have a sound appreciation of the issues and hence the requirements and limitations of the various categories of estimate.

A plan for the preparation of estimates should be included within the overall plan for project development. When deciding what estimates should be provided the following should be considered:

- what detail of information is likely to be available at the time the estimate is required. It is unlikely that sufficient detail of scope for high accuracy estimates will be available until project definition is substantially complete
- improving estimate accuracy requires greater detail of the scope of the work / specification and the time schedule
- for comparison of options, it is unlikely that more detailed estimates will result in a major change to the relative costs of the options: the inaccuracies are likely to be broadly similar for all cases

The limitations of early estimates should always be highlighted to all parties, in particular business management who will later be asked to authorise the project against a more definitive estimate. There is a strong tendency for management to assume that first indicated figures will not be exceeded. This is often a wholly unrealistic aspiration, as usually these early estimates are based upon an incomplete scope of limited definition.

It needs to be emphasised that, for a typical order of magnitude estimate, the eventual project cost can exceed the base estimate by more than 50% within the error limit, even if the scope does not change.

14.1. Estimate categories

Estimates can be broadly categorised as follows:

Type	Purpose	Accuracy
Order of magnitude	early appraisal to assess fundamental economics. Initial review and ranking of options	±60% - ±30%
Study	more detailed economic appraisal. Final selection of best option, scope optimisation	±40% - ±25%
Advance funding	approval of limited funding to allow further development/definition works, initiation of detailed design, ordering of long lead materials, execution of enabling works.	±30% - ±10%
Budget / sanction	approval of budget to allow project execution	±20% - ±10%
Review / control	cost review/control during the project execution	±10% - ±5%

The Accuracy figure stated above may be defined in a number of different ways. There is no right or wrong way, but it is always important that the definition being used is clear to all concerned.

An alternative presentation approach, particularly valuable for early estimates, is to assign levels of confidence to various figures. For example, three costs could be stated:

- 50% confidence - where there is a 50% probability of the figure being exceeded
- 80% confidence - where there is a 20% probability of the figure being exceeded
- 95% confidence - where there is a 5% probability of the figure being exceeded

The three cost figures will differ, but this may give management a better appreciation of the possible outrun. It is essential that a proper evaluation of cost probabilities is carried out in order to ensure that confidence levels are realistic. In practice, this requires the preparation of cost probability curves as shown in table 14.1.

14.2. Estimate quality

The quality of any estimate is limited by:

The quality of the scope of work and specification
How well has this been defined:

- the extent of design and engineering work needed
- the physical content of the equipment and materials (quantities and specifications) to be supplied
- the construction work to be done
- the circumstances under which the parts of the project will be implemented. Time pressures may require payment of premiums. Difficult working conditions may result in lower productivity
- identification of scope items (if they are to be included) such as temporary works, temporary facilities for construction labour, insurance, cleaning, waste disposal, spare parts, document updating, training, first fill process materials, transport, project team travel and other expenses, import duties, project-specific medical and security provisions
- an assessment of the quantity of management required for the project to be developed and successfully implemented

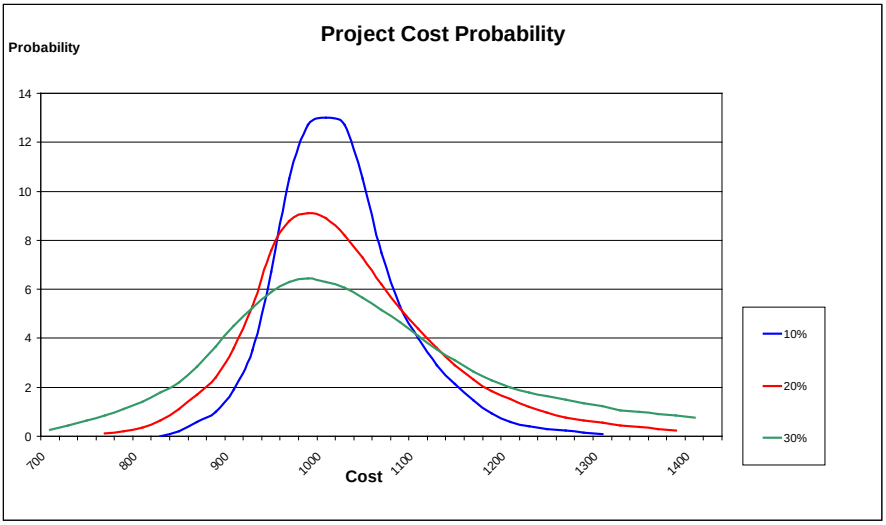
The quality of cost data available

- how accurate is the pricing data for each element of the identified scope? Is it based upon current data or historic data? If the latter, how old is the base data? Data which is 1year old will usually provide a good basis, but if it is 10years old then it will be very difficult to accurately update the cost
- what are the vulnerabilities to short term changes in rates and prices? Prices of most commodities do not change rapidly, but there are exceptions. Custom-made items and specialist services are likely to be priced at levels which reflect current market demand. For example demolition works pricing is dependent upon current prices for scrap metal, which fluctuate significantly. Prices for engineering design may reflect how busy local engineering contractors expect to be in the near future

The above limitations apply to all projects. The later in the overall development and design of the project that an estimate is carried out; the more accurate the estimate is likely to be as the data upon which it is based is more detailed and more likely to be accurate.

The following diagram shows the cost probability curves for a typical project

Figure 14.2a Typical cost probability for 10%, 20% and 30% estimates



The curves have been drawn to reflect common reality for typical projects. The following points should be noted:

- the curves are not exactly symmetrical. There is a distinct credible limit of possible cost at the low end, but at the high end there is a diminishingly low but still credible possibility of very high costs beyond the shown extent of the curves
- the ±10% estimate shows that whilst there is no credible probability that cost would be less than 800, there is a small but entirely possible risk that the cost will exceed 1200. The same principle applies for the other curves
- the ±10% curve shows that there is a distinct possibility, with some 10% probability, that the actual cost will exceed the median cost by more than 10%. That is, there is a 10% risk that project cost will exceed 1100. For the 20% curve, there is approximately a 10% risk that the cost will exceed 1200
- the most probable cost for the project tends to increase as estimate accuracy increases. For the curves above it moves from 960 for the 30% estimate to 1000 for the 10% estimate. This reflects the typical outcome for estimates against a common overall scope. The reality is that the provision of more detail for the higher accuracy estimate usually, though not always, uncovers more items or specifications which increase cost versus those which decrease cost

It is important that all those who are involved with the preparation and use of an estimate understand what the terms used to quantify it mean. For example, the commonly-quoted '10% estimate', which is often used as a basis for project authorisation, can have a number of different detailed definitions. It is not the case that one definition is correct and the others

not so: what matters is that all those using the estimate have a common agreed definition. The detailed definition needs to address:

- what 10% (or 20%, 30% etc) means. A typical meaning is that there is an 80% probability that the actual cost will fall within 10% of the mode figure
- what the mode figure represents. Typically this is the value at which there is a 50 per cent chance of over-spend or under-spend. This should include provision for those uncertain costs which have a probability of 50% or more of occurring

Whether the estimate includes any contingency. This may be provided for several reasons and it is necessary to identify which contingencies are included and which are excluded. See Section 14.12 below.

14.3. Project schedule influence on estimated cost

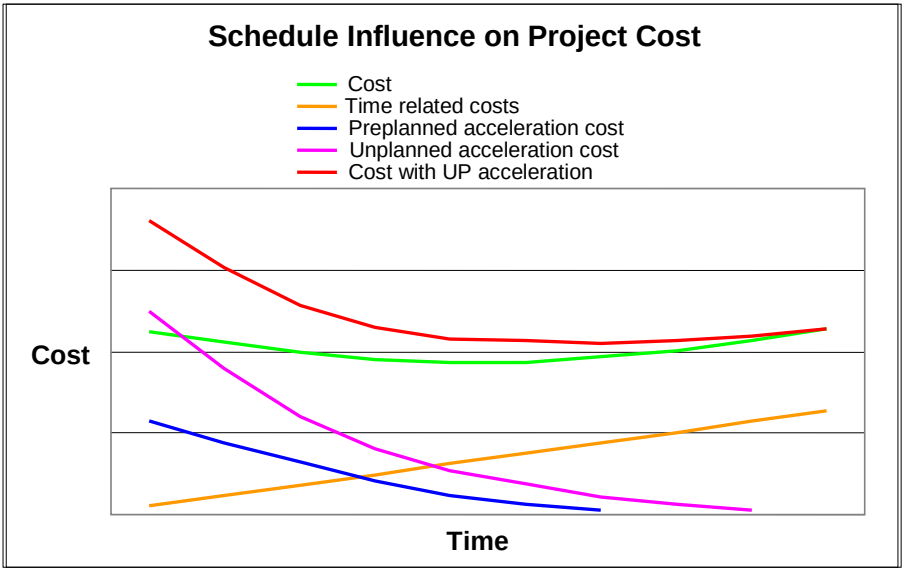
An estimate is only valid for the programme against which the project has been estimated. If, as often occurs, the programme is changed, then there is significant risk of incurring additional cost in order to achieve the revised programme.

- it is very common that the development phase takes longer than initially foreseen. Almost inevitably, this means that more person-hours will be consumed, resulting in higher cost. It may also result in the time for implementation being compressed, although this is usually a lesser cost risk than failing adequately to complete the development work
- repeated starting and stopping of project development causes inefficient working and hence higher costs. This is also the case in the implementation phase
- compression of project implementation, (fast track), brings a significant risk of additional costs, arising largely from the requirement for more intensive management, premiums for shortened deliveries, overtime payments etc. Where the appropriate planning and fast track processes are in place such additional costs may be offset by savings on time related costs. If, however, a fast track process has not been planned into the project at time of authorisation, but acceleration is later imposed, then additional costs will inevitably occur and there is a high possibility that the required earlier completion will not be achieved. This is often the situation when project authorisation is delayed but the original completion date is maintained
- an overall delay to a project may well lead to unit cost escalation

The following chart (table 14.2) shows the typical influence of time upon the cost of a project. Note that these curves apply to time from commencement of detailed design to completion. Time spent on the development and definition phase also has a limited impact upon project capital cost for the reasons stated above.

The chart shows that there is an optimal duration for a project, where the decreasing cost of not paying premiums for fast track offsets the increasing cost for time-related charges. It is often impossible to predict precisely the optimal duration, but for many projects the change in cost for small alterations in planned duration is not large. However, if the required duration is changed after the start of implementation, then the increase in cost is likely to be much more significant.

Table 14.3a Impact of schedule on project cost



14.4. Estimate scope

It is essential that that the scope covered by an estimate is always clear to all who will refer to it. In many cases, the main budget estimate does not cover all of the activities associated with the project and if these are not clearly identified, it is probable that, during the later implementation, stakeholders will have differing views of what was included.

In all cases, there should be a statement of the basis of the estimate. This should typically include:

- a summary of the scope of with particular reference to boundaries (physical, work content and time)
- a statement of accuracy and whether the total estimated value represents a 50% / 50%, 90% / 10% or some other percentage for risk of exceeding the stated estimate
- a statement of contingencies included in the estimate
- identification of the implementation programme assumed
- a listing of known items specifically excluded and, if possible, how it is intended that these items will be funded. Appendix I provides a listing of items which may commonly be included or excluded from a project capital cost estimate, dependent upon the approach
- identification of any significant additional cost risks

At a later stage it will be necessary to provide an estimate breakdown suitable for project cost control. So far as is practicable, the breakdown should be into cost elements which match the physical work breakdown structure.

14.5. Estimates for evaluation of options and for support for continued development

For almost all projects, there is a legitimate requirement to provide initial estimates to allow a management assessment of the basic viability of a proposal and, if there are distinct options available, which one(s) should be pursued. If an organisation has a defined development process, then it is probable that these requirements are included. At this stage there is no need for high quality estimates, but it is imperative that the quality and limitations of the estimate provided are made clear to those who will make decisions based upon it. **There is a tendency for businesses to remember figures stated in early estimates, but to forget the qualifications attached to them**, with the result that when (usually higher) figures are presented as a result of later authorisation quality estimates, there is considerable discontent. Points of note are:

- when comparing options, provided that a similar basis has been used to assess each, it is unlikely that the relative of costs indicated by an early order of magnitude estimate will change significantly as a result of later, higher quality estimates: the inaccuracies will usually be broadly similar for each option unless the scope of an option has changed significantly
- commonly, early estimates tend, for a number of reasons, to understate the final cost. It is therefore vital that any financial evaluations of commercial return and reservation of funds in capital programme budgets recognise this. Viability should always be tested at project cost figures higher than the estimate. If the estimate is a ±30% figure, then there is probably a need to test at base estimate cost plus 50%. If the proposal cannot pass such a test, then there is necessary to review whether to proceed and, if so, whether specific cost reduction measures must be considered
- early estimates often only address the core project (that is items such as permit costs, off-plot facilities, temporary facilities, insurances, commissioning costs, have not been addressed). This is acceptable given the purpose of the estimate, but should always be made clear

14.6. Estimates for provision of advanced funding

There is often a requirement for funding for a project prior to the request for full authorisation. This may cover project development and definition works, certain permits, land acquisition, surveys, land improvement works, purchase of long delivery materials items, detailed design works, etc

It is important that such early funding requirements are identified and notified to the business management as early as practicable within the project development phase. At this time, agreement should also be obtained on the requirements needed to obtain approvals of such funds. Advanced funding approvals should be an integral part of any stage-gate approval process. Key issues are likely to include:

- who has the authority to approve advanced funding and what is the required process? this is likely to depend upon amount required
- what quality of estimate is required for the funds to be applied for?
- what preliminary appraisal of the overall project is required to support the request?
- why is the funding required at the given time and what are the likely implications if authorisation is not given at the requested time?

If a single application for advanced funding covers several discrete purposes, it is good practise to identify clearly the amounts required for each purpose.

14.7. Estimate quality required for project authorisation

There is a legitimate business need for a projected cost of sufficient quality for the project to be evaluated and authorised prior to irrevocable commitment of significant expenditure. It is essential that the project team, the business and those authorising the budget understand what the quality of given estimate is and appreciate there is a trade-off between quality (accuracy) and the extent of data and work needed to achieve that quality.

An agreement must be obtained as to the required estimate accuracy for project authorisation. The often-stated requirement for a '10% estimate' may need to be challenged given the work and time needed to provide this for certain types of projects. This is a particular problem for those smaller projects, typically retrofit, which are scope unique, that is with little or no scope commonality with already-completed projects, and hence have a very limited ability to use historic data from similar scope projects.

It is always good practise to test the viability of a project proposal at cost levels higher than those indicated by the estimate. Even when the authorisation estimate is a ±10% figure (80% confidence that outcome will be within ±10% of the net estimate figure), it would be normal to test at +20% for continued viability. See Section 10.1, commercial appraisal.

Authorisation estimates should always clearly state what contingencies have and have not been included. If there is any specific significant cost risk item which has not been included, this should also be identified.

14.8. Estimating techniques

Database of similar process plants

Where a proposed new process plant will utilise a similar process and have a similar capacity to others which have been constructed in the recent past, (up to 5 years), then, assuming accurate costs are available from the earlier projects, such data provides one of the best ways to estimate the core project. In particular, where there is an extensive database of multiple projects, the averaged data may be considered highly reliable. For example, there is extensive data for gas turbine electric power generation plant, for polyethylene and polypropylene plants and for liquefied natural gas plants as all of these are constructed fairly frequently around the world to a limited number of basic designs. This gives a valid basis for estimating new projects.

Care must of course be taken to account for differences including:

- scale – larger scale projects cost more, but not proportionately to capacity (see below)
- escalation – it may be necessary to address separately design and management, materials and construction, as escalation rates tend to differ significantly
- location – costs depend upon location due to a number of causes. Again, there may be a need to address separately design and management, materials and construction, as the impact of location will vary significantly for different cost elements
- cost of infrastructure. Even basically identical plants will have different associated infrastructure (off plot utilities, roads, warehouses, offices etc), and these elements will have to be estimated individually based on scope
- financing costs, contractual terms. These may well influence overall project

Scaling factors

Scaling factors can be utilised for complete process units and for individual components. The following are indicative approximate cost factors for scaling of projects.

Note - they provide a general guideline only, covering items essentially identical other than in scale (size / capacity).

n = Scale factor (for example n=2 represents a doubling of capacity)

For example, if the capacity of plant to be estimated is 1.5x the existing plant for which costs exist, then cost increase will be 1.5^n . The value of n varies for different categories as detailed below.

Table 14.8a Scaling factors

Category	n	Category	n
Vessels	= 0.65	Electrical	= 0.70
Furnaces and boilers	= 0.70	Structural	= 0.65
Machinery and drives	= 0.75	Civil	= 0.65
Vendor packages	= 0.75	Painting	= 0.65
Other mech. equipment	= 0.70	Insulation	= 0.65
Piping	= 0.70	Buildings	= 0.65
Instruments	= 0.60		
Computer systems	= 0.70		
Design and engineering**	= 0.50	Complete plant	= 0.65 - 0.75
Construction management	= 0.65	Plant modifications	= 0.65 - 0.75**
Construction services	= 0.65		

Note:

- for overall plant n ≈ 0.7 but for design and engineering n = 0.5, hence the design and engineering cost is proportionately greater for small projects

- it is rare that plant modifications are scalable. Usually, there are too many differences from one to another even when they are superficially similar
- scaling is only valid for items which are closely similar except for scale. Two pumps of same power consumption but one rated for high head low flow, the other for low head high flow are not sufficiently similar

Statistical costing of complete plants

For many, but by no means all, complete process plants within a given industry, extensive collection of data has revealed a consistent set of ratios between the purchase cost of main equipment items and the other main elements of the physical project. Hence, it is possible, having identified the cost of the main equipment items, to derive the overall cost of detailed design and management, bulk materials and construction costs. There are, of course, limitations on this technique, including:

- the technique is valuable for initial study estimates, but is not likely to be sufficiently accurate for budget authorisation estimates, except where the proposed plant is very similar, with essentially identical process to others recently constructed
- the ratios vary for different industries / processes, so an industry-specific set of data must be available
- it cannot be used for retrofit projects, for the infrastructure elements associated with most projects, or for the purchase of land and other site unique elements
- adjustments will be required for location
- buildings need to be addressed separately from the process plant within them

Pricing individual cost items using current market data and judgement

Except when data is available from recent, similar process plant, estimating by pricing each cost item within the scope of the project is usually the only means of achieving a high quality, high accuracy estimate. The downside of this approach is that it requires not only a detailed scope of work but also sufficient design details to enable an accurate take-off of sizes, specification and quantities for each element of the scope. The work involved in quantifying each element and converting it into costs is labour intensive, even with the use of computer based estimating tools.

Materials

Market data is readily available for most commodity items, such as standard building materials, structural steel, piping components, cabling, lighting, small tanks and vessels, small pumps, LV switchgear, standard instruments, insulation materials. Provided that the estimator ensures that data is up to date, then it can provide accurate guidance. However, the following must be taken into account:

- significant discounts may be available for large quantities and / or against long-term supply agreements
- where materials are sourced from outside the locality where they will be installed, provision must be made for transport costs and import duties
- if materials are required for delivery in a shorter than normal period, there may be a significant premium cost
- some countries have local content obligations which may require purchase of materials at prices higher than free market levels

For custom made items and those such as large vessels, reactors, heat exchangers, compressors, large pumps, special pumps, HV switchgear, special instruments, special valves, bespoke laboratory equipment or any item made from exotic materials, there is usually no readily available market data. So unless there is specific information from a closely similar item procured in the recent past, then the only reasonably accurate means of estimating cost is to obtain quotation(s). These must be treated with care as they are often obtained against a preliminary specification and this may result in significant deviation from actual costs when purchase is made.

Design and Engineering
Hourly rates for design and engineering (D&E) works are readily available and indeed most contractors are willing to provide their current guideline rates to an owner considering use of the contractor. Contractors usually estimate the total cost for D&E by allocating specific man-hours against each material item in the scope, utilising norms from their database of experience on previous projects. Adjustments are then made for items such as complexity. Additional issues to be considered include the following:

- site visits will be required by the design team. If the location is remote, such visits may involve significant cost
- retrofit projects are not only complex, but may need additional work to review existing plant design, design of elements to be modified or removed and how to integrate new with existing. It may well be essential to employ a site design team for part of the work
- where elements of the design are to be sub-contracted, for example architectural design of a building, it is not only necessary to identify the costs of the sub-contract but also to make provision for co-ordination
- provision must be included for design team follow up to support design issues arising during construction works
- if there is likely to be an extensive need for overtime~~,~~ working, allowance must be made in the rates
- contractors' openly quoted rates may not be the same as those they utilise when tendering on a lump sum basis

Construction
Contractors usually adopt different approaches for different types of construction works. These include:

- building, civil and steelworks. The construction contractor normally supplies materials, and often carries out design detailing; so provision for those costs must also be made. Typically, the cost of such works is estimated based upon material content rather than man-hour content, for example cost per tonne of steel or per square metre of brickwork
- ground works, including piling, will require a specific design for the location. This type of work usually cannot be assessed on the basis of any norms, so often quotations against a preliminary scope are required
- the costs of internal fittings for buildings are very dependent upon specification
- the costs of temporary facilities must always be addressed. These include items such as temporary roads, hard standing for lay-down areas, fences, construction huts for labour and offices, site security, temporary utilities, etc. A specific assessment of requirements for the project will normally be required
- piping fabrication and erection costs are extremely dependent upon material specification, design complexity and construction location congestion

- the cost of installing equipment depends on the difficulty of access. If large cranes (>100T) are required, this can be a significant cost and is time related
- scaffolding costs are notoriously difficult to assess and are very commonly under estimated. Whilst the major scaffolds can be identified, there is always a requirement for additional smaller scaffolds and numerous scaffold modifications
- assessment of likely productivity must be made. This varies significantly from country to country and even regions within countries. If significant overtime and / or double shift work are foreseen then unit productivity will decrease
- overtime working on construction results in additional cost, both directly due to the higher rates payable and indirectly due to resultant loss of productivity (see Appendix K)
- retrofit projects by definition involve construction within existing plant, and this results in lower productivity than on a 'new build' construction site. The extent of lower productivity and hence higher cost depends upon a number of factors (see Section 19 and Appendix K)
- assessment of unit labour cost must be made. If the site is in a region where there is regular work of a similar nature, then rates are likely to be well established, though if there is a shortage of skilled labour due to high workload there may be a need for premium payments. For remote locations, it will be difficult to assess rates not least as it is likely that labour will need to be imported and provision included for a labour camp or lodgings
- provision must be include for work associated with testing, punch listing, handover and precommissioning. This work is labour-intensive and must often be carried out on a shift work basis. Additionally, certain specialist contractors may be required, for example chemical cleaning, and at the time of the estimate it will be difficult to quantify such work with accuracy

Project and construction management

These include the costs of the owner's project staff, of any PMC contractor / consultant and the management costs of any EPC contractor. To some considerable extent it, must be expected that tasks carried out by one party will not have to be duplicated by another. For complete new plant projects, major contractors will normally have statistical data to assess what percentage of total costs will be required for management. The following points are of note:

- in general, small projects require proportionately more management than large
- retrofit projects will require proportionately more management
- contracting and procurement strategy will influence the amount of management required
- fast-track projects will need more management for the period they are in execution, but cost may be reduced by shorter durations, assuming the fast track strategy succeeds
- the size, and hence cost, of the owner's project team in the project implementation phase will depend upon the extent to which the owner requires to audit the contractor's work
- where expatriates from high-income countries are involved, costs will be very significantly higher than for local staff
- it is necessary to identify whether any owner's senior management costs will be charged to the project in respect of their occasional involvement. The same applies for the owner's plant operations management

Commissioning
Such costs are difficult to estimate as the detailed procedures, activities and resources required are rarely well defined at the time of the estimate. Commonly, commissioning requires more effort and time than initially anticipated, especially if the project is a one-off (that is not a repeat of a plant / facility previously constructed to similar specification). For well-established processes, it may be possible to estimate on the basis of statistical data from other similar plant. It is essential identify and agree what elements of commissioning will be charged to a project budget. For many smaller projects related to existing facilities, commissioning costs may either wholly or partly absorbed within the plant operating budget. Commissioning costs may include:

- cost of labour (operators and technicians) carrying out the commissioning and their supervision. These may be the owner's existing employees at the site, owner's employees brought in from other locations, contractor employees, licensors 'employees or combination of these
- equipment commissioning engineers, provided from vendors and contractors.
- the cost of materials and utilities consumed in the commissioning work.

Other elements
In addition to the above, a number of other elements may require inclusion in the estimate. These may embrace:

- costs associated with project development and definition. By the time that an authorisation-grade estimate is to be produced, these costs should be reasonably accurately known as a significant portion will have already been expended, and others should be well identified to the extent of detailed forecasts for each element of outstanding work and other costs
- cost of any permits required
- cost of project financing. If this requires borrowing money from banks or others, there will be interest payable and possibly an arranging fee
- insurance, where provided by the owner. Insurance provided by suppliers and contractors will be included in their tender prices
- spare parts to be provided
- computer hardware and software, including the costs of installation, data loading and training. These can be significant
- travel costs for the owner's project team and contractors engineers visiting vendor premises
- cost of financial and technical auditors
- public affairs costs. Certain large high profile projects will need to publicise what is going on, hold events to keep local authorities and others. Positively disposed and there may be a desire to support certain local organisations, including charities, as a goodwill gesture

14.9. Location factors

The unit cost of many elements within an estimate will depend upon the location at which the project is to be constructed. In other words the cost of two technically identical plants is likely to be different as a result of their being differently located. There exists published data (in industry journals) providing location factors for overall project cost for process plant and these factors can be used as a means of adjusting the known cost based upon existing plant to fit a new location. Use of this technique is reasonable for preliminary estimates. However its use is constrained by a number of limitations:

- in reality, the location factors are different for the various elements of a project. (design, materials, construction etc), so the overall factor is dependent upon how much of each element make up the total cost
- costs may vary significantly within one country, and so for a factor to be useful it must apply to the specific location
- location factors change over time as a result of differential escalation of costs and movements in currency exchange rates. Hence, any data which is several years old must be treated with considerable caution
- patterns for procurement of materials and services are changing rapidly with a major increase in international purchasing. This will certainly influence location factors

14.10. Escalation

It is always essential to identify the time validity of the data used for an estimate. Most commonly, estimates are prepared on the basis of price levels valid at the time and then a provision for future price escalation is added. At present (2005) general rates of escalation are fairly low in most of the developed world, though not necessarily in other regions. Recent significant upward movements in prices for basic commodities are likely cause an increase in certain material costs, and therefore the issue of cost escalation can never be ignored.

The difficulty in identifying an appropriate provision for escalation is that the rate of price change for the cost elements which make up the estimate may differ from one another considerably. Some recent trends are as follows:

- **Design, engineering and project management staff**
  Costs are rising on a man-hour cost basis broadly in line with general wage rates. Overall D&E costs may also be affected by the following:
  - for major projects some work is now being carried out in lower wage cost centres, mostly in South and East Asia. This generates lower costs, though not on the scale of the difference in wage rates as productivity is usually lower, in addition, there is a requirement for additional co-ordination between the contractor's offices
  - productivity gains have been achieved by the introduction of CAD and CAE systems over the last 15 years. It appears that the rate of gain for process plant design is tapering off

- some lowering of design and engineering cost may occur as a result of the engineering contractor sub-contracting detail work to vendors and construction contractors. Only a portion of this is a real gain as the balance appears as a cost elsewhere

- **Materials costs**
  Prices overall are slowly declining, although this masks considerable differences for particular types of material.
  - most commodity items are reducing in price as sourcing moves to low cost countries. However, note the comment below
  - the cost of base materials, principally steel, aluminium and copper, will influence the cost of commodity items. As a result, the reducing cost trend of the last few years reversed in 2003 and continued upward in 2004. Higher energy prices will also have some effect
  - comparative costs for instrumentation and control systems are difficult to track due to the rates of change of technology and the levels of automation, safeguarding and data handling specified

- **Construction costs**
  Construction cost levels and changes in those levels are dependent on location.
  - cost levels are affected by the balance of supply and demand
  - in Europe, there is a slow general improvement in productivity
  - in high wage economies and for remote locations, there is a trend towards modularisation with more work carried out offsite. This can reduce overall costs and will tend to move costs towards the materials component of the estimates
  - costs for process plant demolition works are significantly influenced by the short term value of scrap material, especially steel and copper

Where an estimate relies on historic cost data, especially if the cost data is more than 5 years old, then the level of escalation to be applied should be considered carefully as it is unlikely that a simple application of a published price index will provide an accurate result.

14.11. Currency fluctuations

Where projects will be constructed in less developed countries, it is likely that a significant portion of the actual costs will arise in a number of currencies different from the host country. Additionally, for major projects, if the owner is an international company then it is probable that the estimate provided for project authorisation and subsequent use as a budget for cost control will be denominated in that company's main accounting currency.

It is difficult to predict accurately currency movements even for a few months ahead, so any estimate which has significant exposure to currency fluctuation must clearly identify the exchange rates assumed and what, if any, contingency has been included.

Currency risk can be managed by the owner in various ways:

- accept the risk and make a contingency provision
- hedge the risk by purchase of currency options at fixed rates
- move the risk to contractors and vendors by requiring contracts priced in the owner's accounting currency. The contractor / vendor will assess the risk and try to build it in to their prices

14.12. Contingency

No estimate can precisely identify the cost of each of the individual elements which will eventually make up the overall project cost. There are three basic uncertainties and hence causes of a need for contingency. These are:

- cost uncertainty covering the exact unit cost of a known item.
- scope uncertainty - how many / how much of an item or service will be required?
- specification uncertainty - what are the detailed technical requirements for an item or service?

For most projects, all of the above will apply to some extent. Clearly, the more detailed the definition of the project scope and identification of the required schedule, the less the need for contingency. Hence, in almost all cases, a 10% estimate will need a lower contingency provision than a 20% estimate.

For any estimate, a clearly-identified approach to contingency provision should apply and be agreed by those authorising the project. Issues will include:

- provision for items with a >50% chance of occurring. Usually, this provision is categorised as growth and is included within the base estimate rather than as a contingency. Not including it would condemn the great majority of projects to overspend their budget
- provision of a general contingency added to the base estimate to reduce the risk of overspend to a more manageable level. Typically, this will reduce the risk of overspend to 10% (that is 90 / 10% under-spend / over-spend confidence) Usually, this contingency is released, wholly or in part, for use by the project manager as they see fit. It is unrealistic to require separate approval / release for the numerous, mostly relatively small, requirements for use of contingency which will almost always arise during the execution of a project
- provision of specific contingency for a particular significant cost risk item. Typically, such a contingency is identified and a 'risk fund' established. This money is only released in the event that a request is made as a result of the identified risk(s) occurring
- schedule maintenance contingency for fast track projects, to provide for additional expenditure which may be needed to safeguard a critical schedule, for example premium delivery payments, additional overtime payments. Premium payments which are identified as required or probably (>50%) required at the time the estimate is prepared should be included in the base estimate, not as a contingency

- provision for minor scope changes. Such a provision may be appropriate especially for new technology and retrofit projects where the detailed design, inspections or even early operation may result in a need for changes. This should not be confused with scope growth which occurs as the design and engineering of most process plant project progresses
- provision for currency risk

The last four of the above contingency requirements are often not included in the project budget under the control of the project manager, but are retained by the owner's management, for release in the event of the specific event(s) occurring.

14.13. Cash flow

For all but the smallest of projects, the owner's business will wish to know what the predicted cash requirements will be. Depending on the scale of the investment, this may need to be included in the overall corporate capital budget forecasts or, if smaller, included within the location's general annual provision for small project expenditure.

Typically, an initial forecast is provided at the time the proposal is placed on the project development list (that is it has been accepted in principle as an item to be developed). At that stage, the cost is usually no better than an order of magnitude and expenditure timing is identified only on an annual basis. In some cases, inclusion of the project proposal may have a 'knock on' effect on other project proposals, as most organisations impose limits on annual capital expenditure.

At the time of request for project authorisation, it is likely that, other than for very small projects, the business will require a more detailed forecast of cash flow timing. The need will be for quarterly figures (or even monthly for major investments) and may include both:

- identification of timing of financial commitments
- timing of cash requirements

The timing of cash requirements is normally derived by addressing the individual elements of the estimate, looking at the terms of payment for each and then identifying when payments would be made taking into account the timings in the project schedule. From this, an overall cash flow for the project can be constructed. It is important to take a realistic view based on experience on payment timings, as cash flow is of major importance to businesses.

In some cases, the identified cash flow may present a problem for the business. In such cases, it may well be possible to change the expected cash flow by changing terms of payment. Of course, changes in terms of payment may well influence the absolute cost of an item. Changing terms of payment should only be done, other than in truly exceptional circumstances, before placing an order and preferably before obtaining a quotation. Changing terms of payment after order placement is usually a highly contentious step with negative impact on relationships.

15. Project financing

15.1. Internal financing

Almost all small projects and some larger ones are financed internally by the owner(s). This may involve an increase in general borrowing, but that will not be project-specific. Whilst internal financing removes a significant task and uncertainty from the project development, it does not diminish the need to demonstrate its financial soundness. The owner's finance department will wish to be advised of both the total anticipated funding requirement and also its timing in order to manage the overall business finances.

Where projects are carried out under the provisions of a joint venture, it will be necessary to ensure that all the joint venture partners (owners) are advised of funding requirements. In some cases the share of funding for a project may not be in the same proportions as the overall ownership of the joint venture, and in such cases it is vital that the different financial obligations of the joint venture partners are clearly stated and agreed. This should be agreed as early as is practicable in the project development.

15.2. Financing of project development works

Even where projects will be wholly or partly externally financed, it is unlikely that such financing will be available for the development phase. Hence, the owner(s) will need to finance this work themselves. The following decisions will be needed:

- to what extent will development costs be charged to a project budget or to normal operational budgets?
- if operational budgets are to be charged. It is essential that these costs, if of any significance, are provided for at the time the budget is set. However, some development costs relate to the time of individuals who may well have been provided for in the operational budget in any event
- if a discrete budget is provided, normal practice is that the costs charged will eventually be included in the overall project costs if the project proceeds through implementation. However, in the event that the project is not sanctioned or is abandoned as incomplete, it is usually not possible, for fiscal reasons, to capitalise expenditure and costs must be written off in current year business accounts

15.3. External financing

Many higher-value projects are financed wholly or partly by parties other than the owner(s). Financing routes include loans from banks, venture funds, loans or grants from government agencies and occasionally from customers or suppliers. It is beyond the remit of this handbook to address the full detail of the terms upon which this financing is provided, but certain aspects are likely to impact directly upon the development and definition of the project and these are identified below. In order to get an application for financing into detailed consideration it will usually be necessary to prepare a project information memorandum. This should set out the key aspects, in particular the preliminary commercial appraisal and details of the amounts and timing of financing required including preferred arrangements for repayments. Such a memorandum is only the starting point for what may well be lengthy and complex negotiations.

Banks and venture funds

Banks and Venture funds will require considerable information concerning the proposed project in order to assess and limit their risk. Negotiating the terms of a loan will be a significant activity which may extend over many months. The project manager responsible for project development will require support from the owner's finance and legal departments. Typically, banks may require:

- a detailed economic appraisal of the project, usually with review by a third party
- prior to final commitment of the loan, a firm cost estimate based upon a detailed scope and / or a fixed price tender for project implementation
- banks are unlikely to release funding until the project is fully authorised for implementation and may well link releases to achievement of specific milestones
- banks are often very keen that major contracts are entered into on a fixed price (lump sum) basis in the belief that this provides improved cost certainty. Whether this is truly the case, will depend upon a number of other issues, not least the quality of project definition
- banks are likely to require either their own staff or an independent party regularly to audit the validity of payments and cost projections. This work may well be an additional charge against project cost

Government grants and loans

Governments may be prepared to support projects if they are complementary to their policies. This may relate to the creation of new employment or securing existing employment, support an industrial policy or the achievement of significant environmental benefit. In some cases, even quite small projects may be eligible for government grants, particularly if they are delivering environmental benefits. However, payment of such grants is usually only made on completion of the project.

Almost inevitably, obtaining financial support from government is likely to be a lengthy process requiring considerable presentation of detail concerning the proposed business and how it fits with the government's policies. It is of great advantage when applying for such support already to have gained the support of those, such as local political representatives, who will have influence on the government department(s) that will provide the support.

Government may provide land for the project and carry out or support any needed upgrading of infrastructure such as water and power supplies and roads to the project site. If government funds these items then they represent a direct reduction in project cost which will improve its economics.

Government may also offer an advantageous fiscal regime for the business on completion of the project. Whist this does not affect investment cost; it improves the business economics upon against the project will be assessed.

Government support may be contingent upon provisions for enhanced local content. Utilisation of local content where it is not competitive provides an extra burden on the project in terms of cost and ensuring acceptable quality. It may also require training of local personnel and the need to demonstrate in detail why certain elements of the project cannot be executed locally.

Whilst government may be an enthusiastic supporter of a project from its inception and indicate in principle its willingness to offer financial help, it is unlikely that actual payments will be forthcoming until the project is fully authorised and even then only against achieved milestones. Government will also usually demand a 'claw back' of any grants if the key parameters against which they were awarded are not fulfilled.

Contractors

Contractors almost always indirectly provide some limited financing of a project by default, in that they receive payment for their work and services some time (sometimes the delay is considerable) after they have made payments to their employees and suppliers. In some circumstances for major projects, a contractor will agree to terms which will require them substantially to fund the work in progress and they in turn will often look to banks to support this. In some cases, payment by the owner may be in the form of product from the finished project. Such an approach is attractive to an owner who is setting up a new venture and is in a poor position to gain acceptable terms from banks for financing.

Suppliers

Though not particularly common, suppliers to the owner may financially support a project. This occurs when the outcome of the project will deliver a specific benefit to the supplier. A typical example would be the upgrading of the incoming electrical system needed to provide additional electric power, which may be funded by the electric power supplier if the project outcome involves a significant increase in electricity demand.

Customers

A customer may financially support a project if it arises principally as the result of demand from them. Clearly, any such support will only be provided if it is also beneficial to the customer. Examples of this may include modification to a plant to make a special customer-specified product or the provision of a facility to dispose of hazardous waste. The customer will in such cases usually require some long-term guarantee of supply and pricing.

16. Project authorisations

16.1. Stage-gate project approval process

For almost all engineering projects the project development and definition phase requires considerable skilled resource, some expenditure of funds (directly or indirectly) and a number of decisions concerning selection of best solution, priority, strategy, and indeed whether or not to proceed. It makes no sense to allow a project development team to proceed through the whole of this phase without checking with business management whether the work continues to be optimal to business needs and priorities and therefore likely to receive authorisation and funding when requested. For example:

- a major new petrochemical complex may involve expenditures in excess of €2Bn and hence the development and definition phase itself may extend over several years and require considerable expenditure, possibly €50 – 70M
- a plant upgrading project may only cost €10M, but the nature of the project will demand a detailed project definition package with considerable involvement of personnel with specific knowledge of the plant. Hence the issues include the cost of definition which may be as much as 10% of final spend, the need to commit the time of specific individuals and possibly looking at alternatives to minimise interference with the operation of the plant

It therefore is sensible that any organisation commissioning the development and execution of projects on a regular basis has a defined process which allows business management to review and authorise each significant phase leading up to full authorisation to implement. Even with only infrequent projects, where these are significant to the business, the person leading the development should have a means of advising and verifying with business management at key stages that the key parameters meet business objectives and that it continues to be supported.

A stage-gate process lists the key stages of the development and definition of a project and identifies the requirements for review and approval prior to proceeding to the next phase. In some cases, these processes also continue and provide for reviews and approvals through the project implementation phase. It is inappropriate to suggest a preferred model for a stage-gate approval process as the requirement is dependent upon the needs of the project owner and other stakeholders and the nature of the project itself.

If an existing stage-gate process is not appropriate for the nature of project development, it can in itself become a significant cause of additional work, delay and hence extra cost to a project. The following guidelines are of importance:

- small / simple projects require simple processes. One or two stages are usually sufficient
- larger projects may need more stages. Stage points need to be appropriate for the project and the proposed development and implementation strategy. For example, some projects will require full detailed design and construction contract tendering before finalisation of the budget for final authorisation, while others may be fully authorised against a functional specification and a 20% budget estimate

- it is important to identify clearly what information will be required at each stage
- it is important to identify clearly who is responsible for approval to proceed to the next stage, and also others who need to be consulted
- in many cases, the development and definition work will require explicit funding and in such cases approvals will need to include release of funding for the next stage(s)
- stage approvals are likely to generate the requirement of estimates. The required estimates should be identified well in advance, together with expected quality. Estimates may be required for both funding for the next stage(s) of work and for the overall project. The latter will allow the project owner to assess its continuing attractiveness
- wherever practicable, authority should be delegated down the organisation structure to a manager, or management group, that has real knowledge and ownership of the project. It is also important that the end user is involved in this progressive approval
- where an approval from very senior business management is required, especially if they are not located at the site of the project development, then there must be planning and liaison procedures and processes in place to ensure that this authorisation in itself does not cause significant delay

A model of a typical stage-gate approval process suitable for medium sized projects is provided in Appendix A.

16.2. Authorisation of initial development

As soon as an initial brief review of a proposal has confirmed that it is in principle worth pursuing, a proposal development request should be prepared and signed by the manager of the department who will benefit from the proposal to confirm their support. For major projects it is also advisable, and in many organisations required, to get support at a senior level matching that required for final authorisation. It should then be reviewed and authorised by whoever is responsible for management of the project development programme.

The aim of this initial authorisation is to confirm that the idea merits further development and to identify the use of resources needed and the target to complete this work. A typical example of a development request is provided in Appendix J.

The proposal should identify:

- a summary description of the proposal and the business objectives it will fulfil
- the person(s) responsible for initial development work
- the anticipated duration for initial development
- other parties required to provide input into the initial development
- an outline of work proposed for the initial development
- a source of funding for this phase of work
- the anticipated time frame for the work
- who will be the project sponsor

16.3. Authorisation of further development and definition

This second authorisation is appropriate for larger and complex projects and those where the choice of solution is not obvious. It provides key stakeholders the opportunity to review the work to date and to reconfirm the proposals with the better data and evaluation arising from the initial development work. This is also likely to be the point at which the owner will be requested to provide funding for the balance of the development and definition works.

For very large investments with extended development and definition durations, it is likely that there will be a requirement to review formally and reconfirm support on several occasions given the scale of investment and its likely importance to the overall business of the owner.

As part of this authorisation, the following should be identified and agreed:

- confirmation of the preferred option and its associated outline scope
- if more than one option still remains, a proposed strategy and time frame to clarify which is the preferred option
- objectives for the development and definition phase
- the financial data, including quality of estimate, required to support request for final project authorisation
- the development team leader (note: this may not be the same as for the initial development)
- members of the development team and availability of resource.
- funding requirements
- the need to involve parties beyond the development team, in particular to obtain commitments on the availability of required inputs from plant operations staff etc
- the strategy and schedule for this phase

16.4. Authorisation to commence implementation activities within the development phase

For some projects, especially those to be executed on a fast track basis, the strategy may require that certain activities normally considered part of implementation are commenced prior to final authorisation. Common examples are detailed in Section 22.

Where such work is required, there will be a need to provide funding. This need should always be identified as early as is possible, ideally at the time when funds for detailed development are requested. At that time it may not be possible to identify the amount of funding needed, but it should be possible to agree in principle the intention to make such a request and what information (estimate quality, preliminary business case, supporting information etc) will be required and the process by which the funding will be authorised.

The required financial commitment for implementation activities may be of sufficient significance that approval will be required from the same parties as for the final project authorisation. Unless at the time of the request there is a high degree of confidence concerning final authorisation, it may well be difficult to obtain approval of this advanced funding. In any event, the approving parties are likely to require the following to support a request:

- identification of the works covered by the request
- an explanation of why the works must be commenced prior to full project authorisation and the consequences if this approval is not given
- the quality of the estimate for these works
- any significant risks associated with these works
- expected cash flow requirements
- preliminary appraisal data to show that the project is, subject to the finalisation of appraisal, sound and likely to merit full authorisation
- how the works will be managed and who will do the work
- confirmation that any orders / contracts include acceptable provisions for termination in the event that the project is not authorised

16.5. Authorisation for detailed design and engineering

Although not common in the process industries, a strategy is sometimes adopted whereby all, or a very substantial portion, of detailed design is carried out prior to final authorisation. The main benefits of such an approach are:

- it facilitates the carrying out of a high accuracy project cost estimate
- it facilitates value engineering, without incurring risk of contract change orders
- it resolves a number of risks associated with design
- substantial tendering for main equipment items can be carried out so that orders may be placed as soon as final project authorisation is granted
- it allows construction contracts to be awarded on a firm basis and facilitates the use of lump sum contracts

The disadvantage of this approach is that it may well involve commitment of 10-15% of total project cost prior to final project authorisation. Hence the authorisation of detailed D&E is likely to require a formal approval request in a similar manner to that stated below in Section 16.6, as in reality it is making a significant commitment towards full project authorisation.

16.6. Project final authorisation

Project authorisation is normally, although not always, the end point for the project development and definition phase and indeed is one of the key objectives for that phase. It is therefore important when proceeding with project development to identify requirements for project authorisation. The following are commonly required:

- an overview of the purpose and justification for the project, including financial appraisal
- the relationship to overall business objectives
- an overview of why the proposed project is the preferred option. This should include summary of other options considered
- a summary of project scope
- a cost estimate to an agreed level of accuracy
- an appraisal of the impact of the project upon the business. If the project aims to provide a commercial benefit, then the appraisal should test variations in project cost (for example +20%) and issues such as lower sales volumes, lower margins etc
- identification of any significant cost risks
- the projected cash flow and, for large investments, how the company will meet this
- any other costs outside the project but linked to it, for example the closure of a redundant facility
- identification of the proposed overall project schedule and any key intermediate dates
- overview of the project implementation strategy
- people requirements within the owner's organisation
- any significant impact of the project upon third parties with whom the company has relationships, for example customers, suppliers, employees, joint venture partners, shareholders, banks and any other finance providers, national and local government, regulatory authorities, local community, competitors, special interest groups
- any significant risks associated with the project and how it is proposed to manage and mitigate them

In many cases the authorising bodies will only wish to see executive overview information, but it is essential to have available the more detailed data for viewing if required.

It is vital to know the process for project authorisation and how it works in practice. This is generally company-specific and will often vary within an organisation, dependent upon the location, scale and category of the project. Many organisations have formal authorisation procedures, though in practice they are not always followed. Shortcuts may be allowed, but also sometimes support is required from individuals who are not formally within the approval process. It may be the case that projects which can nominally be approved locally in theory will need head office support for the allocation of funds.

Where project authorisations are needed from head office, there is often a need to submit papers by a certain date before a senior management meeting to review project capital requests. Typically, such meetings are relatively infrequent, so failure to get the project reviewed and approved at one meeting can result in a delay to authorisation of several months.

Some projects will also require approval from external parties. It is vital to identify what is required and when within the overall project programme. Parties include the following:

- many larger projects, particularly those involving introduction of hazardous processes or significant environmental impact, are likely to require government and associated regulatory approvals. Requirements vary from country to country, although in many cases approval in principle can be achieved with outline information during the development phase. These authorities may still demand to review the project technical details at a later stage, before allowing the completed project to be taken into service
- project finance providers will usually require review of the detailed cost estimate and commercial appraisal in order to provide some assurance that the ability to repay debt associated with the project is secure. In many cases, the finance provider will engage the services of an independent project consultant to assess both the commercial viability and the proposed implementation strategy. In some cases, finance providers will require the additional assurance of a firm lump sum tender for project implementation before releasing their funding
- joint venture partners will usually wish to put a project that they will partly finance though their own authorisation procedure. This may not be required for relatively small projects as there often addressed by local management under provisions of general discretionary small projects budget

17. Joint ventures

Manufacturing facilities may be owned by two or more parties in a joint venture arrangement and some new joint ventures will have as an initial objective the construction of new manufacturing facilities. Existing joint ventures may wish from time to time construct new or extend existing facilities. Alternatively, multiple parties may decide that a project should be executed as a joint venture, but with individual owners each owning specific parts of the completed facilities.

It is not within the scope of this handbook to address the generality of content of joint venture agreements (JVA). These are often long, complex legal documents which of necessity address many subjects not directly related to engineering projects. It is, however, essential that if an engineering project of any significant scale is to be developed and executed, there is suitable provision within a JVA to provide the project manager and their team with a mandate to carry out the necessary works.

In the case of a new joint venture, where the construction of manufacturing facilities is one of the initial objectives, it is possible that the full JVA is not in place during much of the project development and definition - that is, finalisation of the JVA is proceeding in parallel with project development. In some cases, the finalisation of the JVA will be contingent upon the joint venture parties agreeing that the proposed project is attractive, which will only be confirmed when there is substantive project definition and a good quality estimate upon which final appraisal can be carried out.

For existing joint ventures there will be many instances, especially for larger projects, where there is no certainty that the project will proceed until a final appraisal is carried out, which almost inevitably will be towards the end of the development and definition phase.

As a consequence, it is vitally important that, where there is no existing finalised JVA in place which provides for the process and management of project(s), there must be an interim agreement to cover project related work up to the point where the finalised JVA can take over. Such an interim agreement must also provide for the possibility of discontinuation of the project.

It is vital to recognise that in many cases the business objectives and priorities of the various joint venture parties are not identical. It is therefore essential to ensure that the project objectives and strategies are acceptable to all. This may need compromises which will have to be negotiated. Such issues must be resolved in the project development phase so that final project authorisation is based upon an agreed set of objectives and strategies.

17.1. Joint venture agreement for project development and implementation

As indicated above, a joint venture must provide a mandate to the project manager and their team to allow development and implementation. Such a mandate could be provided within the overall JVA for the joint business, or it could be a separate agreement. The requirements for the project will, as for most elements of project development and definition, depend upon the scale and complexity of the project. Small projects which are authorised and funded by the local management of an existing joint venture facility may well not require any additional agreements.

In many cases, the preparation of the JVA will be an integral part of the project development works. The work and time required to produce it and get agreement of all the venture parties should not be underestimated.

The following list summarises issues which should normally be covered within a project JVA. This should not be considered an exhaustive listing. There are likely to be additional project-specific issues to be addressed. The relationship to the overall joint venture business JVA must also be addressed:

- outline the project scope and its objectives. Identification of target completion date. Outline of project strategy
- identify the project management team (PMT) and its leadership. This may include representatives from more than one JV partner
- identify roles, responsibilities and authorities of the PMT. This will usually include those normally applying to an owner's project team, but in the case of a JV it is even more important that they are explicitly stated and agreed. There may also be some additional items as follows:
    - relationships to the various JV partners, including reporting requirements
    - mechanisms for project approvals
    - detailed identification of authorities and requirements for key decisions within the project development and implementation
    - mechanisms for provision of monies in order to make payments
    - procedures for approval of change orders and requests for additional funding as needed
    - identification of when the pmt will handover to the owner's operating team(s)
    - coordination with the joint venture parties to ensure that project remains compatible with their other business needs
    - continuing responsibilities after handover
- identification of all key stages (stage-gates) where formal approval will be required from joint venture parties to proceed further. Identification should explicitly advise what is expected at each stage
- identification of other requirements for approvals from joint venture parties
- Identification of the process for the PMT to obtain monies needed to make payments. Note that funding may not always be in the same proportions as final ownership of the completed facility. Funding may also be supplied by parties (for example banks, governments) other than the joint venture parties
- provisions for project insurances and indemnities
- confidentiality agreements
- provisions for termination of the project before completion
- force majeure
- applicable law, means for resolution of disputes

18. Specific requirements for new site projects

'New site' means a completely new location remote from owner's existing facilities.

It is entirely possible that some of the requirements listed below may apply to the development of certain projects which are not new site, especially major projects which involve a significant addition to the owner's assets.

The development of new site projects must address the many issues that will arise as a result of site selection, and these are by no means confined to engineering. In many cases, certainly if the location is in a new country, it will entail the setting up of a new legal entity to represent the project and the subsequent business that results. As a result, these types of project are most commonly headed by a venture manager who is able to represent the owner at a senior level (see Section 5.4).

Listed below are the more common issues which may need to be addressed. Inevitably, the list cannot be exhaustive. Most of these items will need to be covered within the project development phase. The business issues are somewhat beyond the remit of this handbook, but the more common items are summarised. The reality is that the various elements of a project are interrelated and influence one another.

Engineering Issues for the project to be constructed

The following issues commonly apply when carrying out an engineering project on a new site remote from owner's existing facilities. Many may also apply to projects on existing sites, but the extent of work needed in the new site case is usually far greater and / or more complex.

- temporary accommodation, offices, living quarters, etc
- climate data - impact upon design and construction
- utilities, temporary and permanent
- regulatory approvals, data
- site data, topography, ground conditions, drainage
- requirements for site improvement, road and other access
- labour, skills availability
- local availability and capability of construction and maintenance contractors
- local availability of engineering materials

Business issues

For projects which involve the establishment of a new site facility, the non-engineering business issues are often more extensive and possibly more complex than the engineering. During the development phase, some of these issues will need not only to be developed and defined but also to be finalised before the implementation of the engineering project may proceed. The venture manager (see above) will have overall responsibilities for these business issues, whilst delegating the engineering development work to the development project (engineering) manager.

The following is a summary of issues which will commonly need to be addressed. The listing cannot be exhaustive as requirements vary from project to project as does their relative importance and complexity:

- identify a preferred site and establishing that it site can be purchased or leased on acceptable terms. Execute purchase / lease once the project is confirmed
- if in a new country, identify and understand laws, regulations, customs and practices and how these will influence the development and implementation of the project. Adapt the business development processes to be compatible
- agree in principle with local government, and possibly national government, that they will support construction of such a facility
- the regulatory approval process to allow the project to proceed is likely to be more extensive than for projects on existing sites, especially if the facility is considered (rightly or wrongly) to be potentially hazardous or polluting. If a public enquiry is required then the process will take many months or even several years
- set up a business organisation to develop and implement the project. In many cases (almost certainly, if located in a new country), this will require a new registered legal entity
- if the project will have more than one owner, then a joint venture agreement will be needed (see Section 17)
- resource staff to manage the development and implementation of the project
- identify and establish a proposed organisation to operate the completed facility. Carry out assignment, recruitment, training etc
- identify requirements and arrange all needed training for all staff employed at the new facility
- identify required permanent utility requirements. Where these involve interconnection with established suppliers, agree who will manage and pay for this and how. (Note this is also an engineering issue)
- if the location is remote, identify and setting up temporary (and possibly permanent) facilities for staff and labour, offices, workshops and living accommodation
- develop management systems and procedures
- develop site safety and environmental cases
- set up business finance and accounting systems
- set up other business IT systems
- set up local procurement systems
- identify and negotiate for supplies of feed stocks and other process materials
- set up maintenance systems
- identify and negotiate for supplies of general materials and services for the operating facility
- develop potential product consumers (customers)
- identify probable means of delivery for product. Set up logistics systems where needed

19. Specific requirements for retrofit projects

Many small and medium sized, and occasionally large, projects are retrofit or part retrofit exercises, in that they aim to modify and / or extend an existing plant or facility. Such projects have some additional requirements in the development phase and as a result generally require more input than an equivalent sized new build project.

The following section identifies the more significant items, together with aspects where requirements are different in detail from new build projects.

Minimising impact upon existing production may be an important secondary project objective. If this is so, effort should be made to quantify this. This objective may need to be carefully evaluated as it can significantly impact upon project strategy and cost. Disruption to production can affect the profitability of the ongoing business, but if properly planned this may be minimised or even eliminated.

Existing design and engineering data

Inevitably, a retrofit project has numerous interfaces with existing facilities. The project definition package must provide substantial information covering the existing plant / facility. In order to provide this there will be a need to:

- identify data likely to be required. Check its availability and, in particular, whether it is complete and up to date
- if data is not complete and / or up to date, what measures will need to be taken to meet the requirements? Who will do this work and when? If the work is to be done by a contractor, it is essential that they are explicitly advised of this requirement. It is also essential to recognise the time consumed by this activity. Ideally, this work should be largely completed within the project definition phase, to provide a firm basis for detailed design and to reduce project risk
- determine whether existing drawings are to be used for the project, whether a new set is to be produced or a combination of both
- identify standards and specifications to be used for the project and review compatibility with those used for the existing plant

Process design

For retrofits to process plant, there will often be a need to carry out substantial process engineering in the definition phase in order to verify the compatibility of the existing process with proposed new facilities. Failure to carry out such work would present a major risk to project scope. Work required will typically include:

- identify and detail the new and revised process elements and the associated design requirements for utilities, feedstocks and additives. This should include checks that the existing infrastructure has the capacity to accommodate additional requirements
- ensure that flowschemes clearly identify what is new, what is existing and what parts of the existing are to be removed. This may need a separate set to show removals if they are extensive

- check the sizing and rating of existing equipment, pipes and valves which interface with the project. If this not done a significant outstanding uncertainty remains
- check existing utility systems; a process change can impose a disproportionate increase in required maximum capacity. For example, if flare / vent headers have to be replaced, this could be a major additional scope item
- identify tie-ins and check that piping and equipment being tied into have the capacity for new duty. Carry out first-pass evaluation to identify timing / conditions under which the tie-in must be carried out
- identify whether modifications are needed to control and / or safeguarding systems. If so, a functional requirement specification will be required. This must address the whole of the systems affected and detail capabilities following project completion
- carry out an initial process safety review to identify any significant implications of the project
- if new process technology is involved, identify specific requirements. Associated risks should be evaluated and, if appropriate, a contingency plan developed. The implications of an existing plant not performing after project completion are possibly even more serious to a business than in the case of a new build plant

Project strategy

The project strategy will need to address a number of additional issues:

- check access to existing plant data and verify its validity
- ensure provision of plant-specific knowledge, especially concerning process and process control. Recognise the need for involvement of plant-based staff (or others who have detailed knowledge) throughout the design and construction phase. Ensure that they will be available when needed
- determine the extent of requirements design and safety reviews, including the identification extent of existing plant to be included. Reviews will need to include plant-based staff
- agree overall timeframes for the project and for any specific time sensitive elements. This agreement will need to include plant operations and, if significant production interruption is foreseen, also the overall business
- agree the design approach. Will existing drawings / documents be reused? Will a multi-discipline 3D CAD model be utilised? What is the requirement for the updating of existing design documents and requirements for ‘as built’ documents?
- determine the location of the design team as there will be a significant requirement for detailed field checks and measurements. It is therefore inevitable, even with the availability of electronic data transmission, that designers’ requirement to visit to the plant / facility site are not significantly constrained. If the design contractor has an office close to the plant site, then it may be acceptable to carry out the design in this office. However, if the design contractor’s office is remote from the site then the setting up of a site design office must be seriously considered
- identify tie-ins and how they will be executed. Note: the need to address not only piping tie ins but also instrumentation, electrical and civil
- identify requirements for dismantling / demolition including how it will be managed
- identify the split of work. There may well be some specific activities for which the owner may wish to use their own staff

- identify who will be responsible for managing construction contractors commercially, technically, in SHE compliance, in schedule compliance. The plant operations staff will need to be involved as they will most probably retain authority for issue of 'safe work' permits
- determine which construction contractors should be used. Those with existing plant knowledge will normally be favoured
- agree safe practises for work within or adjacent to existing live process plant. Identify permit processes. Agree with plant operations in principle what work they will allow within live plant and what must be done at plant outages
- identify who will manage handover, precommissioning and commissioning. Identify who will carry out tasks related to this. The plant operations team are likely to require significant involvement
- identify requirements for preparation of revised operating and maintenance manuals and for training of operators. Identify resources to carry this out
- identify requirements for the update of the maintenance management system
- work for practical maximisation of off-site work
- identify any issues regarding redundant equipment and materials, especially if these may be contaminated

Project estimates and authorisation

The development of a high accuracy estimate (±10%) is usually much more difficult for retrofit projects. It is most unlikely that there is a database of similar scope projects from which an extrapolated basic cost can be derived and hence estimating has to be wholly based on an item by item cost. Retrofit projects have a far greater risk of the occurrence of emerging works and difficulties often arise in accurately assessing labour productivity for in-plant construction works. The following should be addressed:

- identify and agree the basis upon which project authorisation will be sought. In particular, agree the quality of estimate to be provided. It is often impracticable to provide a '10% estimate' for a retrofit project without carrying out significant detailed design work. This will require time, probably the employment of a design contractor and significant spend. It results in project approval (or rejection!) at a time rather late in the overall project cycle. If the business management insists on such an approach then the requirements and consequences of it must be made clear
- if a ±20% quality estimate is used, then the project evaluation should address the economics at +20% (or even +30%) cost to determine that the project would still be attractive. If a project is only marginal at +20% cost then in many cases the business owner is likely either to reject the project as they will have better use for their money or demand a cost reduction exercise
- highlight areas of significant estimating uncertainties and / or any significant assumptions made in determining the estimate. In particular, identify assumed access to the plant for construction works

20. Regulatory (legal) requirements

20.1. General requirements

Regulatory requirements impact upon the development and implementation of engineering project in many ways:

- a considerable number of projects are developed as a result of the need to comply with statutory laws and regulations and the requirements of business regulators in the case of industries such as water and electricity supply
- the scope of many other projects will include elements aimed at such compliance. Many large client companies have corporate policies, standards and targets related to safety, health and environment which also effectively impose requirements of a similar nature and which may be more onerous than legal obligations. Within the development of a project there will be a need to optimise the means by which such regulatory obligations are fulfilled
- almost all large projects and many smaller ones will require a permit from a government body to allow construction and operation of the plant / facility
- the design and construction of the facility will need to be carried out in compliance with many statutory codes and regulations
- there will in many cases be a requirement to develop or update site regulatory documentation which shows how the site is managed and operated in respect of SHE matters

There are many forms of regulatory requirements; some demand specific absolute compliance, such as the need for fail safe, safety relief devices on (most) fluid pressure systems. However, even in such cases the detail design of the system remains with the project development and design team, subject to acceptance by the regulatory authority.

Other regulatory requirements, whilst having a clear general objective, are not specific in terms of detailed requirements. An example is environmental legislation aimed at improving energy efficiency / reducing greenhouse gases. Here, overall targets are set for industries and in some cases for individual companies, along with incentives and penalties. How they are achieved is largely left to the individual company.

In certain industries, the portfolio of projects will be dominated by those aimed at achieving regulatory targets. This is most notable in the water industry where prices to consumers are controlled by a government regulator and a key factor in setting those prices is the agreement of a programme of projects and their related costs over an extended period, typically 5 years. Most of these projects are aimed at improving waste water quality. The agreement of how, and to what extent, targets will be met in what time frame is likely to be the subject of a major negotiation with the regulator, which will require the water company to have carried out considerable development and pricing of project proposals in order to make a coherent project programme proposal.

Within the EU there are national targets for reductions in greenhouse gases and other pollutants. These demand improvements from industry, and are accompanied by incentives and penalties for not achieving targets. Inevitably, the process industries as major energy consumers and producers of various waste streams are the focus of requirements for improvement.

The power generation industry has obligations and incentives to increase the percentage production from renewable sources. This can be achieved in various ways including hydro-electric, wind, biomass either in dedicated plant or as co-firing in conventional power plant. Alternatively, the companies can buy such power from others or buy emissions certificates from others which effectively increase their allowance for CO_2 emission.

In respect of all of the above it is essential for a successful business to assess carefully how it will optimally meet its regulatory obligations. The scope for review of alternatives in order to achieve an optimal solution is no less valid than for projects where there is a direct commercial return on investment. Points to be considered include:

- always investigate non-project possibilities. Some safety requirements may be achieved by means other than a capital project. Training, changes in procedures or changes in process may achieve required results at far less expense
- check the real probability of an unsafe event. Even where the consequences of an event are potentially severe, it is unlikely that spending significant monies is justified if probability is very low, for example less than once per 100 years. It makes sense for all health and safety proposals to utilise a risk matrix (probability x severity) in order to assess whether a project is justified. In carrying out such a risk assessment, it is essential that the party who makes the assessment using the matrix is both knowledgeable and objective. If the issue is likely to be contentious to external parties, for example the general public, it may be valuable to have an assessment made by an independent third party. (See also Appendix L)
- environmental projects quite often have an economic benefit such as recovery of valuable product from waste streams or reduced energy costs. These benefits should be taken into account when assessing project options and viability even though they may not have been the original driver for project development
- environmental requirements are very often subject to the 80% / 20% rule. It may be possible to achieve significant improvements relatively easily or cheaply, but getting the best possible result (from an environment viewpoint) may be very expensive. Regulators will often be open to negotiation as to what is reasonable, but the owner will need to carry out appropriate development and costing of options in order to demonstrate that a proposed route is overall optimal. In the UK and elsewhere, there is a general requirement to adopt 'best available technology not entailing excessive cost (BATNEEC) in order to gain regulatory approval for environmental performance. The process plant owner will need to demonstrate what excessive cost is
- do not confuse safety requirements with reliability requirements. For example, a pressure system will require a suitable safety relief valve, but whether a spare valve (and associated isolation valves etc) is to also be installed will usually be a function of the desire to test / overhaul a valve without shutdown of the system, which is not a safety issue. Hence the inclusion of the second valve should be judged on economic grounds

20.2. Regulatory interfaces

As indicated above, all engineering projects must take into account regulatory requirements. To this end it, is good practise to engage with the relevant regulatory authorities during the project development phase. In some countries, this is virtually an obligation as no site work would be permitted without the required permits, but even where this is not the case it is sensible to make contacts earlier rather than later to ensure that any problems can be addressed before they become critical and cause delay.

Requirements will differ from project to project and from country to country. Where the project is to be at an existing manufacturing location, it is probable that the local site management will be aware of the necessary processes, the regulatory bodies involved and, most valuably, the specific individuals to be contacted within the regulatory bodies.
On new sites and especially in new countries, this is information is much less likely to be immediately available and therefore obtaining it and making initial contacts will be an important task for the project development team, see also Section 18 above.

21. Tendering, evaluation and selection of implementation contracts

It is beyond the scope of this handbook to provide a detailed treatise on processes and good practise for contract management, but it is appropriate to provide overview guidance as this is often an important element of work during the latter stages of the development phase.

It is common practise that towards the end of the development phase, all the necessary preparations are made for letting either the project managing contract (EPC or turnkey) or where the owner retains overall management, the contract for detailed design work. This has two significant benefits:

- to defer this work until after project is authorised would add a considerable duration onto the overall schedule
- obtaining the tender prices allows verification (or otherwise) of a significant element of the project authorisation estimate

The only negative is that if the project does not proceed then this significant element of work and its associated cost is wasted.

In some cases, the owner may proceed further and even award the contract within the development phase in order to enhance project progress. In such cases it is of course vital that the contract includes:

- clear and appropriate provisions for termination in the event the owner decides not to authorise or significantly defer the project
- clear identification indicating which elements of the contractor's overall scope may be progressed during this period prior to project authorisation

The following are some key aspects which will require to be addressed in the management of this tendering and evaluation work:

- check the quality of the scope of work / specification. Identify any significant deficiencies and address how these will be managed. Quality of scope will always be reflected in the validity of the tender pricing. This is important regardless of the form of contract, but is especially crucial in respect of lump sum type contracts
- carry out a careful appraisal in order to select the bidder list. Normally, the final list should not be more than 4 contractors, all of whom the owner should be ready to employ if they provide the best value tender. To allow a large number bids results in:
    - a waste of many contractors' effort for no gain
    - the risk that, if contractors are aware of the large number involved, they may decide to not bid or to minimise the effort they put into the initial bid
    - the work required for tender appraisal increases

Initial listing of possible bidders may be much longer, but should be reduced by a prequalification exercise.

- check that the commercial terms of the contract are compatible with the scope and technical specification and that the required deliverables from the contractor are clearly stated
- provide sufficient time for tendering – this will be a function of the scale and complexity of the scope and the form of contract. In general, lump sum, and in particular turnkey-type contracts require more work from the bidder as they are taking much greater financial risk and responsibility. Contractors would always like more time, but truly inadequate time will result in:
    - the contractor including large contingencies in their prices and / or qualifying their tender
    - additional tender appraisal time to sort out non-compliances and lack of detail in tenders
    - the contractor later becoming highly focused on recovering the results of the inadequacies of their tender
- ensure that clarifications, and any other additional information provided during the tender period, are given to all bidders so that their tenders will be on a comparable basis
- identify and agree the process and key elements which will contribute to selection and develop a scoring system. Appendix M provides an example, agreement of the process with the management body, for example the tender board, that will later be responsible for reviewing and accepting the project manager's recommendation
- identify who will carry out tender appraisal. Recognise that it may be an intensive exercise and ensure that the needed resource is available
- carry out an initial review of tenders received. Eliminate those which, for commercial and / or technical reasons, are unlikely to be finally selected. This will allow focus on the remaining, potentially acceptable, tenders. Reasons for rejection of tenders should always be recorded and confirmation sought from the appropriate management body, for example the tender board
- check the quality and experience of the key personnel the contractor is offering. If they are satisfactory, ask the contractor to confirm they will be allocated to the project
- ensure any non-conformances of tenders are resolved. If resolution affects other tenders still being actively considered, then ensure that other bidders are immediately informed
- ensure, so far as is possible, that all contractual issues are resolved and exact wordings agreed before contract award. To leave this until later simply stores up problems
- where bids are rejected due either to their being commercially and / or technically unattractive, advise the bidder as soon as practicable. However, be aware of sensitivity concerning other bids still being considered

22. Implementation activities within the development phase

For some projects, especially fast track, with long delivery materials or significant technical risks, the strategy may require that certain activities normally considered part of implementation are commenced prior to completion of development and definition and before final project authorisation. Most commonly these may include:

- further progressing the process design to ensure that there remain no outstanding areas of significant uncertainty. An example would be work needed to resolve complex issues arising from a process safety study
- preliminary designs for connections to existing facilities (tie-ins) in order to confirm the validity of the concept. For example, if the location of a HV electrical connection had to be changed, the consequent work and cost involved could be very significant
- developing detailed specifications for long delivery equipment and materials
- tendering and review of tenders for these items
- placement of orders for long lead equipment and materials
- carrying out design / engineering of specific elements where there are particular uncertainties, and hence risks. This may include design related to specific value engineering opportunities
- further developing the plant layout
- carrying out ground and topographic surveys
- developing detailed specifications for site preparatory works. Review of tenders for such works
- carrying out site preparatory works. This may include demolitions, site clearance, site improvement (load bearing improvement, levelling), fencing, construction of site roads, utility interconnections

These works may represent a considerable financial commitment and therefore appropriate funding will be required.

As a part of the project strategy, it will be necessary to identify who will manage these works and who will carry them out. Ideally, in each case this would be the same party as if the work were to be carried out within the main implementation phase. However, this may not be practicable as relevant contracts may not be in place, in particular, an EPC contract for overall project implementation may well not be finalised. It may therefore be necessary for the owner's project (development) team to manage such work directly.

Where orders are placed and contracts are awarded, they will in most cases need to include provisions for termination in the event that the owner later decides not to approve the project. It may also be appropriate to include provision for the assignment of orders to a future managing contractor (EPC), in order that these elements are not excluded from their responsibilities.

23. Assessing the quality of project development and definition

Achieving a high quality of project development and definition is identified throughout this handbook as probably the single most important factor in determining a successful project outcome. Indeed, the whole purpose of the handbook is to provide guidance in achieving this. It is therefore important to provide methodologies to allow an objective assessment of work done in developing and defining a project so that those involved can either be assured, so far as is practicable, that the desired quality is present or, if not, to be able to identify the deficiencies and take required remedial action.

There are various tools available from consulting organisations which aim to provide for such assessments. This handbook provides two main options:

Appendix N - project definition checklist

This listing can be used at any time during the development and definition of a project in order to review the extent and quality of work done and what may still be required.

Appendix P - project definition rating process

This allows conversion of the checklist provided in Appendix N into a scoring system. This is useful in assessing whether sufficient definition has been achieved to allow commencement of project implementation. The value derived from such a rating is sometimes referred to as the 'front end loading' for the project. Naturally, it is essential that the scoring covers only those aspects of development and definition which are relevant to the particular project. If elements not relevant were scored it would result in an artificially depressed score.

The following provides guidance on scoring:

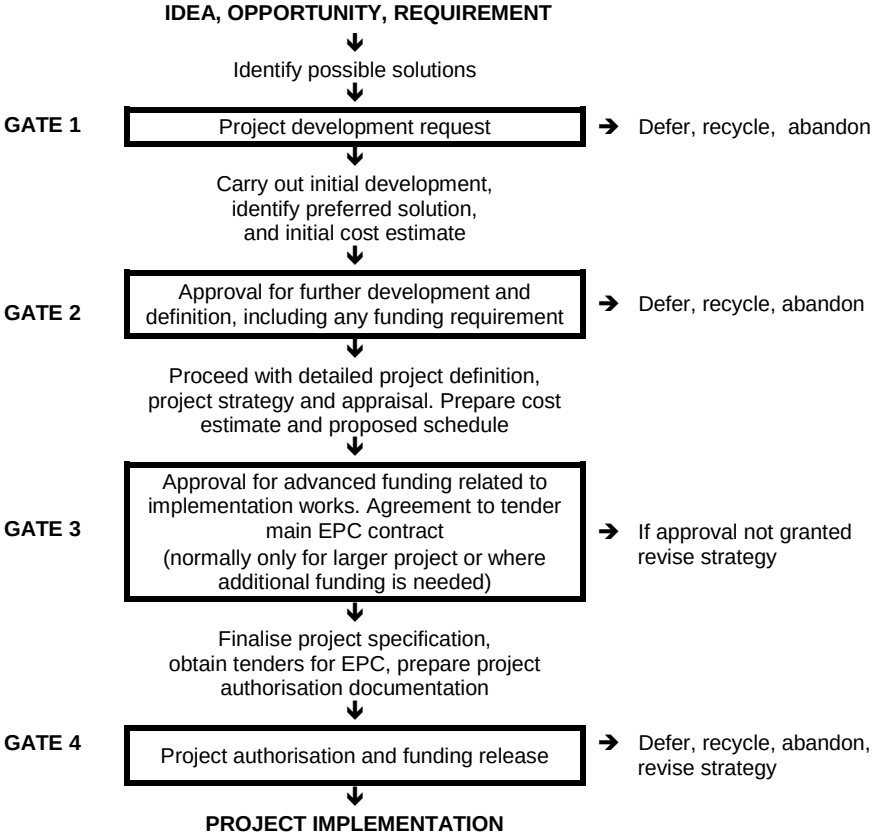
Score	Comment
Below 55%	Inadequate. If implementation proceeds on this basis, there is a high probability of problems being encountered.
55 – 70%	Marginal. Risks remain, but if care has been taken to provide for close management and early rectification of the identified deficiencies, proceeding with implementation may be acceptable.
70 – 85%	Satisfactory. Proceeding with implementation should not incur any major risks related to lack of definition. However, identified deficiencies must still be managed.
Above 85%	Good. No significant deficiencies. However, achieving this level of definition may have resulted in high cost and extended time in development.

Any review and appraisal should be carried out by the whole core project team, and where possible also involve other parties who are able to provide valuable input. If an engineering contractor has already been involved or has already identified to carry out the implementation design and engineering, then their involvement will be of great value. Using a project manager not involved in the project to provide peer review is also valuable.

Appendix A – Typical stage-gate process for project development

The following is a typical process suitable for medium and large projects. Very large projects, such as construction of new site complex or major new joint venture, would usually require a more extensive process; small projects a simpler process

At each of the gates shown below there would be a management review of the development up to that point and of the proposed next steps. The level of management involvement would be dependent upon the scale of the project and the business authorisation requirements. In any event, the final asset owner must support the proposal at each gate.



The above shows only steps up to project authorisation. Some organisations extend this process, especially for large projects, through project implementation and to a final post implementation review.

Appendix B – Examples of best option analysis

Example 1 – Options for increasing manufacturing capacity

This example provides an overview of possible options and issues which may be faced by a multinational manufacturing organisation when considering how to achieve a significant increase in manufacturing capacity.

The listing is indicative only and credible options will differ for any given project. The purpose of the listing is to illustrate the broad range of options which could apply and the extent of work which may be required in order to make an informed judgement in selecting a preferred option.

Some possible options:

1. Limited debottleneck / productivity improvements to existing manufacturing facilities
   - low capital requirement
   - relatively fast implementation
   - may only yield modest capacity gains
   - does not provide any increased diversity of manufacturing capacity
   - unlikely to yield significant reduction in manufacturing costs

2. Major upgrading of existing facility
   - higher capital requirement
   - disruption of manufacturing during upgrading works (what is business cost?)
   - may yield capacity gain equivalent to new plant
   - existing production staff available, some retraining may be needed, maybe some recruitment / redundancy will result
   - possible government grant if it can be demonstrated alternative is closure
   - existing supply and distribution chains in place
   - existing infrastructure basically in place, but may also need upgrading

3. Build new facility next to existing
   - capital requirement higher than for 2 above, but maybe not significantly
   - needs suitable available land
   - avoids disruption of existing production
   - will need some additional staff if it is to run in parallel with existing
   - otherwise similar to 2 above

4. Build facility at alternative existing manufacturing location
   - any of 1 to 3 above may apply
   - comparative assessment of different locations
   - impact on locations not selected for new investment

5. Build new facility at new location – developed country
    - capital required probably higher than for 3 above as it will require purchase of land and complete associated infrastructure
    - need to identify potential operating costs, especially labour key supplies, utilities, logistics, taxes
    - may provide support to marketing for increased sales in country / region
    - government grants and favourable tax regime may be available
    - need to understand and comply with local legal / fiscal regimes
    - need to recruit and train staff
    - need to set up new subsidiary
    - need to identify and engage local suppliers of goods and services
    - need to set up logistics for supplies and finished products
    - if this new facility results in closure or downsizing elsewhere, need to assess impact

6. Build new facility in another country – developing country
    - issues generally as per 5 above
    - labour costs likely to be significantly lower, but need to check skills availability
    - possible language issue
    - need to check availability of local support services for facility operation
    - local legal / regulatory regime may not be entirely clear
    - logistics costs for supplies and for product may be higher
    - construction costs may be lower, but may be offset by additional cost for imported specialist materials
    - probably will need to second expatriates for construction, commissioning and early operation

7. Purchase an existing facility
    - relatively fast route to achieve additional capacity
    - only viable if a facility that meets technical requirements is available at an acceptable price
    - will most probably involve taking over existing facility legal obligations, including existing labour force
    - transition of ownership may result in need to make many detailed changes which will require considerable management effort over first 1-2 years
    - need to decide whether to leave existing facility management in place or replace it

8. Contract out manufacture to a third party
    - avoids significant capital expenditure
    - some loss of control of business. risk of third party failure to perform
    - need for agreement to ensure long-term commercial attractiveness, and also to allow flexibility for changes in requirements
    - negative impact on existing employees, especially if it results in job losses

9. Do nothing at present
   - avoids capital expenditure for the present
   - avoids risk of facility being underutilised if projected sales increase is questionable
   - risks market share being taken by competitors
   - risks present facility failing to keep up with competitor facilities in terms of efficiency, productivity, quality
   - does not preclude future construction of additional capacity

Example 2 – Recovery of feedstock from a liquid waste stream

This example shows the diversity of options which may apply even for a fairly small project.

It is based on a real case requirement aimed at recovery of valuable feedstock (80% of total) from a liquid (light hydrocarbon) waste stream. The project had both a reasonable projected economic return and environmental benefit. Capital cost was approximately €6M

Options considered were:

1. Construction of distillation unit with capacity based on existing requirement
   - reasonable capital cost gives optimal economic return
   - proven technology, so low risk
   - would still be useable in case of limited plant capacity increase
   - surplus steam is available for distillation unit so utilities costs are low

2. Construction of a large scale distillation unit with additional capability to upgrade future feedstock supply in case of major increase in plant capacity or new larger plant
   - higher capital cost (approximately 2x option 1)
   - higher running cost
   - no guarantee of future major plant capacity increase
   - at present, plant capacity economic return is far poorer than option 1

3. Utilisation of new technology (Pressure Swing Adsorption) for recovery
   - capital cost expected to be slightly less than 1 above (range 80-100% of 1) but with more cost risk
   - could be provided as a skid mounted unit, so site construction work is less than option 1
   - technology relatively complex and not commercially proven. Concerns about reliability and need for higher level of maintenance
   - involves royalty payment which results in higher operating cost

4. Ship waste stream via existing pipeline back to feedstock supplier for reprocessing
   - lower capital cost (approximately 30% of 1)
   - flow rate is very low for pipeline so unit operating cost for pipeline is relatively high
   - feedstock supplier has quality and capacity concerns over the impact of introducing waste stream into existing process. Would insist on batch segregation and batch analysis. Feedstock supplier is essentially not supportive of this proposal
   - would have some minor negative impact on feedstock supply quality
   - feedstock supplier would want a (modest) fee for reprocessing
   - operating costs not easy to assess hence economic return is difficult to assess

5. Ship waste stream by truck back to feedstock supplier for reprocessing
    - capital cost similar to 4 above
    - generally as 4 above, avoids pipeline operating costs, but trucking cost is likely to be similar or higher
    - would need temporary storage of a hazardous material prior to truck filling

6. Burn waste stream in existing boilers
    - lower capital cost (approx 30% of 1)
    - does not achieve full economic or environmental benefit as it is only practicable to burn approx 60% of waste stream
    - fails to recover the feedstock content of the waste stream which is valuable, hence overall economic return is poor

7. Do nothing
    - not acceptable in medium term due to environmental obligations
    - fails to achieve business benefit from feedstock recovery

The eventual choice was to carry out a combination of option 1 and 6. This yielded both improved economics and environmental performance versus option 1 alone, as it allowed not only full recovery of feedstock but also the ability to use most of the remaining waste stream as fuel for the boilers instead of burning via a flare.

Appendix C – Listing of typical stakeholders

The following table identifies some of the more common stakeholders who may have an interest in a project proposal and what their interests may be. The listing can only be generally indicative as each proposal will have its own specific set of stakeholders and associated interests. Additionally, within the groups identified it is quite possible that there will be individuals with their own differing interests. For example, young employees may be looking for employment security whilst older ones may see a project as a means to deliver early retirement.

Stakeholder	**Main interests**
Internal stakeholders (within owner's organisation)	
Senior business management	- Compatibility with business objectives - Securing / improvement of business performance, enhancement of corporate reputation, meeting legal obligations - Concerns about financial and business impact
Sales / marketing	- Ability to provide improved / more competitive product to customers as soon as possible - Concerns about any product supply disruption
Finance	- Securing / improving business financial performance Identifying cash requirements for projects and impact upon overall profitability and cash flow
Plant operations management	- Provision of improved operations (financial, reliability, SHE) - Securing the future of the plant. Need to prepare operating procedures and train staff - Concerns about any operational interruptions
Maintenance dept	- Provision of reliable plant. - Provision of appropriate maintenance facilities
Company SHE management	- Ensuring compliance with government and corporate requirements in design, construction and plant operation
Employees at site	- Impact on future employment prospects Impact upon working conditions - Need for training plant safety issues
Project team	- Provides challenge, career development - Concern to ensure adequate project development and agreement of a sensible project implementation strategy
Process engineering	- Implementation of new processes raises profile. - Provides challenges, career development

Stakeholder	Main interests
Research and development	- Testing new / improved processes to demonstrate validity and commerciality of R&D
Owner's other locations	- Concern about impact on location (that is possible transfer of business)
Public Relations	- Need to ensure positive impact on public and government
External stakeholders (outside owners organisation)	
Joint Venture partners	- Ensuring project proposal is compatible with their business objectives - Checking that their share of cost reflects share of benefits to be gained
Shareholders	- Proposal supports overall business objectives. - Does not present an excessive financial burden or other major business risk
Customers	- Provision of improvements to product specifications, pricing, availability - Concern about any supply disruption during project implementation
Feed-stocks, additives, utilities, logistics suppliers	- Changes in requirements may result in increased or reduced business. - May also require changes to means of delivery - Threat from owner reviewing who supplies
Engineering contractors	- Opportunities to provide services associated with possible project and later for maintenance and other support - Enhances future business prospects - Threat from introduction of new contractors as competitors
Material and equipment suppliers	- Opportunity to supply materials and associated services
National government	- Securing / additional employment. - Securing / additional GDP. - Enhancement of the environment. - Increased tax revenue from more profitable business - Concerns about any possible loss of employment at site or elsewhere - Concern about any possible negative views from public - Checking that terms for any grants are complied with

Stakeholder	Main interests
Local government	- Securing / additional employment locally, both direct and for local suppliers - Improvement of local environment - Concerns about loss of local undeveloped land (farmland / countryside) - Concern about any new safety and environmental implications for local population - Concern about environmental impact of construction works and completed facility
Regulatory bodies (SHE)	- Compliance with regulations - Achieving environmental targets
Local population	- Employment and business opportunity issues - Environmental impact both for construction and operating plant - Any perceived safety issues for local residents
Special interest groups	- Environmental impact
Trade Unions	- Employment impact, short term and long-term - Health and safety of members - Impact on conditions of employment
Competitors	- Threat from increased competition - Possible opportunity if owner ceases to make certain products
Finance providers	- Need to ascertain that project when completed will support repayment of loans - Need to confirm no major financial risks
Land owners (especially for pipeline projects)	- Agreeing fees for use of land - Compensation for and repair of any damage - Means of access. - Future access if needed
Highway authorities	- Identification of any abnormal usage, possible disruption and damage - Any requirements for excavations, modifications - Any long-term significant change to traffic flows

Appendix D – Checklist for engaging a contractor / consultant to execute and manage project development works

Following is a listing of some aspects which should be addressed before engaging a contractor / consultant for the purpose of general execution and management of project development and definition works.

It is important to select on the basis of the contractor / consultant best able to do the work required, as opposed to lowest cost, as the quality of their work will have a significant influence on overall project outcome, whereas their cost will represent a small fraction of total project cost:

- have all the main elements of development / definition work proposed to be contracted out been identified?

  Note: Accurate quantifying of the work content is usually not possible at this stage in the project development
- are all the deliverables and associated timings required from the contractor clearly identified?
- do any work elements require specialist skills only available from a specialist contractor? If so will the general contractor manage the specialist or will the specialist be contracted separately?
- many aspects of development work must to some extent involve the owner's staff. Identify who needs to be involved and how they will interface with the contractor. In particular, identify joint review processes, their approximate timing and required attendees
- is it intended that the contractor selected for the development work may be involved with the project beyond the development phase? This is a project strategy issue which will impact on contractor selection and terms of contract. The contractor should be made aware of intended strategy before engagement. Following are possible cases:
  - the contractor to continue to act for the owner on a project management consultant basis. that is, the contractor acts for owner but is not the implementation EPC contractor
  - the contractor will be considered as preferred bidder for the EPCM contract, possibly on a negotiated basis
  - the contractor will be considered as a bidder for EPCM contract but on a competitive tender basis
  - the contractor will be used for detailed design, but not for procurement and construction
  - the contractor will be specifically excluded from project implementation works

  Note: criteria for selection in respect of follow-on work are not addressed here. See Section 21 in respect of selection of EPC contractor

- Identify all the skills and knowledge requirements needed from the contractor. This may include:
  - Experience of issues related to the country / location of the project
  - Recent process experience relevant to the project
  - Retrofit experience if appropriate to the project
- check the proposed contractor for skills and specific recent experience in the type of project development work foreseen. Checks must apply to the contractor's office where the work will be carried out for this project
- obtain details and check out recent project development work by the contractor from their office in question. Contact the clients for whom this work was carried out
- ensure that the proposed contractor's project manager and other key staff have relevant experience
- check the contractor's work loading and availability of the key personnel they are proposing
- if the work will involve any commercial evaluation of tenders, check out the contractor's processes for this. Ensure clarity in respect of the owner's involvement in tender evaluations
- if the work involves management of sub-contractors, check out the contractor's processes for this. Ensure clarity in respect of the method of payment of sub-contractors
- ensure that the terms of contract are appropriate for this type of work and that the proposed contractor agrees. Ensure that there is an appropriate mechanism for authorisation in respect of additional work which will arise. The mechanism must be responsive but also control growth of work and hence expenditure

Appendix E – Template for project execution plan suitable for a small / medium-sized project

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For many small projects, the project execution plan (PEP) document will be issued only once, usually timed to provide advice associated with the request for project authorisation. However, if the project is foreseen to require considerable work within the development and definition phase, serious consideration should be given to the preparation and issue of an earlier version which focuses on the requirements and strategy for development phase.

1. Project description

1.1 Project title

1.2 Objectives and priorities

- identify the key objectives of the project. Include main parameters of owner's requirements, such as reference to product throughput, specification, quality, safety improvements, future cost savings, project cost, time
- identify compatibility with overall business objectives
- identify developments / changes to objectives since commencement of development
- cover provisions for future expansion / development

1.3 Scope of the project

- give an executive summary of scope of work and basis of design
- provide additional detail, if appropriate, for outstanding activities required for project authorisation

2. Key issues, risks, sensitivities

This section highlights as a summary those aspects which are of key importance to the particular project and which will require special attention during its execution. How these will be tackled may be further detailed in the relevant section of the PEP. For some simple projects, it may not be necessary to identify any aspects here:

- technology, own or third party, especially where new or developing
- licensing agreements
- significant elements of the basis of design which remain to be determined, or which will require the use of non proven processes or equipment
- project schedule, especially where fast track or required to meet fixed dates
- use of non-standard or potentially hazardous construction techniques
- unusual contractual arrangements relating to any elements of the project
- abnormal concerns with regard to authority approvals (planning permission, SHE)
- significant deviations from normally used technical or SHE standards, specifications, procedures
- any significant resource constraints (key individuals)
- abnormal cost risks

3. Cost and schedule

3.1 Cost estimate

- party responsible for preparation of project control estimate(s)
- executive summary of estimate currently available
- timing of estimate(s)
- quality of future estimate(s) required and any particular risks associated
- provisions for contingency, general and specific

3.2 Cost control

- who will be responsible for cost monitoring and control?
- review / reporting frequency
- identify deviations from normal techniques

3.3 Project schedule

- identify proposed overall schedule
- identify key / critical activities / milestones
- identify the responsible party for project detailed planning
- identify the level of planning proposed for the project

- if the project is fast track, identify special measures to be applied and critical resource requirements

3.4 Change control

Changes to projects usually result in their requiring additional time and / or cost. Changes may also lead to the original objectives not being wholly fulfilled. Typically, the later a change occurs the more severe the impact. It is therefore necessary to employ an effective change control procedure. The principles only should be described within the PEP, with reference to availability of full procedure:

- identify procedure(s) to apply internally during the development and execution phases
- these should cover technical as well as cost and schedule change
- identify procedures to apply to contractors
- specify authority levels for changes
- clarify change reporting procedures
- identify procedures for provision of additional funds

4. Division of work and resourcing

4.1 Division of work

The intended roles and responsibilities of all parties directly involved in the execution of the project should be identified and the needed resources quantified. The timing at which the various resources will be needed should also be identified. Identify as appropriate parties responsible for:

- project basic definition
- management of development up to authorisation
- preparation of basis of design
- definition of standards / preparation of project specification
- preparation of estimates
- preparation of project overall master plan including PEP
- obtaining authority approvals
- management of the authorised project
- management of contracting for works delegated to contractors
- execution of preparatory works, or example soil surveys, sit clearance
- design of outside battery limits facilities
- design of inside battery limits facilities
- execution of project design safety and operability reviews
- procurement
- management of construction
- development of health and safety plan for construction works
- execution of construction (by discipline)
- project quality assurance

- preparation of operating instructions / training
- management of precommissioning
- commissioning

Where responsibilities lie within the owner's organisation, identification of departmental responsibility should be carried out, in particular defining the responsibilities of the project team and the owner's operating unit.

Where the interfaces between different parties are not straightforward, the means by which this will be managed should be addressed.

4.2 Resources

For a project to be effectively executed requires the provision of sufficient human resources with the appropriate skills to carry out the needed tasks at the appropriate times. Availability of resources is likely to be one of the main criteria for determining the extent to which work is carried out by contractors, or by affiliates of the owner, as opposed the owner doing the work itself. It must, however, be remembered that any contractor will require technical and commercial management by the owner and that in itself will require resource.

For those activities which are to be carried out by the owner, the total resource requirement should be identified by discipline, by volume and by time.

For example: process engineer:

40% of 1 person for period up to authorisation
60% of 1 person for 4 months following authorisation
20% of 1 person for balance of project

For activities to be carried out by other parties, it is necessary to identify the resources by discipline likely to be needed and the method by which the parties' capability to provide will be assessed.

5. Contracting

The purpose of employing contractors is to obtain specific works, services and goods which the company cannot or does not wish to provide itself. In order to ensure that contracting provides works, service and goods needed to meet the project's objectives it is necessary that a contracting strategy be identified. The following is a checklist of aspects which may require to be addressed:

- identify works, services etc for which contracting is the preferred means of supply
- a summary scope of work and objectives for each intended contract, including options
- capabilities and resource required from the contractor for each contract
- method of contractor selection (ender list and preferred tender selection)
- type of contract and reason for type selection
- single or competitive tendering
- responsibility for preparation of tenders, tendering, evaluation, contract award and administration

- commercial and technical management of contractors
- management of contractor / company and contractor / contractor interfaces

6. Safety, health, environment, operability and maintainability

Most companies' policies and government legislation will require ensuring that activities are conducted in such a way as to take foremost account of the health and safety of all persons working on the project and those who will be involved in future operation and maintenance. There should also be proper regard given to protection of the environment both during the execution of the project and in the operation of the completed facility. In implementing this policy, local legislation must be complied with.

For each project, it is necessary to ensure that all relevant aspects of health, safety, environment, operability and maintainability are addressed, managed and resolved. The PEP should identify the key issues and the management strategy for addressing their resolution. The following checklist is a guide:

- identify the key process / operational safety requirements to be addressed as part of design
- identify the impact of the project on existing facilities
- list the statutory authorisations and permits required and who is responsible for obtaining them
- identify responsible parties for ensuring design safety
- prepare a Safety, Health and Environment statement for the project
- identify need for and timing of SHE reviews (HAZOP, HAZAN etc). Identify parties required to participate in these studies and how the follow-up will be managed
- identify design reviews for constructability, operability, maintainability and safe egress
- provide an overview of construction safety strategy and responsibilities. Include, where applicable, consideration of impact of adjacent operating plant / facilities
- consider disposal of construction waste, for example contaminated spoil, ground water
- define responsibility for update of COMAH case / IPPC case

7. Engineering, procurement, construction (EPC)

Engineering, procurement and construction are the core activities of project implementation which translate the project development work, the basis of design and project specification into a completed facility to meet the defined objectives.

In order to achieve the objectives in a safe and effective manner and to ensure that the facility will subsequently be able to operate in a safe, reliable and efficient manner, it is necessary to ensure that this work is properly planned and managed. The PEP should identify the organisations, resources and interfaces intended for the execution of this work and highlight aspects where particular attention will be required and proposed methods of tackling them.

The following checklist indicates areas which may need particular attention. The list is not exhaustive and each project has its own needs:

- project organisation for EPC, including split of responsibilities
- interfaces between organisations and departments, particularly process engineering and instrumentation
- verification of basis of design
- identification of design problem aspects
- timing and scope of design reviews
- design quality control, auditing
- agreement of procurement strategy and procedures
- pre-ordering of long-lead materials
- management of vendors, particularly equipment package supply and others where there is a complex design interface
- procurement quality control
- management of construction safety, including identification of any particular concerns, for example complex lifts, false-works, large excavations, confined spaces, adjacent operating plant
- construction site hygiene
- definition of completion
- management and execution of handover
- industrial relations
- construction quality assurance
- precommissioning and commissioning interfaces

8. Precommissioning and commissioning

In order to bring the new or modified facilities into service, it is usually necessary to carry out precommissioning and commissioning activities. These require to be planned and managed and the PEP should identify the key features of how this will be achieved. The following should be considered:

- identify roles and responsibilities for the various aspects.
- who will be responsible for the detailed planning of precommissioning and commissioning and when will this be required?
- who will manage precommissioning, commissioning?
- who is responsible for handover punch-listing?
- what handover documentation is required and who is responsible for provision?
- is the use of vendors' engineers foreseen?
- what training of operating and maintenance personnel is required and who will manage this?
- what are the requirements for performance testing?

Appendix F – Common forms of contract for project implementation works

The following listing provides a listing of the more common generic types of contract used for project implementation. In reality, there is a huge number of possibilities many of which have similarities to others. It is not possible to indicate which types are better than others as this is a function of circumstances and project requirements. For nearly all types it is possible either to tender competitively for the contract or to negotiate with a preferred contractor or indeed a combination of both.

Type of contract	Comments
1. Reimbursable - project management consultancy (PMC)	Used (usually on large projects) where the owner does not have the resource to carry out project detailed definition and the tendering for implementation works. In many cases, PMC is retained to act as owner's representative through the project implementation. They are not the EPC Contractor. Merits – provides appropriate skills when needed. Demerits – need to control cost of PMC to the project. PMC may not always act fully in owner's best interest.
2. PMC with incentives	Still essentially reimbursable, but incentives aim to align more closely PMC with owner's objectives. Incentives usually relate to achievement of key milestones in PMC work and to overall project cost. Incentives must be progressive and carefully structured. Merits – as above plus improved drive to achieve targets. Demerits – as above but incentives mitigate.
3. Lump sum turnkey (LSTK) (Note this is one particular form of EPCM contract)	Contractor is responsible for delivery of the whole project implementation (cost, time, quality) in accordance with the contract specification. The specification must identify all the owners' specific requirements (scope, quality, time) in detail. May or may not include commissioning. Especially useful in cases where contractor is also the holder of process expertise and / or supplier of main equipment. Merits – most of project risk is given to contractor. Requires less supervision from owner. Can be very cost and schedule effective. Demerits – time for preparing, tendering, and evaluation of contract tends to be long. Any changes to specification will be very costly and likely also to lead to claims for extra time. Compliance with specification requires to be closely monitored. Higher risk of contract disputes.

Type of contract	Comments
4. Engineer, procure, construct, and manage. (EPCM) fixed fee for E&M, reimbursable for P&C.	Contractor has principal responsible for delivery of the whole project implementation but with some owner involvement and sharing risks related to vendor and sub-contractor performance. Contract specification must fully detail owner's specific requirements (scope, quality, time) in detail. May or may not include commissioning. Merits – some of cost risk is taken by owner, so contractor, needs less contingency in tender cost. Tendering time is shorter than for LSTK. Impact of any owner changes is usually less severe than for LSTK. Contractor will better check quality of vendors and sub-contractors. Demerits - time for preparing, tendering and evaluation of contact tends to be long. Requires more involvement of owner: in addition to checking compliance with specification, also needs to verify proper cost control of vendors and subcontractors
5. Engineer, procure, construct, and manage. (EPCM) Fixed fee for E&M, reimbursable for P&C. With target incentives.	Generally as 4. above but including incentives re overall project cost and possibly also re project schedule Merits – generally similar to 4 above. Target cost incentive will drive EPC contractor to control costs of vendors and sub-contractors. Target schedule incentive will drive progress. Demerits – generally similar to 4 above. Incentive schemes may make contractor more claims conscious for any perceived changes. Final payments of incentives likely to need negotiation.
6. Engineer, procure, construct, and manage. (EPCM) fully reimbursable.	Contractor responsible for delivery of the whole project implementation but with owner involvement and significant risk sharing. In particular, owner takes main cost risk. Contract specification does not need to be fully detailed, although detail is still beneficial. Merits – allows for fast tendering as work needed to tender is much reduced. Allows finalisation of specification without major claims arising. Allows owner to participate in design and engineering detail. Likely to lead to high quality outcome. Low risk of significant contract disputes. Demerits – risk that owner continues to make changes. High vulnerability to escalating costs. Some vulnerability to extension of schedule, hence owner will need larger input for project control.

Type of contract	Comments
7. Engineer, procure, construct, and manage. (EPCM) reimbursable with target incentives	Contractor responsible for delivery of the whole project implementation but with owner involvement and significant risk sharing, in particular, sharing of cost risk. Contract specification does not need to be fully detailed. Good detail is still beneficial and if significant changes arise, contractor may wish to revise targets. Merits – generally as 6 above. Incentives will improve drive to control costs and schedule. Deters owner from making changes. Can be carried out as a project partnership. Demerits – generally as per 6 above. Some risk of sacrificing quality for cost and time.
8. Contract for engineering and procurement, owner manages separate contracts for construction.	Useful in the case of small and medium-sized projects, especially those involving substantial work within owner's existing facilities. Owner will contract construction with local contractors who have existing site knowledge or even use own labour for some of the work. Merits – avoids the difficult aspect of retrofit construction management by contractor. Owner has knowledge of site established practises for retrofit construction. Owner's project management should have closer relationship to plant operations to facilitate handover and commissioning. May allow lump sum contract which would not be possible if construction were included. Demerits – adds a major interface and splits project responsibilities. Not conducive to minimising overall schedule.
9. Owner manages, procures. Contracts separately engineering and construction	Generally similar to 8 above. If owner considers they have procurement capability, then this can reduce project costs. Merits – generally as 8 above. Owner may be more efficient at procurement for smaller projects. Demerits – generally as 8 above. Adds major interface between engineering and procurement
10. Owner carries out E&P owner manages separate contracts for construction	For smaller projects where owner retains project engineering and management and engineering capability, but has insufficient design capacity. Merits – often results in lower cost than using an EPCM contract for smallish projects. If project development has not been thorough, this route is more able to cope with changes. Owner's design staff have inherent site knowledge of existing facilities, standards and specifications. Owner is often more efficient at procurement of small-quantity material requirements. Owner can select appropriate form of contract for each element of the project. Demerits – may stretch owner's project capacity, resulting in delays to project and possibly to other works. Greater risk of preference engineering adding to the project scope. Requires owner to maintains significant project capability which may sometimes underutilised and hence not cost effective for overall

Type of contract	Comments
	business.
11. Design and build	Contractor is engaged to carry out detailed design on reimbursable or target cost basis. Procurement and construction then tendered on lump sum or guaranteed maximum price based on the completed design and specification. Not common in process industries. Merits – allows owner to check design meets their requirements and adjust if costs appear excessive. Provides a high-accuracy project cost before final commitment to procure and construct. Low vulnerability to change after design completion. Demerits – usually leads to a longer overall project schedule. Compliance to specification requires to be closely monitored.
12. Alliance contracts	Very useful if owner has an ongoing demand for contractor services related to project design and management. Contract is usually reimbursable, but with performance incentives. Merits – alliance contractor develops detailed knowledge of owner's technical and business requirements. Facilitates rapid mobilisation to start works; contractor can very effectively assist in project development. Contractor will be more efficient and hence cost effective. Allows for sensible risk sharing. Avoids repeated tendering. Demerits – arrangement needs major effort and time to set up. Initial performance during learning curve likely to be disappointing. Must have continuity of work for the contractor. Difficult to objectively assess contractor performance vs. their competitors.

Other Incentives	
General comment re incentives	Incentives should only be considered where the contractor has real ability to influence achievement. Incentive schemes should be simple in their formulation and payments / penalties should be progressive relative to degree of achievement. Incentive schemes where the contractor is vulnerable to a large step change in payment as a result of marginal failure to achieve a target figure are likely to have an overall negative impact on performance.
Construction safety	Only useful if based on achievement of improved performance versus what are established norms. If the frequency of accidents is used, this must include those which result only in minor injuries, as lost time incidents (LTI's) are so infrequent as not to be statistically valuable. It is also possible to use outcomes of construction site audits – , for instance the number of non-conformances found by joint owner / contractor audits. Consider whether incentives should go to the contractor or their staff.

Quality	This is a very difficult to incentivise as there are so many different elements to quality and it usually makes little sense to focus on only one or two. Overall design quality can be approximately measured by the percentage of design documents which must be revised post release as final, though even this must filter out causes not related to contractor performance. Such a measurement system is time-consuming. There is no simple way to measure overall construction quality. Performance guarantees, especially if they include reliability, are in fact a form of quality incentive (see below).
Schedule	Schedule is commonly the subject of incentive systems, but should only be so if schedule is of particular importance to the owner. Schedule incentives can result in a contractor becoming over-focused on achieving schedule at expense of quality. Also, a contractor will look to identify causes for delay outside their responsibility. Schedule incentives / penalties should always be progressive so that there is an incentive for the contractor to perform even under adverse conditions.
Performance of the completed facility	There may be several measures by which performance is assessed such as output capacity, meeting product specification, percentage of feed converted into saleable product, energy efficiency plant on-stream factor. Provided the scope of contractor's work has significantly influenced these parameters, then it is usual that their contract includes guarantees for performance linked to achievement. The terms of the guarantee may either require remedial work and / or impose penalties for failure to achieve the specified performance. Penalties should be progressive, dependent upon the degree of non-achievement: a bonus should be considered in the event of exceeding specification, always providing that enhanced performance is of value to the owner. One problem is that carrying out valid performance tests can be difficult due to operating constraints. Items such as reliability / on-stream factor may take many months to determine and may be influenced by factors not related to the contractor's work.

Appendix G – Generic index for project technical specification

Part A - general information

1. introduction
2. basis of design and engineering
3. summary scope of the project
4. summary scope of contractors work
5. exclusions from contractors scope of work and division of responsibilities
6. laws and regulations

Part B - design and engineering

1. design policy
2. layout and plot plan
3. safety and environment
4. design conditions and information
5. pressure relief systems
6. flowschemes
7. buildings and civil engineering
8. mechanical equipment
9. piping design
10. product handling and packaging systems
11 laboratory and other specialist equipment
12. electrical and instrumentation engineering
13. inter-discipline liaison
14. design for construction

Part C – project control and documentation requirements

1. preparation of design and engineering documents
2. provision of documents and drawings
3. planning, scheduling and progress reporting
4. estimating, cost reporting and control
5. change order procedures
6. meetings
7. correspondence and other communications

Part D – procurement

1. procurement approach
2. requisitioning and tendering
3. vendor / subcontractor prequalification
4. bid analysis and approval
5. purchase orders
6. expediting
7. inspection / tests at manufacturers' works
8. bulk materials
9. control of changes to bom's and technical requisitions
10. procurement plan and status reporting
11. approval of vendor's design

Part E – construction

1. scope
2. construction site management
3. site facilities
4. site safety management
5. industrial relations
6. quality assurance, inspection and testing at site
7. materials and equipment at site
8. temporary electrical circuits
9. protective clothing
10. work areas
11. construction programme and progress reporting
12. punch listing and systems testing
13. mechanical completion
14. handover and precommissioning
15. ready for start-up (RFSU)
16. commissioning

Appendix H – Project scope items which may be excluded from EPCM / turnkey contract

Even where a contractor has responsibility for the overall implementation of a project (for example in EPCM and turnkey type contracts), it is usual that some elements of the overall project are excluded from their scope and responsibility. It is always important that items excluded are clearly identified, usually in the project specification, together with indication as to which other party will be responsible for them and responsibility for the co-ordination of interfaces. Typically, a listing of exclusions will follow that of included deliverables.

There is no consistency as to which items are excluded, as this depends entirely on the strategy adopted for the project. The following list identifies some of the items more commonly excluded. This listing must not be considered as a recommendation to exclude. Inclusion / exclusion is an issue of overall project / contracting strategy.

Scope element	**Party typically responsible if outside EPCM contractor scope**
Site topographic and geological surveys	Owner using specialist contractors
Site preparation works	Owner using local civil works contactor
Design, procurement and construction of OSBL works	Various managed by owner or PMC on behalf of owner
Buildings detailed design	Owner using specialist consulting engineer / architect
Buildings construction	Building contractor managed by owner or by architect on behalf of owner
HV electrical system stability studies	Specialist consultant
Utility supply cabling / piping for construction temporary supplies to match-line	Owner manages local contractors
Temporary offices for owners project team	Owner using local supplier
Procurement of spare parts	Owner based on info provided by managing contractor.
Control System software configuration	Owner possibly assisted by specialist consultant or equipment vendor
Purchase of portable laboratory equipment and other testing equipment	Owner
Purchase of office equipment	Owner
Purchase of portable safety equipment and personnel protective equipment for plant staff	Owner

Scope element	Party typically responsible if outside EPCM contractor scope
Purchase / leasing of non-fixed operating and maintenance equipment (for example fork trucks, bolt tensioning equipment, hoists)	Owner
Identification of process and utility systems for handover and commissioning	Owner
Third party verification of vendor designs and tests in accordance with pressure vessel design codes	Owner possibly utilising an inspection agency
Preparation of plant operating manuals	Owner
Preparing documentation and submissions for regulatory obligations (IPPC, COMAH, COSHH)	Owner
Obtaining operating permit	Owner
Training of plant operating and maintenance staff	Owner / process licensor / equipment vendors
Precommissioning works	Joint management owner / contractor using construction contractors or other local contractors
Commissioning	Owner
Post start-up final site cleanup	Owner using local contractor
Updating of existing site drawings / documents / records / computer data to incorporate new plant / facilities	Owner

Appendix I – Items for inclusion or exclusion from estimates and budgets

Clarity as to what a project estimate includes and excludes is vitally important. There should always be a statement to accompany an estimate identifying the (not obvious) inclusions and exclusions.

The following is a listing of commonly occurring costs, which sometimes are and sometimes are not included in a project estimate. This list is provided for information only; it is for the project manager and the budget provider to decide whether such costs are included. Items not included in the core estimate may still require to be estimated in order for appropriate provision to be made in other budgets:

- initial project feasibility / development costs
- purchase of land
- temporary works and facilities.
- enabling works
- interconnecting utilities
- surrounding infrastructure such as roadways, area lighting, fencing
- time of owner's staff such as plant operations, management (outside the project team)
- financing costs
- donations to local community
- licence fees
- legal fees, regulatory fees
- project insurances
- updating of existing plant documentation including regulatory documents
- updating it systems such as stock control, maintenance management, accounting systems (production / process control is part of the core project)
- provision of office furniture and equipment
- provision of portable laboratory and other testing equipment
- training of staff to operate and maintain the new / modified facility
- process materials and lubricants – first inventory
- personnel protective equipment for plant staff
- spare parts
- cost of utilities supplied to construction site
- additional site security
- commissioning works
- site clean-up and beautification
- disposal of waste material
- facility formal opening event
- demolition of redundant facilities where not directly needed to build the project
- redundancy / redeployment of staff
- allocation of shared costs (multiple projects)
- provision for scope changes
- contingencies

Appendix J – Example project development request form

The following is a suggested format suitable for use in the development of smaller projects which can be authorised within the authority of manufacturing site management.

Plant / Facility	Originator	PDR No	Date

Part 1 Initial Development

Summary Description of Proposal

Summary Objectives of Proposal

Order of Magnitude Cost ----------

Development Leader Phase 1 ----------

Other Resources needed for Phase 1

Target Completion for Phase 1 ----------

Funding required for Phase 1 ----------

Phase 1 Development Agreed – Asset Manager ----------

Phase 1 Development Agreed – Site Manager ----------

Part 2 Detailed Development and Definition

Summary of Scope option chosen for detailed development together with justification. If multiple options still under consideration indicate proposed remaining work to finalise selection.

Anticipated project cost (Order of Magnitude) €----------

Key development objectives

- Prepare final scope and specification – Target Completion
- Prepare Project Execution Plan – Target Completion
- Prepare Authorisation Estimate – Target Completion
- Other

Resource Requirements – Identify individuals where possible for internal resources

Name	Est. Manhours
Development Team Manager	
Process Engineering	
Mechanical Engineering	
Civil Engineering	
Instrumentation	
Process Control	
Others	
External Resources –	

- Name of Organisations
- Means of Employment

Funding required for Phase 2 Development €----------

Estimated Duration for Phase 2 Development Months----------

Priority Critical / Urgent / Routine

Plant Shutdown Related Y / N

Reasons for Priority

Phase 2 Development Supported – Asset Manager---------- ----

Manager Projects----------

Authorised – Site Manager----------

Appendix K - Factors affecting construction labour productivity and cost

The following data is based upon information collected in UK during the late 1990s. The exact ratios may not be currently valid in UK or for other countries, but the principles are.

Hourly labour cost levels for construction work outside normal working hours (UK)

Type of Working	Increased hourly Cost
Overtime on normal working days	30 – 40% for additional hours up to 4hr additional per day
Saturday working	40 – 50%
Sunday and holiday working	80 – 100%
Shift working (8hr shifts)	20 – 30% for all shift hours
Shift working – supervision	80 – 100% (covers additional personnel and premium rates)

Notes:

The above costs are for general guidance only and do not include for any loss of productivity associated with overtime and shift work.

Construction productivity levels for retrofit projects and other 'in plant' work in UK
(Comparison with normal productivity for a standard working week on new build projects)

Type of working	Productivity loss
Work on existing off-plot facilities	10 – 20% loss
Work within existing process unit (in service)	20 – 40% loss
Work within existing process unit (shutdown)	15 – 30% loss
Work in areas of difficult access (additional loss)	10 – 30% loss
Overtime working – up to 10hr overtime / week	5 – 10% loss on all hours worked
Overtime working - 10 to 30hr overtime / week	15 – 20% loss on all hours worked
Shift working	15 – 20% loss on all hours worked

Notes:

a) the above figures are for general guidance only and assume ongoing working for a period of at least a week

b) losses stated above are, to a considerable extent, cumulative

Appendix L – Risk assessment matrix for SHE and other business issues

The following is a typical matrix for assessing the need and urgency for action in respect of a foreseen SHE / business issue.

Assessment of the rating must be carried out by individuals who have relevant detailed knowledge and understanding of the issue and of the facility / process to which it relates. Wherever possible, factual statistical data should be used to support the assessed probability rating. In some cases, the use of external experts may be appropriate to carry out or participate in the assessment.

	CONSEQUENCE					**← LOW**		**PROBABILITY**		**HIGH →**
	People - Risk to health and safety	Assets and Business - Financial risk*	Environment Risk to environment	Reputation Risk to business reputation	**RATING**	Never heard of in industry (highly improbable)	Heard of single incident (possible but unlikely)	Has occurred in company /several times in industry (but infrequently)	Occurs at least once per year in the company	Occurs several times / year on this facility
RATING						**A**	**B**	**C**	**D**	**E**
↑ **LOW**	Slight injury (first aid)	Slight loss / damage (<€10k)	Slight short term effect	Slight	**1**					
	Significant injury (lost time)	Limited loss/ damage (€10k-€100k)	Minor effect, limited duration	Limited/ minor	**2**		**Manage by continuous improvement**		**In depth review at management level**	
POTEN-TIAL	Major injury/ permanent disability	Significant localised loss/ damage (€100k-$1M)	Moderate local effect	Consider-able but local/time limited	**3**		**and simple low cost measures**	**Highly undesirable – look for risk reduction without excessive cost**		**Unacceptable - measures to avoid or significantly mitigate must be taken**
	Single fatality	Major loss / damage (€1M-€10M)	Major effect	Significant	**4**	Recheck probability				
HIGH ↓	Multiple fatalities	Extensive loss/damage (>€10M)	Massive effect / long-term impact	Major and long-term for whole business	**5**	If verified, no action needed				

Note * Values of financial risk will need to be adjusted to reflect the size of the business
Figures in the matrix reflect those which may well be valid for a major business with turnover in excess of €1bn / year

Appendix M – Tender appraisal score-sheet

The following provides an example method of comparative assessment of tenders for an EPC-type contract for a multidiscipline process plant. The principles can be applied to virtually all tender appraisals, though the detail should be customised to meet the needs of the project. In this example, it is assumed that the EPC contractor will proceed on the basis of a provided basic design package (or licence package) and that the performance of the finished project is not, therefore, a significant issue in appraisal of the tenders.

The table format below is a useful means of providing a management overview of the appraisal. It would, of course, be supported by further detail in order to justify the scoring and ranking.

		Tender A	Tender B	Tender C
Technical (50%)	**Contribution**			
Project management	15% (1)	n x 15% = (2)		
Project controls	10% (1)			
Process engineering	15% (1)			
Detailed design and engineering (4)	25% (1)			
Procurement	10% (1)			
Construction management	25% (1)			
Technical total =T				
Commercial (50%)				
Normalised price	80% (1)			
Other commercial (5)	20% (1)			
Commercial total =C				
Overall score (3)		50%T+50%C		
Additional notes (6)				
Technical compliance				
Technical issues				
Commercial compliance				
Commercial issues				
Tender prices				
Tender as opened				
Adjustments (7)				
Normalised price (8)				
Overall ranking (9)				

Notes

1. The percentage represents the assessed relative importance of the element being assessed. This should be set and agreed for the project before tender appraisal starts. Similarly, the weighting between technical and commercial should be set and agreed with the owner's senior management before appraisal.
2. The element score for a tender will then be the number of points awarded (n = 1 to 10) multiplied by the relevant percentage.
3. The overall score will be achieved by combination of the technical and commercial scores.
4. Detailed design and engineering may be further subdivided into individual disciplines.
5. 'Other commercial' is included to allow consideration of issues such as compliance with commercial terms, contractor's commercial attitude, rates for additional works, other items which may influence final costs.
6. Additional notes are provided to indicate the presence of other aspects which should be considered. This is not scored but a brief comment made such as yes, minor deviations, and significant deficiency. Clearly, if there are significant deviations these must be addressed in supplementary comment outside the tabulation. It is of particular importance that any serious concerns are identified. These would certainly include:
   - very poor assessed capability, in a particular discipline which may not show in the overall scoring. for example, assessed very poor instrument and control engineering
   - indicated very low or very high man-hour content for certain elements of the work
   - significant commercial non-compliance, for example unwillingness to provide bank guarantees
   - elements of the pricing which are very low or very high in comparison to expectation

   It is possible that significant deviations and / or deficiencies could result in a tender being not preferred in spite of an overall best score. If this is potentially the case, then great care must be taken in assessing these elements to ensure that the negative assessment is truly justified.
7. Adjustments. This is the total amount by which the tendered price must be adjusted fully to comply with the intentions of the tender. These adjustments may be needed as a result of errors, omissions or misunderstandings. The amount to be included may be determined as a result of a bidder providing revised prices and / or the owner making an assessment.
8. Normalised price. This is the price arrived at as a result of addition or subtraction of the adjustments to the price on the tender as opened. It should provide a true basis for bid cost comparison. It is not intended to represent the forecast of final contract cost - that is, it does not aim to address cost of any change orders. If such a forecast is required on the appraisal then it should be shown separately.
9. Overall ranking. This reflects the overall outcome of the appraisal. It will not necessarily exactly reflect the overall score, but if there is a discrepancy, the reasoning for this must be provided. Tenders with unacceptable elements of non-compliance are usually not ranked. Where elements of non-compliance may be acceptable, they must be noted and specific approval obtained for them if it is intended to award the contract on that basis.

Appendix N – Project definition checklist

The quality of the definition phase is one of the key elements which will determine the success or otherwise of the overall outcome of any project. It therefore is of considerable value to review the project definition works prior to final commitment to their use as the basis for project implementation.

The following is a general project definition checklist. It is focused on requirements for a complex process plant, but is also generally valid for other process facilities although not all points will be relevant. Where projects are to be constructed at a new site, some additional aspects may require to be addressed.

For projects where only a functional specification is to be provided then many of the items will be addressed by the main contractor and to that extent a negative response to the checklist questions would be acceptable provided it also confirms that the item is one where the main contractor has full discretion / responsibility.

A Project objectives

A1 Have the key project objectives been identified, agreed and clearly communicated? This must identify the driving forces for the project and specify what are most important from the viewpoint of the business.

A2 Cost is always important, but for this project, what is its importance relative to other key drivers? If unavoidable, will additional expenditure to achieve other objectives override the desire for low cost?

A3 Schedule (both general and any specific target dates). Has schedule importance been agreed? Is there an overriding requirement to meet a fixed completion date? This might be dictated by a plant scheduled outage, a market commitment or a legal obligation.

A4 Functional performance requirements. Have specific performance requirements in terms of capacities, product quality requirements, plant availability and reliability, environmental performance etc been identified?

Answers to the above should aim to identify the relative importance of various drivers. Simply stating that all are important is not useful. Consider what are the critical success factors.

B Project strategy and management

B1 Has an implementation strategy been defined for the project? This must align with the business objectives and provide an overview of how the project will be implemented.

B2 Project execution plan (PEP). Has a more detailed plan of execution been prepared? This should be agreed by all parties involved in the project, especially the sponsor. Ideally, it forms a part of the authorisation documentation.
The PEP should include:

- business objectives
- procurement and contracting strategy
- she during implementation
- overview project time plan, identifying critical activities and key hold points
- technical overview and any critical aspects
- identification of design standards and specifications
- outstanding issues remaining from definition package
- basis upon which cost control is to be managed
- identification of resource requirements (own staff and contractors)
- identification of key risks and mitigation plans

B3 Has the project time plan been checked to assess its overall validity and to identify critical and near-critical activities? Has this plan been accepted by the business management and other key stakeholders? Have any significant schedule risks been identified and a management strategy for them devised? Has a schedule control system been set up?

B4 Has a project authorisation estimate been prepared? Has the accuracy level been agreed with those responsible for authorisation? Have any significant cost risks been identified and have appropriate levels of contingency been assessed and agreed?

B5 Have the requirements for cost control been identified and appropriate mechanism set up:

- preparation of detailed estimate against an agreed scope
- identification of any special cost risk issues (for example sub-optimal time schedule, currency risk)
- preparation of spreadsheet programme or equivalent to monitor costs
- mechanisms for collection and analysis of cost data
- scope change management system
- reporting requirements

B6 Have needed project responsibilities and authorities been agreed (commercial and technical)?

B7 Has a project risk assessment been carried out to identify any significant (scale of consequence and / or probability) risks to the achievement of the business objectives? If so, have mitigation plans been identified and responsibilities assigned? Has a plan for revisiting identified risks been included?

B8 Have all own staff resource requirements been identified? Have specific skills and knowledge requirements for the project been addressed? Has the availability of these resources at the times required been agreed and any potential resource conflicts addressed?

B9 Have requirements relating to SHE been addressed including requirements of national regulations?

- has provision for safety reviews been made?
- have any specific / unusual hazards been identified and if so have risk assessment and remedial measures been identified?
- which party will fulfil roles of principal contractor and planning supervisor?
- is notification to the appropriate authorities under national regulations required?
- will one or more specific project health and safety plans be required? who will produce these?

B10 Has the strategy for execution of the detailed design and engineering been identified?

- if a contractor is to be used, has sufficient time been provided to allow for tendering and negotiation of the contract?
- for contracted-out design and engineering works, has consideration been given to the location where this work will be executed?
- if the works involves modification / extension of existing plant, has sufficient client resource been provided to assist in giving contractor specific data and understanding of existing facilities?

B11 Is the procurement approach identified?

- who is responsible for procurement of materials?
- are sufficient resources available to ensure that enquiries, orders and follow-up are carried out at required timings?
- will the project require special effort to ensure required delivery of key items?
- are there specific requirements for who may supply certain items?
- are time-critical items identified as well as the steps needed to ensure early ordering and timely delivery?

B12 Is the approach for provision of construction services identified?

- who is responsible for procurement of construction services? are they aware and able to provide contracts at the required timings?
- have the means by which contracts are to be entered into been identified and agreed (forms of contract, scope split of work / services, tendering approach)?
- does the project schedule include time for development and tendering of contracts?
- have contractors with required capabilities been identified for all elements of construction services needed?
- if existing term / core contractors are to be used, have they been consulted and the availability of their resource been checked?

B13 Have the requirements for handover, precommissioning and commissioning been identified complete with identified roles and responsibilities?

B14 Have the required interfaces with the plant operating and maintenance team been identified? These should include the following:

- participation in development of the definition package
- requirement for comment on designs / vendor drawings
- participation in design safety reviews
- management of permits to work on existing plant
- requirement for plant shutdowns for construction, tie-ins etc
- process and responsibilities for pre-commissioning and commissioning together with responsibilities
- operator training requirements
- requirements for 'as built' documentation
- general project requirements

C Technical standards and specifications

C1 Are the standards and specifications to be applied identified and recorded?

C2 Is there a specific requirement for compatibility with existing plant standards?

C3 Have any project-specific specifications been identified?

C4 Is there a requirement to procure certain items from a specific vendor to ensure standardisation or to meet specific performance requirements or for compatibility with existing plant installations?

D Process design

D1 Is there a completed set of process and utility flow diagrams showing all new equipment, main piping and control systems and interconnections with existing plant and facilities? Have these been developed to the point where they are a valid basis for detailed design?

D2 Is there an operating philosophy document against which design should be executed?

D3 Is there a tabulation of heat and material balances? Does this include heat input and output for major equipment items, including all heat exchangers, within the unit? Does this include material balances and material input and output for all equipment items within the unit?

D4 Has a set of process (and utility) engineering flow schemes (PEFs or P&IDs) been prepared? What is the development status of these drawings? PEFs should show all equipment, all piping and valves (sized) and all instrumentation, together with and specific additional requirements such as tracing, line slopes, specific elevation requirements. Where the project is retrofit a clear, separate identification of what is new and what is existing should be made. In general, PEFs are considered to be a key element within the scope definition package of project.

D5 Are there equipment data sheets which identify for each item of equipment design conditions, performance data, sizing data, nozzle sizes, energy requirements, sealing requirements metallurgy, applicable design standards, insulation requirements, internals details? These should include modification of existing equipment.

D6 Have existing equipment items, piping systems and other items been checked out for their suitability for revised duties?

D7 Is there a line list which identifies each pipe, together with sizing, design conditions, piping class, and connectivity? For retrofit projects, has line numbering for new lines been agreed?

D8 Are all utility requirements identified, with quantities, design conditions, etc? Are existing utility design conditions identified, for example, temperature, pressure, quantities available, etc? Have connection points been identified? This should include any sewer connections.

D9 Are all process and utility tie-ins identified? Have the requirements under which the tie-in must be executed been identified?

D10 Is there an instrument list which provides process data for every instrument together with its location?

D11 Is there a requirement specification and / or logic description covering the control and safeguarding systems? If these will be extensions of existing systems how will this be achieved in both design and installation?

D12 Are relief valves and bursting discs, vents and flare systems identified and sized? Have existing ones been checked out for any revised duties?

D13 Have all electric power requirements been identified? Have sources of power been confirmed?

D14 Is the area classification plot plan provided to show the environment in which electrical and instrument equipment is to be installed?

D15 Has a HAZOP or other design safety review been carried out? If not will one be required? Will an instrumentation protective function (IPF) review be required? For retrofit projects, has the extent of the safety review been defined - that is to what extent existing facilities must be reviewed?

E Layout and piping

E1 Are there overall layout drawings showing locations of new equipment? Are locations defined and agreed with plant operations and maintenance?

E2 Are piping classes identified?

E3 Are any special valve requirements identified and detailed? Must these valves be from a specific supplier?

E4 Are design requirements for all tie-ins available, for example, type of tie-in / size, hot tap, cold cut, flange, screwed, weld, cut and weld? Have these been reviewed with plant operations to check installation feasibility?

E5 Are piping layout special requirements identified? For example slopes, long radius bend, requirements re high or low points, jacketing, provision for pulsation, cyclic operation conditions.

F Buildings, civil and structural

F1 For any new or modified buildings, is there a functional specification and preliminary layout? Are there any special design requirements, for example blast resilience, special HVAC requirements, special temperature or humidity requirements, clean room specifications?

F2 Have requirements for building internal fittings and finishes been identified?

F3 Is data available for existing ground conditions? For example, topographic survey, soil survey, water table, contamination data, information in respect of any existing underground objects (old foundations, pipes, sewers, cables).
Has any requirement for surface grading or ground improvement been identified?

F4 Is design code climate data available? For example, design wind-speed, rainfall rate, snow loading, earthquake factor.

F5 Are layouts and elevations for new structures and platforms identified?

F6 Where existing structures are to be reused / modified are existing design details / calculations available? If not, how will this issue be addressed?

F7 Are finish coating requirements for steel identified? For example fireproofing, galvanising, painting.

F8 Are service requirements and routings for sewers and underground piping identified including tie-ins to existing?

G Instrumentation and control

G1 Is the extent of automatic control to be provided described? What are the criteria for control and safeguarding systems redundancy? Are there specific process / control requirements for start-up and shutdown?

G2 Has the extent of interconnection, extension of existing systems been identified?

G3 Is there a written control and safeguarding philosophy and user requirement specification covering normal operation, start-up and shutdown? Are redundancy requirements identified?

G4 Is there a detailed instrument listing covering all instruments required, together with full design data. Are locations of all instruments identified?

G5 Is there a listing of preferred vendors and, for special requirements, identification of specific instrument model numbers to be used?

G6 Where extension of existing systems, for example DCS, SGS, PLC is contemplated, has expandability been checked out? Can modification / extension work be done with plant in service or must a shutdown be provided?

G7 Has the process for configuration of DCS, PLC displays been identified? Who will do this work?

G8 For safeguarding systems, has instrumentation protective functionality rating been assessed?

G9 Are new, or extensions to, gas detection or fire detection / alarm systems required?

H Electrical

H1	Have all requirements and locations for electric power been identified, including voltage levels, control requirements, UPS requirements, variable speed drive requirements?
H2	Have source(s) of new power requirements been identified, including any new switch house equipment needed? Have means of interconnection (tie-in) been assessed?
H3	Have the electrical single-line diagrams been produced or existing ones marked-up?
H4	Are routes for new cabling identified?
H5	Have any requirements for electric tracing been identified?
H6	Have additional lighting requirements been identified.
H7	Are there any requirements for cathodic protection?
H8	Do grounding or lightning protection systems need to be installed or extended?

J Fire protection and safety requirements

J1	Is any additional fire prevention / fire fighting equipment required? For example firemain extensions, deluge systems, fire monitors, fire extinguishers, foam systems, damper panels, fire doors, etc
J2	Is any new safety equipment required? For example safety showers, specialised PPE for operators.
J3	Have safe means of egress been addressed in layout of new facilities?

K General requirements

Some further technical data will be needed to define functionality and performance requirements which will influence the detailed design and implementation of the project. Requirements are often very project-specific, so the following are simply some of the more common items.

K1 Have performance capabilities for all operating cases been identified? In the case of a retrofit project does this represent a significant change from existing?

K2 What are the criteria for equipment sparing?

K3 What are requirements for maintainability and equipment access / lifting / pulling beams / cranes?

K4 Has constructability been considered? What constraints on construction are imposed by access to existing plant and buildings? Are there constraints due to proximity of public rights of way?

K5 Is dismantling or demolition required? If so, has the scope been identified in detail including any needed temporary works? What safety requirements will apply? Is the timing identified?

K6 Has the required information in respect of existing plant / buildings been identified? Are design documents covering existing facilities available and have they been assessed for their completeness and accuracy? If not, has a plan for additional work needed been developed?

K7 Have project documentation (including electronic documentation) deliverables been identified? Has the extent of reuse (new revisions) of existing drawings been agreed?

Appendix P – Project definition rating

The quality of 'front end' definition is a key element which will determine the success or otherwise of the overall outcome of a project. It is therefore useful to have a tool which can assess the quality of a definition package and provide a score. This will usually be done at the time when authorisation to proceed with implementation is being considered, although nothing precludes use at other times. It aims to assess whether there is sufficient definition present to provide the required quality of estimate and allow a sensible move to the detailed design and implementation phase.

The score sheet identifies a series of categories, which are in turn broken down into elements. These are as defined in Appendix A above. In order to score a project definition package the following steps are required:

1. Each category needs first to be weighted to reflect its relative importance to the definition of the project **and this must be done for the individual project,** as weightings will, to some extent, be dependent upon the specific project. The following example is based upon typical category to total weightings for a process plant project. Actual weightings should be developed by the project team and agreed by key stakeholders.

A. Project objectives	=12%
B. Project strategy and management	=22%
C Technical standards and specifications	= 8%
D. Process design	=15%
E. Layout and piping	=10%
F. Buildings, civil and structural	= 7%
G. Instrumentation and control	=12%
H. Electrical	= 5%
J. Fire Protection and Safety	= 3%
K. Project General Requirements	= 6%

TOTAL	=100%

The relative weightings would need to be significantly different for other types of project, but in every case the total sums must amount to 100%

Examples

a) A new laboratory building – Category F would have a much higher weighting. Categories D, E, G and K would have much lower weighting.

b) Existing plant reinstrumentation – Category G would have a much higher weighting. Categories D would be somewhat lower weighted, categories B, E, F would be much lower weighting and category J may not be required.

Scoring is then conducted by evaluating the level of definition of each element in order to derive a category score. The score for each category will be in the range of 0 → 4 where:

0 = Item is relevant, but no definition work done
1 = Outline definition only
2 = Some detailed definition, but significant outstanding work
3 = Essentially defined, minor omissions only
4 = Fully defined in all respects

Where a category is not applicable for a project, it should not be addressed and the overall score assessed without it.

Score sheet

The following score sheet has been completed as an example based on weightings for a typical process plant. A new plant at an existing location is assumed, so a number of retrofit elements will not apply. Other elements are reduced but not eliminated as there will still be some interfaces and requirements for compatibility with existing facilities.

	Category / element	Score	Weight	Sub-total	Total
A	**Business objectives**				
	A1 Project objectives	4 / 4	35%	35.0	
	A2 Priorities	2 / 4	15%	7.5	
	A3 Overall schedule	3 / 4	15%	11.2	
	A4 Functional performance requirements	3 / 4	35%	26.3	
				80.0	
	Category percent of total		**12%**		**9.6%**
B	**Project strategy and management**				
	B1 Implementation strategy		10%		
	B2 Project execution plan		15%		
	B3 Project schedule		10%		
	B4 Project authorisation estimate		10%		
	B5 Project cost control		5%		
	B6 Project authorities		5%		
	B7 Risk assessment		5%		
	B8 Resource requirements		10%		
	B9 SHE requirements		5%		
	B10 Design strategy		8%		
	B11 Procurement strategy B12 Construction strategy		4% 5%		
	B13 Requirements for handover, pre- and commissioning		4%		
	B14 Interfaces with plant operations and maintenance team		4%		
	Category percent of total		**22%**		

	Category / element	Score	Weight	Sub-total	Total
C	**Standards and specifications**				
	C1 Required standards / specifications	3 / 4	40%	30.0	
	C2 Compatibility with existing plant / facilities	1 / 4	5%	1.2	
	C3 Project specific specifications	3 / 4	40%	30.0	
	C4 Nominated suppliers	2 / 4	15%	7.5	
				68.7	
	Category percent of total		**8%**		**5.5%**
D	**Process / piping**				
	D1 Process and utility flowschemes (PFS)		5		
	D2 Operating philosophy				
	D3 Heat and material balances		7		
	D4 Process / utility engineering flowschemes (PEFs)		9		
	D5 Equipment data sheets		6		
	D6 Checks on existing equipment / plant				
	D7 Piping line lists				
	D8 Utility requirements		6		
	D9 Tie in list		6		
	D10 Instrument list		5		
	D11 Control and safeguarding requirements		6		
	D12 Relief / Vent systems				
	D13 Electric power systems requirements				
	D14 Area classification				
	D15 Design safety and environmental reviews				
	Category percent of total		**15%**		
E	**Piping and layout**				
	E1 Layout drawings		15		
	E2 Piping classes		10		
	E3 Valve technical requirements				
	E4 Tie in detailed designs				
	E5 Piping special requirements				
	Category percent of total		**10%**		

	Category / element	Score	Weight	Sub-total	Total
F	**Buildings, civil and structural**				
	F1 Buildings functional specification / layout		13		
	F2 Buildings internal fittings requirements				
	F3 Ground data				
	F4 Climate data				
	F5 Layouts and elevations for new structures				
	F6 Data for existing structures to be modified				
	F7 Finish coatings for structures				
	F8 Requirements for sewers and other underground piping				
	Category percent of total		**7%**		
G	**Instruments and control**				
	G1 Extent of control and safeguarding systems		10		
	G2 Interconnections with existing systems		6		
	G3 Control and safeguarding functional requirements		6		
	G4 Instrument listing				
	G5 Instrumentation special requirements				
	G6 Capability of extension of existing systems G7 Configuration of display screens				
	G8 IPF review of safeguarding systems				
	G9 Requirements for gas and fire detection and alarms				
	Category percent of total		**12%**		

	Category / element	Score	Weight	Sub-total	Total
H	**Electrical**				
	H1 Details for individual electrical equipment items				
	H2 Power sources and connections				
	H3 Single line diagrams				
	H4 Cable routings				
	H5 Electric tracing				
	H6 Lighting requirements				
	H7 Cathodic protection				
	H8 Lightning protection and earthing				
	Category percent of total		**5%**		
J	**Fire protection and safety requirements**				
	J1 Fire protection equipment requirements				
	J2 Safety equipment requirements				
	J3 Review of safe means of egress				
	Category percent of total		**3%**		
K	**Project general requirements**				
	K1 Performance requirements				
	K2 Equipment sparing				
	K3 Access and maintainability requirements				
	K4 Constructability assessment				
	K5 Demolition and dismantling requirements				
	K6 Data from existing plant / facilities				
	K7 Project final documentation requirements				
	Category percent of total		**6%**		
	TOTAL		**250**		
	Percent score				

To arrive at a percent score:

1) sum the weighting of ‘not applicable’ items then multiply x 4
2) deduct from 1000 to develop new ‘maximum possible score’
3) percent score = (actual score / max possible score x 100%

Appendix Q - List of relevant references in ECI publications

The following list is confined to only those elements of the listed documents which are of particular specific relevance to the topics addressed in this handbook.

Active Workbook

Active Principle 1	Effective project concept and definition
Active VEP 1.2	Project definition and objectives
Active VEP 1.3	Project planning
Active VEP 1.4	Value analysis
Active VEP 1.6	Information management strategy
Active VEP 1.7	Procurement strategy
Active VEP 4.1	Information management
Active VEP 5.1	Project risk management
Active VEP 7.1	Project control

ECI Active Manual of Value Enhancing Practises for Small Projects

VEP MP 01	Management / stakeholder buy-in
VEP MP 02	Project development and definition

ECI Fast Track Manual

Chapter 6	Concept stage
Chapter 7	Development
Chapter 8	Definition

Public Private Partnerships, a Review of the Key Issues

Chapter 2	Specifying the project effectively

The Engineering and Management of Retrofit Projects in the Process Industries

Chapter 6	Senior management support
Chapter 7	Initial development and project definition
Chapter 9	Estimating and cost control
Chapter 10	Planning and progress monitoring
Chapter 13	Risk management

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