Chapter 1: Introduction and background

> **"All across the world, in every kind of environment and region known to man, increasingly dangerous weather patterns and devastating storms are abruptly putting an end to the long-running debate over whether or not climate change is real. Not only is it real, it's here, and its effects are giving rise to a frighteningly new global phenomenon: the man-made natural disaster."**
> **Barack Obama (3rd of April 2006)**

1.1. Climate change and the Kyoto Protocol's Clean Development Mechanism (CDM)

Climate change is a global problem that will not be solved without long term vision and commitment. In 1997 the Kyoto Protocol was adopted at the Third Session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC, 2007). Thereby, Annex-I countries, or industrialised countries, accepted legally binding commitments to reduce greenhouse gas (GHG) emissions. The signatory countries agreed to reduce their anthropogenic emissions of GHGs by at least 5% below 1990 levels in the commitment period 2008 to 2012. The targeted GHGs are CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 (UNFCCC, 2007).

Companies can satisfy the locally applicable air pollution legislation and still vent large amounts of GHGs to the atmosphere. Technologies exist that could potentially help alleviate GHG emissions (Johnson, 2006), but there must exist an incentive for companies to go beyond the legislative requirements regarding air pollution. Various such financial incentives exist for GHG reduction. The Kyoto Protocol drives one such an incentive, the clean development mechanism (CDM) (UNFCCC, 2007), whereby industrialised countries, and the companies within these countries, could earn GHG emission reduction credits. The incentives for developing countries to participate in the CDM are acquiring technology, acquiring foreign capital and accelerated growth. The CDM aims to mitigate GHG emissions by offering a regulatory framework for proven emission reductions in developing countries though technological interventions by developed countries. Emission reductions are quantified in so called certified emission reduction (CER) units that are tradable on the open market. A CER is simply the prevention of one tonne of carbon dioxide gas equivalent emitted in a developing country. The other targeted GHGs are all related via a global warming potential (GWP) rating back to an equivalent carbon dioxide. For example, methane (CH_4) has a 21 fold GWP potential than carbon dioxide (CO_2). This implies that one tonne of CH_4 emissions prevented is equivalent to 21 tonnes of CO_2 emissions prevented (UNFCCC, 2007).

Hasselknippe (2003) describes the mechanisms of emission trading. In essence CERs are traded on the open market at a price driven by supply and demand pertaining to specific projects; the trends in the carbon market are reported by the World Bank (Capoor, 2007). Michaelowa (2003) provides more information regarding CDM transaction costs. The CDM is governed by the Executive Board (EB) under the Kyoto Protocol, whilst the trading of the CERs is facilitated by many entities such as the Carbon Finance Unit of the World Bank (2007).

1.2. The CDM: A Project Based Approach

Each CDM project is unique, but each CDM project will have the same generic components and types of parties involved.

The party that is interested in registering a CDM project is referred to as the Project Proponent (PP). The Project Proponent can also be a group of parties depending on the commercial arrangement of the company/entity with the potential for emission reductions, parties/entities with the know-how to develop CDM projects, and potential investors in such projects. The potential investors can invest by acting as buyers of the resulting credits or the credits can be sold to a 3rd party. The PP will then be the seller of the credits earned.

All CDM projects need host country approval before the Executive Board, under the Kyoto Protocol, will start to evaluate the merit of a project. The CDM term used for the governmental entity in the host country that must provide this approval is the Designated National Authority (DNA). In South Africa the DNA is hosted by the Department of Minerals and Energy (DME, 2007).

An impartial third party is required to validate, verify and certify all emission reductions resulting from a CDM projects. This impartial third party is known as the Designated Operational Entity (DOE) and has to be accredited by CDM Executive Board for the services it will provide to Project Proponents. Normally these DOEs are traditional auditing firms.

As stated earlier the CDM is governed by the CDM Executive Board (EB). Only the EB can register a CDM project and issue associated CERs.

Figure 1.1 illustrates the components of a CDM project, the flow of the project, and the involvement of the various parties discussed above.

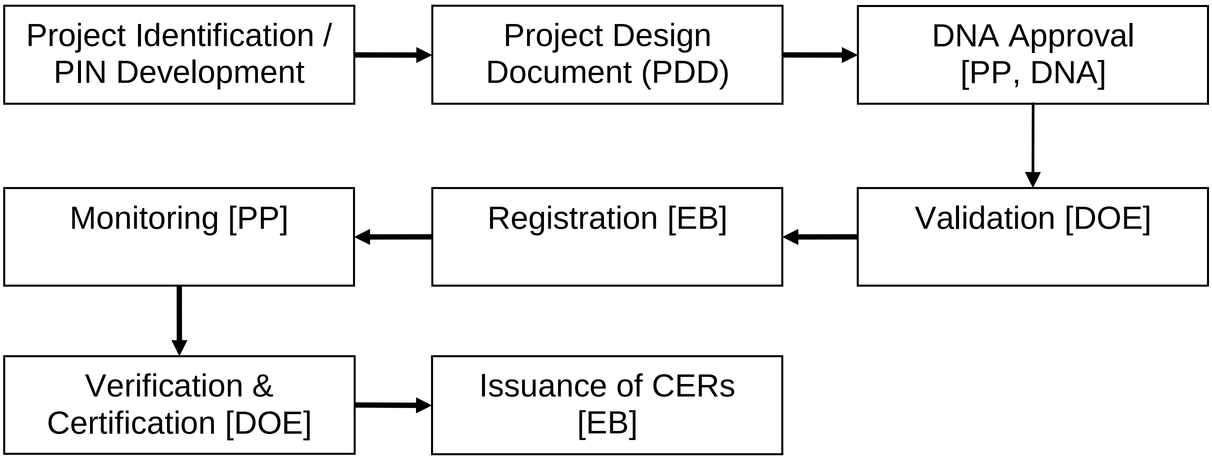

Figure 1.1: Flow diagram of CDM process and party involvement (adapted from UNDP, 2006)

First, a Project Identification Note (PIN) is drawn up which briefly states the goals and processes to be used in a potential CDM project. In South Africa the Project Proponent can at this early stage apply for provisional host country approval from the DNA. It must be noted though that drafting and submitting a PIN is considered to be a voluntary step.

As a next step every CDM project is required to submit a Project Design Document (PDD). This PDD is a comprehensive document that indicates how an approved CDM methodology will be applied. The methodology sets the rules used by which certain technologies are used to mitigate/reduce GHGs in the proposed project activity[1]. If no approved methodology exists that can be applied to the proposed project activity then a new methodology has to be drafted and approved by the CDM EB as part of the proposed project activity[2]. The purpose of a methodology is also to establish the GHG baseline for the proposed CDM project activity. In this context the concept of the baseline has a specific definition implying "*the scenario that reasonably represents GHG emissions that would occur in the absence of the proposed project activity*." – see Mizuno (2007).

The DNA must provide final host country approval when the PDD with approved methodology has been completed. It is at this stage that a DOE is required to evaluate the proposed project, and if the DOE is satisfied with the methodology and PDD, then it can be submitted to the CDM EB for registration. The final decision for project registration rests solely at the CDM EB.

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[1] In the CDM context a methodology is a non-project specific guideline that must be adhered to. The methodology, which requires approval by the EB to be usable, defines monitoring principles whereas a project specific monitoring plan will have to be followed to monitor the achieved emission reductions. The emission reductions achieved is then audited and quantified through the process of verification. The PDD is the document that indicates how the non-project specific CDM methodology is applied to a specific project.

[2] Methodologies and PDDs are comprehensive documents. Examples of Methodologies and PDDs can be downloaded from the UNFCCC's website: http://cdm.unfccc.int/

In order to earn CERs after project registration the Project Proponent needs to apply the monitoring plan, as described in the PDD and methodology, to prove that GHG emission reduction was achieved. The verification and certification of this GHG mitigation is then the task of the DOE. Only after the verification and certification by the DOE will the CDM EB issue CERs to the Project Proponent.

1.3. Rationale of the research

As a project-based system, emission reduction schemes necessitate the approval of aspects of the project relating to technical aspects, distributed regulatory approval, and distributed financial approval. As early as 2000 the World Business Council for Sustainable Development (Moorcroft, 2000) identified various barriers, represented as choke valves, in the CDM project life cycle. Moorcroft (2000) stated that: "*CDM methodologies and processes will create bottlenecks and raise transaction costs*". (These barriers are depicted in Figure 1.2.)

Moorcroft further stated that the: "*CDM project investment carries with it an important new dimension: it attracts a global level of scrutiny, over and above host country processes which must be satisfied for any project investment, regardless of the CDM. The investment and trade-related functions of the CDM therefore need to be organised with the minimum of bureaucracy and it will be particularly important to keep additionality*[3] *and baselines*[4] *as simple as possible*".

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[3] Additionality is the concept whereby a potential CDM project proves that the project activity would not have taken place in the absence of the financial incentive offered by the CDM. Proving additionality is mandatory for all CDM project. The Additionality Tool developed by the CDM Executive Board may be used to prove additionality.

[4] The project baseline is the GHG emissions that would have taken place if the project is not implemented.

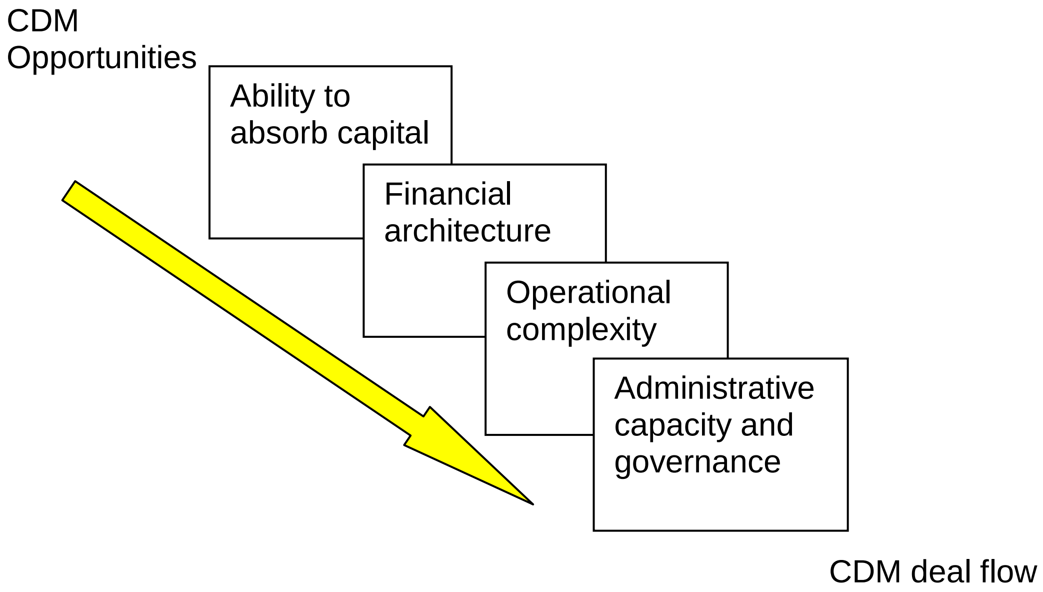

Figure 1.2: Barrier analysis of CDM process (Moorcroft, 2000)

Much research has been done on the issues raised by Moorcroft, but it would seem that at least some of these concerns still exist and other concerns have been highlighted by researchers. Examples of this include:

- Moorcroft identified the “ability to absorb capital” as a concern and that it depends on various factors including political and security risks, the prevailing ethical and legal frameworks, and business and investment infrastructures. It is interesting, if the view of Leqocq and Ambrosi (2007) is also considered, that capital constraint countries, especially those in sub-Saharan Africa, account for a very small percentage of all credits traded. It can then arguably be stated that the ability of sub-Saharan Africa to absorb capital has not significantly increased between 2000 and 2007.

- The “financial architecture” will either exacerbate or improve the ability of CDM projects to attract investment – see Moorcroft (2000) for further details. With banks and financial institutions having international reach it can be argued that banks in developing countries ought to have developed financial architecture abilities for carbon projects or at least have access to these skills.

- The “operational complexity” refers to the CDM methodologies and processes that, according to Moorcroft, will create bottlenecks and raise transaction costs. The greater the complexity the lower the deal flow. Winkler et al. (2005) also raise transaction cost and lack of potential sustainable development benefits as reasons why emission reduction projects outside of the CDM could be considered for African projects. Brent et al. (2005) indicated the complexities associated with sustainable development criteria for CDM projects specific to South Africa. “Governance and administrative capacity”, which forms part of the operational complexity, refers to possible administrative delays and barriers that will depend on the CDM governance system, the structure, roles and processes that are adopted. It is stated that there will be constraints on the number of projects that can be serviced with competent, experienced and professional staff. There are considerable lead times associated with project development which can take years, especially with large projects. Winkler et al. (2005) aimed to address the institutional capacity issues especially regarding DNAs in Africa. Arguably governance and administrative capacity is still considered a concern in the South African context as will become clear later on in the research.

It is then the aim of this study to focus on CDM projects in Africa, and specifically South Africa. The reason being that so few African projects exist (Leqocq and Ambrosi, 2007) and although South Africa has had some success with CDM projects there is still a strong driving force to increase the amount of projects (Little et al., 2007).

The study aims to focus on risk management and the integration of all the additional aspects encountered in CDM project development. This will be done by looking at some aspects of the project management landscape of CDM projects in South Africa.

1.4. Related theory

A brief overview of some project management principles and models will be presented here as an introduction of the discussion to follow. Obtaining information on the classical project management approach followed today is an easy matter. Various project management models and standards have been developed since the middle of the 20th century. These models and standards include, amongst others, PRINCE2 (2005) and PMBOK (2004). There are large similarities amongst classical project management models and/or standards irrespective of which model and/or standard is used. The generalized project management sequence is depicted in Figure 1.3: Generalized project management sequence (adapted from Openlearn, 2007), which is rather similar to the typical PMBOK (2004) phases in a project life cycle. The question then is: how does project management differ in an emission reduction project?

Figure 1.3: Generalized project management sequence (adapted from OpenLearn, 2007)

Novel aspects of emission reduction projects have been researched. These aspects include the influence of CDM transaction costs (Michaelowa et al., 2003) and specifically how it relates to South Africa (Little et al. 2007). Another focal point of research was the contentious issue of CDM additionality which was studied in depth as early as 2000 – 2001 (Shrestha and Timilsina, 2001, Gustavsson et al., 2000) and later by Michaelowa (2005) and Streck (2009). Also recently Michaelowa (2009) discussed the evolution of the theoretical definition of additonality and importantly real world implementation in CDM projects.

The intricacy of stakeholder engagement is a further important aspect that should be discussed along with CDM transaction cost and additonality. In the South African (SA) context the National Environmental Management Act (NEMA) of 2006 (SA DEA, 2006) referred to Environmental Impact Assessment (EIA) considerations that should be adhered to before specific projects can be undertaken - there are specific listed items that would trigger a project to do a full EIA report before government consent will be given. The regulations of 2006 included much more stakeholder participation than any previous environmental legislation - previous legislation would be the original NEMA act (SAGG, 1998). The same can be said for the 2010 NEMA (cape>gateway, 2010), which broadened the compulsory stakeholder participation even further and thereby increased complexity and timelines. The SA DNA will not provide any host country approval for any project if a project does not conform to the SA NEMA and subsequent acts.

CDM projects also require stakeholder participation and in the PDD the PP must specify:

- Which local stakeholders' comments were invited;
- A summarized description of how comments by local stakeholders have been invited and compiled;
- A summary of the comments received should be given; and
- Report should be given on how due account was taken of the comments received.

Brown and Corbera (2003) have used a stakeholder multi-criteria scheme to explore the range of stakeholders, their roles, interests and perspectives, based on a carbon sequestration by means of forestry project in Mexico. However, an integrated strategy to manage all the stakeholders was not developed. Little et al. (2007) also discussed the intricacies and perceived complexities that exist in SA CDM stakeholder participation.

Haites and Yamin (1999) have already argued as far back as 1999 that the amount of registered CDM projects and the ease of implementation will benefit from a flexible pragmatic approach. They state that: “*there is no right way of doing business under the CDM*”. This statement indicates a lack of structure in managing CDM projects and shows the ad hoc intervention which characterized early CDM project management approaches.

Furthermore, ZhongXiang (2005) states that developing countries typically lack a “clear institutional structure” and an “implementation strategy” system for application, approval, and implementation of CDM projects. ZhongXiang (2005) concludes that through capacity building aspects such as established streamlined and transparent CDM procedures, including sound governance must be developed through an integrated framework. Specific to South Africa Little et al. (2007) focussed on identifying various seemingly loose standing factors which they grouped into facilitating and inhibiting factors.

In this study the various historical attempts made at investigating the project management landscape and approaches of the CDM system will be grouped as indicated in Figure 1.4.

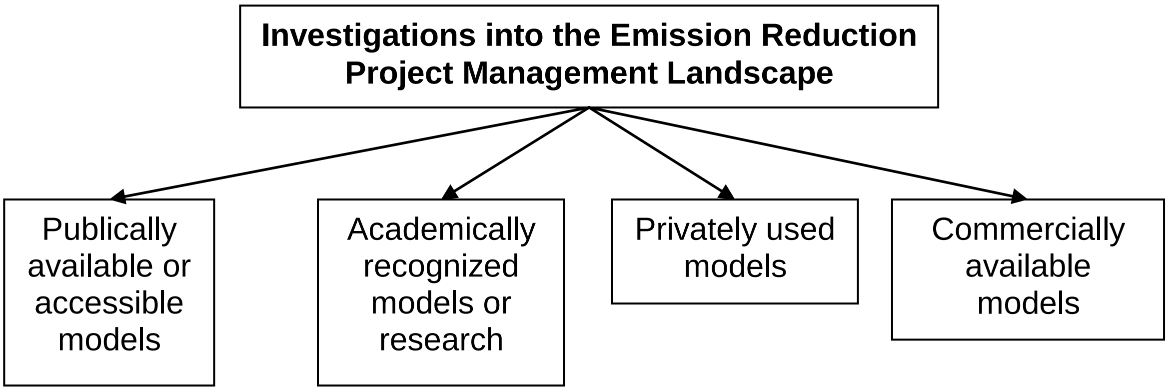

Figure 1.4: Grouping historical investigations into the project management landscape of the CDM

Focussing on publically available or accessible models:

In this research publically available or accessible models will include information that is easily accessible by using tools like an internet search engine. It will exclude:

- Work published in academic journal or conferences. See academically recognized models or research for this; and
- Models and/or computer programmes that can be bought. See commercially available models for this.

One of the first comprehensive management approaches to CDM project management was developed by the European Bank for Reconstruction and Development (Ecofys, 2004). Their project management model addresses the additional requirements posed by CDM project management as illustrated in Table 1.1. Extra project management requirements are included in parallel to the classical project management approach.

In the “Feasibility Assessment” phase the applicability of the CDM to the proposed project must be investigated. Issues like the economic viability of the project without CDM registration must be answered. The number of potential CERs must be quantified and the influence of these credits on the projected project revenue.

During the “Project Structuring Phase” additional documentation, like the project design document (PDD), must be completed. During this phase the contribution of the proposed CDM project to the sustainable development of the host country must also be addressed.

Table 1.1: Additional project management steps required in the CDM process (Ecofys, 2004)

Conventional Project Cycle	Additional CDM Steps
1. Project Identification	
2. Feasibility Assessments Project design Environmental feasibility Technical feasibility Financial feasibility Identify partners	Preliminary assessment of possible delivery of credits Preliminary assessment of possibility to monitor emissions
3. Project Structuring Phase Contracts Power purchase agreements Governmental permits Environmental permits Building permits Arranging finance and signing agreements (grants, loans, etc)	Development of project design document (PDD) Preparation of environmental impact assessment (EIA) Organisation of public consultation Development and validation of baseline and monitoring plan
4. Implementation Phase Construct or upgrade plant / facilities	Install monitoring facilities
5. Operational Phase Monitoring and evaluation: Financial, environmental and technical aspects	Monitoring and verification and/or certification of emission reductions

Another model was developed by SouthSouthNorth (Kantor, 2005), entitled the CDM Practitioners' Toolkit. This toolkit made a lot of progress in addressing the interlinked concepts of, amongst others:

- The climate context;
- Technology;
- Emission reductions;
- Finances;
- Sustainable development;
- Project architecture;
- Team management; and
- EIAs and stakeholder consultation.

Unfortunately, in the opinion of some South African CDM experts[5], this model did not gain wide spread acknowledgement or use. When it was asked why this model wasn't used the comments included that the model was:

- Too complex for practical use;
- Not geared to stay updated with CDM regulatory changes; and
- Extremely rigid in its application.

As of October 2010 the model is no longer available to the public.

Focussing on academically recognized models:

Initial research done by Janssen (2001) pointed to possible investment risk management of CDM and Joint Implementation (JI) projects by using methods of insurance and diversification. Similarly, Laurikka and Springer (2003) developed a framework for evaluating the investment risk for CDM projects. The result of the study was the conclusion that risk can be mitigated by following a portfolio approach. The reason given is that not all projects are affected by the same risk factors or affected to the same extent. The mentioned research unfortunately does not take the South African, or indeed African, scenario into account where project diversification is not always possible due to a lack of possible projects. The intricacies of technological, environmental, social and economic factors were highlighted by Laurikka and Springer (2003).

Flamos et al. (2005) highlighted the complexities of the CDM with regards to additionality, contribution to sustainable development, and financial feasibility including transaction cost - also see Dyer et al. (2006) regarding the complexities of sustainability and sustainable development. Flamos et al. (2005) aimed to address some of these complexities by developing the Clean Development Pre-Assessment Tool (CDM-PAT) and Dyer et al. (2006) developed software called CDM-Select. Both models were developed to be freely available to users via the internet. Unfortunately the tools are not currently (January 2011) available online anymore.

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[5] See section 4.4 for a discussion on who these "experts" were and how they were chosen.

Prengel (2004) focuses on risk mitigation of Chinese CDM wind energy projects. Although the research is quite focussed there are some general concepts that can be extrapolated for other technologies in other developing countries. One such concept is found in the discussion regarding standardization. According to the researcher the lack of "*clear rules and approval processes on a national level is seen as a main barrier for CDM investments*." This can be related back to the SA CDM landscape if one considers the institutional shortfall highlighted by Little et al. (2007) to be similar. It is then argued that a more integrate management approach can be followed to aim to address these shortfalls.

Focussing on privately used models:

Arguably many CDM project developers will have software used in-house to trace project development, project management and risk management. For this research access to these resources were limited or non-existing. The success of these models, for the African and South African perspective, is highly debatable if considered that international CDM developers are present in South Africa and still there are very few registered CDM projects. This aspect is discussed later.

Focussing on commercially available models:

Carbonflow (2010) developed commercially available software like Connect+, amongst other tools, to aid in managing carbon project emissions. The company claims that their products can aid in managing the worldwide stakeholder process involved in CDM project development. Another benefit of the software is that it also aims to aid in portfolio management. It is then safe to say that Carbonflow acknowledges the complexity associated with CDM projects and aims to provide a management tool.

One major drawback of the software is actually one of its strengths being that the software aims to manage the inputs of all stakeholders. The result is that if all parties (PP, DNA, and others) do not use the software and update it frequently then much of the benefit is lost.

Unfortunately the widespread use of any of these commercially available CDM software platforms is highly questionable within the South African CDM space according to South African CDM experts[6]. The only way in which it is possible to trace back the application of these software tools to registered CDM projects in South Africa will be to ask South African CDM experts. It is of interest to note that the South African DNA commented favourably on the use of the Carbonflow software - the SA DNA is as DNA not directly involved in project development, but should provide host country approval for any CDM projects.

Another player in the commercial CDM software space is ICF International (2010). From their literature it is clear that, as in some of the cases mentioned above, country-specific CDM issues and portfolio management are recognized as aspects that should be managed during CDM project development.

IFC International has various software packages and applications, including the:

- Carbon Planning Model – This tool aids in carbon market scenario analysis for modelling carbon prices. Carbon price modelling is important to address risks issued with project income, but has little to do with other project development risks; and
- Kyoto Project Risk Management System – This system aims to address and quantify risks associated with CDM projects. This is achieved using a spreadsheet question and answer approach which then weighs the input factors. This can indeed be a very handy tool, but project risk and the weighting there of is a dynamic process implying

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[6] See section 4.4 for a discussion on who these “experts” were and how they were chosen.

> that the once off evaluation of a project is not sufficient. Risks should be identified and managed on a continuous basis for various aspects throughout the CDM project development lifecycle. Managing risk once off or separating it from project management does not necessarily result in successful CDM projects as continuous project management is also required.

It is important to note that many of the sources of information (academic, commercial or in-house models) identified similar concerns, but try to manage these concerns differently. What is also of interest is to note that the diverse sources all aim to achieve aspects of risk management and project management without simply adding another layer of complexity to standard project management tools such as PRINCE2 and PMBOK.

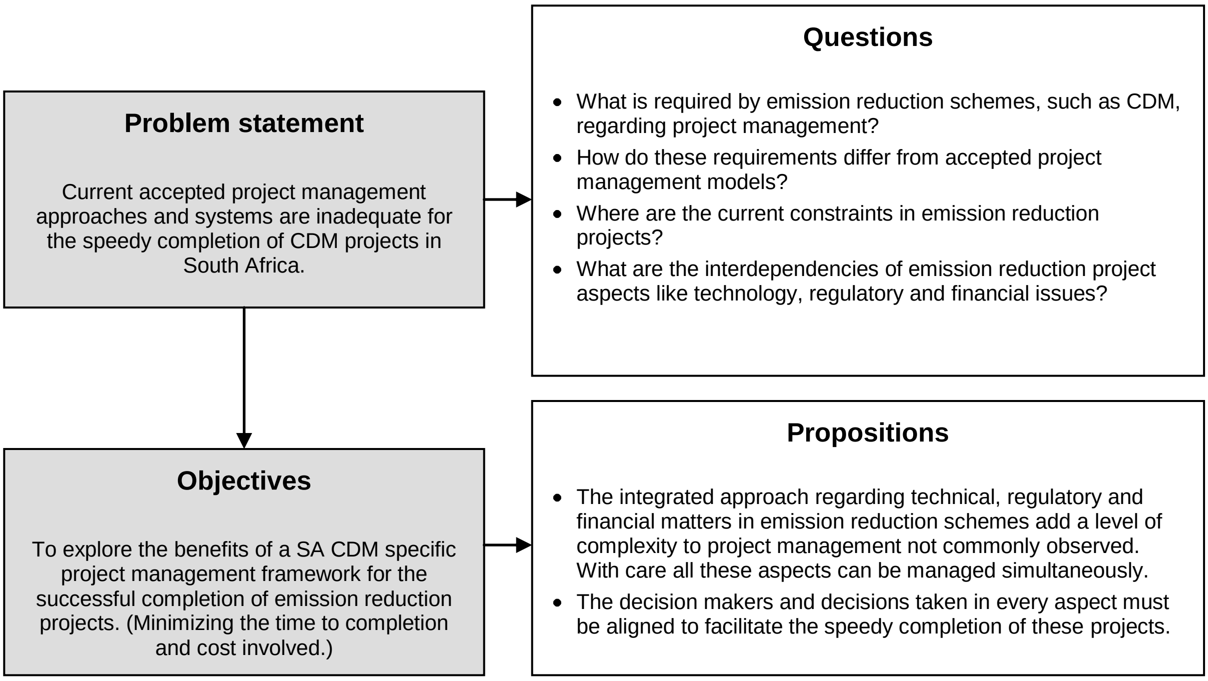
1.5. Problem Statement and Research Objectives

The research questions then become:

- Why are there so few registered SA CDM projects?
    - What are the current CDM project management approaches followed for CDM projects in SA?
    - Do SA CDM developers use and know of above mentioned research?
    - Do SA CDM developers need some other tool to be more successful?
    - How can project management (current and amended) procedures be formalised with regards to CDM projects in the SA context?

It is considered critical for this research to involve SA CDM experts as to ensure that the output can practically be used. This research then aims to investigate the overall strategy for CDM project development in Africa, and South Africa in specifically, as opposed to focussing on the individual aspects such as additionality. The objective will be to achieve risk mitigation through SA CDM specific project management.

The focus of this research is then to shift from individually researched CDM novelty aspects, to investigating overall risk mitigation through project management. Figure 1.5 is a flowchart representing the research problem statement, questions raised, research objectives and propositions.



Problem statement

Current accepted project management approaches and systems are inadequate for the speedy completion of CDM projects in South Africa.

Questions

- What is required by emission reduction schemes, such as CDM, regarding project management?
- How do these requirements differ from accepted project management models?
- Where are the current constraints in emission reduction projects?
- What are the interdependencies of emission reduction project aspects like technology, regulatory and financial issues?

Objectives

To explore the benefits of a SA CDM specific project management framework for the successful completion of emission reduction projects. (Minimizing the time to completion and cost involved.)

Propositions

- The integrated approach regarding technical, regulatory and financial matters in emission reduction schemes add a level of complexity to project management not commonly observed. With care all these aspects can be managed simultaneously.
- The decision makers and decisions taken in every aspect must be aligned to facilitate the speedy completion of these projects.

Figure 1.5: Research problem statement and objectives

The success and completion of an emission reduction project is defined as achieving registration and subsequent issuance of CERs.

One of the aspects of these emission reduction projects that this research aims to address, but cannot formally quantify, is the speedy completion of the projects. Hopefully, with time, the practical application of the research and the evolvement of the results will aid in speeding up emission reduction projects.

1.6. Benefits of aligning CDM project management with standard project lifecycle phases

Aligning the CDM project process and project lifecycle phases with specific application to Africa and South Africa is a field of study not widely exploited yet. The following benefits are envisaged for aligning and integrating the CDM project process and project lifecycle phases:

- The ad hoc project management commonly found in CDM projects, according to the SA CDM experts[7], can be structured;
- The need to force CDM project management into standard project management models designed for other types of projects will be alleviated; and
- The state of development of CDM projects will become more apparent to parties who are not CDM experts.

1.7. Importance of the research problem

This research will be valuable to the following parties:

- Entities interested in developing emission reduction projects, including companies in the private sector;
- Entities involved in emission reduction project evaluation, such as the designated national authority (DNA) of South Africa and designated operational entities (DOE) certified by the UN to audit such projects; and
- Entities already developing emission reduction projects, such as CDM developers.

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[7] See section 4.4 for a discussion on who these “experts” were and how they were chosen.

1.8. Limitations and assumptions of the study

This study focuses only on the CDM emission reduction project structure. Currently the first commitment period of the Kyoto Protocol and CDM will expire in 2012. The timeframe of the emission reduction scheme could be viewed as a limitation with regards to this research. It must be remembered that emission trading as such is guaranteed to be a viable business case far beyond the Kyoto Protocol's first commitment period 2012 expiry date if one considers that the European Union Emission Trading Scheme Phase II will run to end 2012 (Kopp, 2007) and then Phase III will come into effect 1 January 2013 running up to end 2020 (Kettner et al., 2009). Furthermore the USA California Global Warming Solutions Act (2006) that aims to cut emissions by 80% below 1990 levels. The lessons learned from the CDM in combination with this research can help the emission reduction protocol that is to replace and/or extend the Kyoto Protocol.

CDM projects are open source information once a project is in the validation process and the PDD is open for public comment, but until such time each developer guards project specific information. This, combined with the competitiveness of project developers in general, can hamper the sourcing of data needed for questionnaires, surveys and interviews.

For this reason the technical complexity of each individual project does not influence the applicability of the model. This research also does not aim to prescribe how technical aspects beyond the CDM realm should be addressed in individual projects. Let us consider the example where emission reductions will be claimed for energy efficiency in a new building. The model proposed in this research could be applied for the emission reduction aspect of the project, but standard/existing project management approaches should still be followed for the civil/construction aspects of the project.

It is important to note that this research will mostly be of exploratory nature. The reasons for this include:

- The lack of peer reviewed academic literature on the project management of emission reduction incentive projects specifically focussed on Africa and South Africa. The result is that previous theories or work could not be tested as there are little or no previous work; and
- The amount of CDM registered projects in South Africa. At the start of the research there were 10 registered projects in South Africa and this number grew to 17 at the end of the research. Establishing statistical evidence from a population size of 17 is misleading.

1.9. Proposed research approach and strategy

The approach to the research is set out in Figure 1.6.

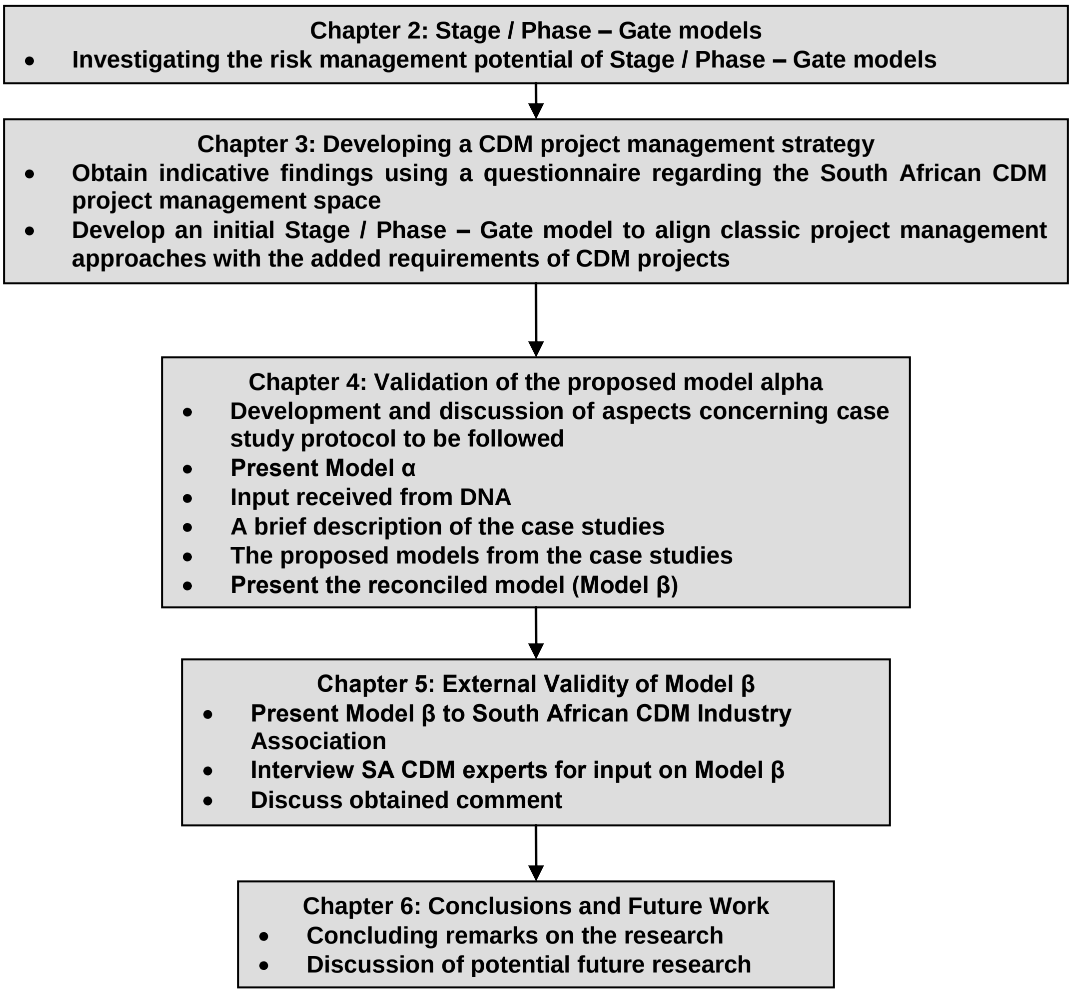

Figure 1.6: Strategy of the research study

Chapter 2: Investigating the risk management potential of a stage/phase-gate project management approach[8]

> **"I have also found that the overall effectiveness of a risk management process is primarily determined by two factors, namely, technical sophistication and implementation efficiency."**
> **Edmund H. Conrow**

2.1 Introduction

A set of phases and gates adopted within a company often forms the basis of a comprehensive project management methodology of the company; policies and procedures relating to a variety of aspects such as cost management, risk management, environmental, safety and health, procurement, project communication, amongst others, are defined for each phase of a project. Criteria that need to be met regarding each of these aspects are defined for each project phase.

At first glance it would seem that stage/phase-gate models could be applied with success to CDM projects. This is true if the CDM risk management literature (see previous chapter) and the distinguishable deliverables of a CDM project is taken into account. This said, more investigation is needed and Chapter 2 focuses on investigating stage/phase-gate models.

Labuschagne (2005) and Brent and Petrick (2007) attempted to establish some conformity between a range of views regarding project management phases; sixteen different references that suggest various project lifecycle phases or stages are listed (2007). Table 2.1 gives an adapted version of the latter work with the different phases, aligned as far as possible to generate a generic project management model.

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[8] This chapter has been published in a peer-reviewed journal: Lotz M, Brent AC, Steyn H, 2009. Investigating the risk management potential of a stage/phase-gate project management approach. Journal of Contemporary Management 6, 253-273.

Table 2.1: Phases in the project lifecycle (adapted from Brent and Petrick (2007))

No.	Reference	No. of phases	Project phases									
1	Parker and Skitmore, 2005	4	Concept	Contract awarded	Execution phases							
					Design	Planning						
2	Labuschagne and Brent, 2005		Conceptual	Planning	Testing	Implementation		Closure				
3		7	Idea generation	Pre-feasibility	Feasibility	Development and execution	Commissioning	Launch	Post implementation review			
4	Pillai et al., 2002	9	Project selection phase			Project execution phase			Implementation			
			Screening	Evaluation	Selection	Technology development	Production development	Performance development	Production		Marketing	Sales
5	Kartam et al., 2000	6	Feasibility	Design	Procurement	Construction	Start-up	Operation				
6	Jaafari and Manivong, 1998	5	Planning	Design	Procurement	Construction management	Commissioning of facility					
7	Vanhoucke et al., 2005	6	Conception	Definition	Planning and schedule	Execution	Controlling (monitoring)	Termination of project				
8	Cleland, 2004	4	Definition	Planning	Execution/ control	Close-out						
9	X-PERT Academy, 2005	5	Initiation	Planning	Execution	Controlling	Close-out					
10	PMI, 2002	5	Initiation	Planning	Execution	Controlling	Closing					
11	Kerzner, 2001	5	Conceptual	Planning	Testing	Implementation	Closure					
12	Steyn et al., 2003		Clarifying need	Feasibility	Definition (design and development)	Implementation (project execution)	Hand over and project closure	Support and maintenance				
13		6 – 8	Pre-feasibility	Feasibility	Basic development	Execution			Start-up and hand-over		Evaluation and operation	
						Detailed design		Procurement	Construction			
14	Tarr, 2003	9	Pre-feasibility	Site selection	Feasibility	Feasibility report		Board decision	Detailed design	Construction	Operation	Closure
15	Buttrick, 2000	7	Proposal	Initial investigation	Detailed investigation	Develop and test		Trial	Launch/ close	Post implementation		
16	DANTES, 2005	6	Idea	Concept	Investigation	Development		Validation	Launch			

The risk management advantages of such a staged/phased project management approach are much neglected in literature. The objective of this chapter is to investigate how a staged/phased project management approach may lower project risk.

The risk managing potential considered is both overall and within project phases by considering project life-cycle phases as stages. Historically stage/phase and gate processes were primarily used for product development projects. Risk reduction that results from the overall staged/phased approach is differentiated form risk reduction achieved by each of the embedded stages/phases. At a micro risk management level (the level of the embedded stages/phases) each phase/stage of a project should contribute to systematically reducing the risk associated with a project. This is briefly addressed by Anderson (1996) when he states that risk is managed by allocating development funds based on the successful completion of each phase/stage of development. For a more detailed discussion see Lotz et al (2009).

2.2 Project lifecycle stages and phases

Projects are, by definition, unique endeavours. This implies unknown factors, uncertainty and risk. The cumulative cost of a project typically follows an S-curve. Initially, during the early phases such as the idea phase and feasibility phase, costs rise gently. During the design or definition phases, costs increase somewhat and as the implementation/construction/manufacturing phase is reached, costs – and therefore risk - rise exponentially. Therefore, while relatively accurate, detailed plans for the immediate future are possible, only “broad-brush”, “rough-cut”, high-level plans are possible for the longer term. The use of phases and gates is underlying to rolling-wave planning that implies that, while overall, high-level plans should always exist, detailed plans are only developed for an imminent phase of a project.

Each phase has the objective of reducing the risk of subsequent phases in a cost-effective way; a relatively small amount of money is spent on a phase to lower the risk of subsequent phases. If the risk of subsequent phases cannot be reduced sufficiently, the project can be terminated at the end of an early phase.

The project manager can provide a high-level plan for the overall project and a detailed plan for the imminent phase only. Ideally the project manager commits himself only to the detail plan for the imminent phase.

The end of a phase is an important milestone in the lifecycle of a project where the project team typically presents the work performed to a project review board (comprising of customers and other stakeholders). If one considers the customer to be the client of the CDM project developer then this can be seen as a feedback session to the client. The benefit will be that the client is kept up to speed with project development. This point also serves as a gate that needs to be opened for work on the succeeding phase to be authorised.

The review board therefore has two functions to perform at the milestone: to look back to validate the work performed during the phase, and looking ahead to evaluate detailed plans for the subsequent phase as well as updated high-level plans for the rest of the project. The function of looking ahead also involves assessment of risks and authorisation of the next phase. Allocation of project funds for each phase is based on the successful completion of the preceding phases and where a preceding phase does not succeed in reducing risk satisfactorily, it can be addressed; for example additional work may be requested before authorization is given to proceed to the next phase.

Looking back should prove that the objectives of the phase and all criteria set for the phase have been met. The review board evaluates, validates and approves the work performed during the phase and formally accepts the deliverable or deliverables of the phase. Before the phase is formally closed out, it is confirmed that there are no outstanding issues. Payments are typically made following such formal approval.

As the work performed during a project phase typically provides more information, the overall plan for the rest of the project can be updated. Also, the completed phase typically provides inputs for detailed planning of the succeeding phase.

Following the approval of a completed phase, the project team typically presents to the review board a proposal or tender for the next phase, based on detail planning that has been done for the imminent phase. The review board evaluates the sufficiency of the detailed planning for the next phase, availability of resources, risks involved and the feasibility of the rest of the project. If the review board is satisfied, the next phase of the project is authorized.

The Stage-Gate process of Cooper (2001) is considered a typical example of a project management approach with stages (phases) and gates that include pre-project phases such as Discovery and Idea Screening (see Appendix A). The National Renewable Energy Laboratory (NREL, 2001) states that such a stage/phase-gate management process is an approach for making disciplined decisions about research and development that lead to focused process and/or product development efforts. The purpose of such a project management approach is to reduce costs and time to market for product development (NREL, 2001). A staged/phased-gate project management model is also used by companies in the process industry, e.g. Exxon and Rohm and Haas, system developers, utility companies, the construction industry, defence industry, and many others.

2.1. Components of a staged/phased-gate project management model

As the name implies, this practice makes use of stages and gates, where a gate implies that a part of the project activity is reviewed and a stage defines a specific work load that has to be completed before moving on. A table summarizing what ought to be achieved and verified at each stage and gate respectively is provided in Appendix A (Cooper, 2001). The complete high-level five-stage process of Cooper (2001) that includes pre-project phases is illustrated in Figure 2.1.

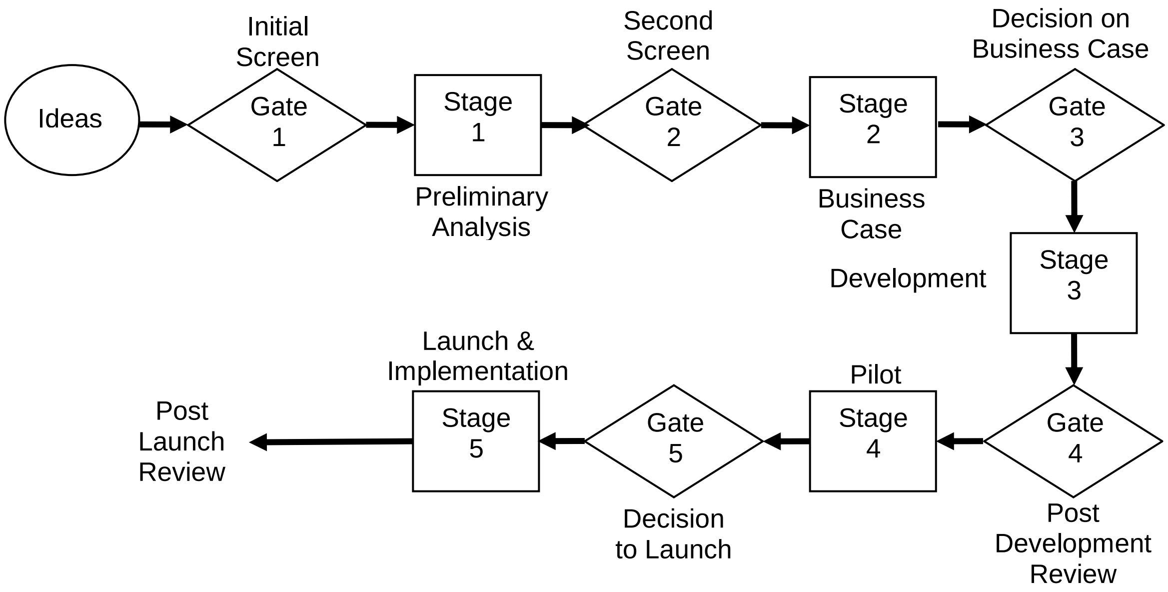

Figure 2.1: Comprehensive Stage Gate Project Management Model (SGPMM) as suggested by Cooper (2001)

The project reviewing at a gate has the following objectives (NREL, 2001):

- Proof that objectives of the previous gate and stage have been met;
- Proof that the objectives of the current gate have been met; and
- Set objectives for the following stage and formulate the next gate criteria.

The gate evaluation process can contribute to portfolio management (Cooper, 2001). To prioritize projects a "right-hand side" was added to the block representing a gate and the relative importance of the project is compared to projects that require the same limited amount of resources. Figure 2.2 illustrates the proposed dual purpose gate structure. Gate evaluations can have the following outcomes (NREL, 2001; Riley, 2005; Ayers, 1999):

- Pass – the goals of the previous stage were met and it is decided to further pursue the specific project;
- Recycle – all goals are not met, the current stage needs further work/investigation;
- Hold – work on the project is suspended for various possible reasons; and
- Stop – the project is stopped permanently due to various possible reasons.

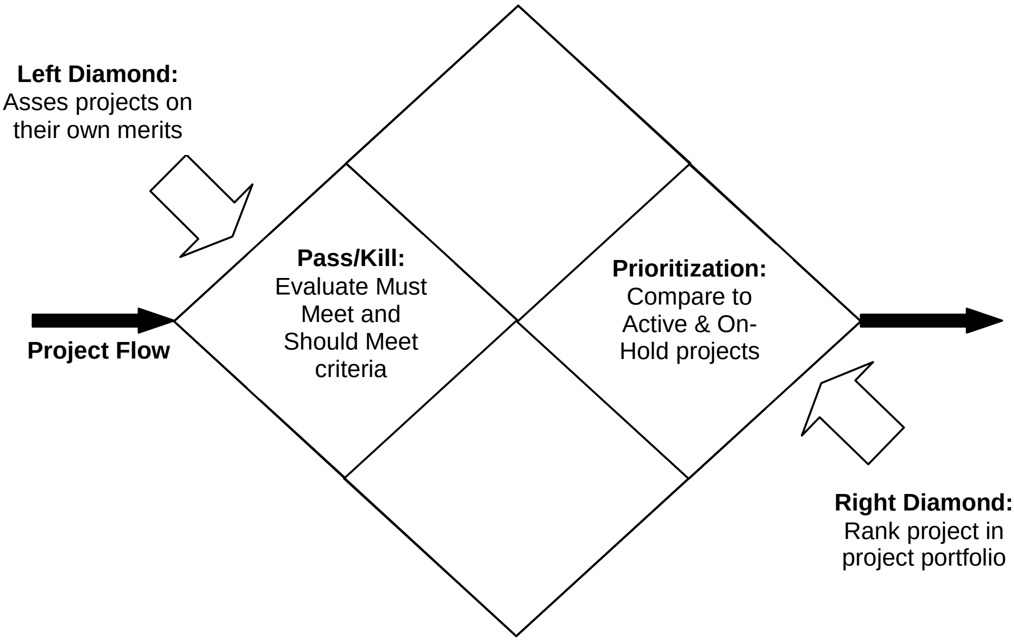

Figure 2.2: The gate structure as proposed by Cooper (2001)

Cooper et al. (2000) warn against having gates with poor decision criteria. A gate should predominantly result in a pass/stop decision and a prioritization process rather than a simple checklist of completed tasks. They propose the use of a scorecard with “must meet” non-negotiable criteria and a “should meet” scoring system. Various other systems for scoring exist, e.g. a matrix approach. Table 2.2 illustrates the gate scorecard proposed by Cooper et al. (2000).

Table 2.2: The proposed "must meet" and "should meet" structure of Cooper et al. (2000)

Must Meet Criteria	**Should Meet Criteria**
Evaluated as binary ‘Yes’/’No’ decision. Typical Must Meet criteria:	Evaluated using a scoring system (0 – 10 scale). Typical Should Meet criteria:
• Strategic alignment • Technical feasibility • Positive return Vs. Risk • Project killers	• Strategic fit • Product advantage • Market attractiveness • Business synergies • Technical feasibility • Risk Vs. Return

2.2. Advantages and disadvantages of a staged/phased-gate project management approach

It is argued that the advantages of a staged/phased-gate model include (Cooper, 2001):

- Capital expenditure is controlled as an exit at every gate;
- Time spent on projects are controlled as an exit at every gate;
- Adding clarity and flexibility to project management, especially in research;
- Weak projects are ended sooner;
- Focus on quality of project execution, important project steps and completeness of the project;
- Allows for fast-paced, parallel processing with a multifunctional team approach;
- Cross departmental collaboration; and
- Strong customer/competition orientation.

In contrast to the foreseen advantages it was noted by the NREL (2001) that a staged/phased-gate process can lead to artificial gate decisions. The impression can be given that the gates represent a simple checklist of future events that are known for certain. It can be argued that this is not the case since the resulting project plan of a staged/phased-gate process represents the best guess estimate of future events (Cooper, 2001). The fact is that all project planning is based on estimates; it is not unique to the staged/phased-gate process and this should obviously not prevent project planning. The guessing nature of the model will have to result in frequent updating of a project plan. The staged/phased-gate process should not be seen as a stagnant once-off model, but rather as an evolving process with definite early termination possible at every gate (see section 2.2).

The linear appearance of a staged/phased-gate process might lead one to assume that, if all project stages are completed sequentially, the time and cost advantages of parallel stage execution cannot be achieved. Overlapping of activities and of phases (fast tracking) is however commonly practised and a staged/phased-gate process does allow for parallel stage execution, but this has to be described explicitly in the staged/phased-gate process as the parallel execution of stages still requires authorization at relevant gates. It must be noted that a project phase is typically performed by a multi-disciplinary, cross-functional team and could deliver multiple outputs. Concurrent engineering (Smith, 1997) dictates that these multiple outputs should not be developed in series.

Sebell (2008) and Bessant et al. (2005) raise various concerns regarding the rigidness and the innovation potential of a staged/phased-gate process. Their concerns, and arguments against such concerns, are summarized in Table 2.3.

Table 2.3: Addressing concerns raised by critics of a staged/phased-gate process

Critic source	Critic	Response from the researcher
Sebell (2008) **Bessant (2005)**	A staged/phased-gate process is only applicable for incremental innovation and not breakthrough ideas or innovation. Breakthrough innovation requires a more dynamic model.	In a stage/phase-gate process time could be allocated to idea generation. Some ideas can be incremental advances and other ideas can lead to breakthrough innovation. The limit to the level of innovation is determined by the quality of the ideas and not by the stage/phase-gate process.
Sebell (2008)	Unanswered questions in the early stage will not let the truly breakthrough ideas to pass initial gates.	The objective of early project gates is to do early idea screening. It is accepted that early stages/phases will not deliver qualitative answers for gate appraisals.
	Backing from top management is necessary for innovative breakthroughs. A project team alone is not sufficient.	Idea generation can come from a top-down approach or a bottom-up approach. These ideas could be breakthrough ideas irrespective of the origin. After idea generation the project team has the authority and responsibility to be able to act autonomous to other company activities or projects.
	Staged/phased-gate processes are logic driven and resource allocation based. It is about consensus decision-making driven down into the organization.	

2.3 The risk management potential of stage/phase-gate models

Risk mitigation that results from the overall approach includes doing the *right project*; it includes pre-project phases and forms part of the project portfolio management process. In addition, each phase *within* a project contributes to *doing the project right*. Risk can also be eliminated by terminating the project; in the case of pre-project phases as well as in the case of within-project phases, the 'gate' at the end of a phase can lead to the termination of the project in order to eliminate risk.

Jafaari (2001) states that risk management is a fundamental characteristic of project management and backs this argument by indicating that risk management is one of the nine project management characteristics as described in the PMBOK (2004).

It can be argued that a stage/phase-gate should aim to reduce the risk associated with projects. This is in agreement with Anderson (1996) who states that a phased approach provides a disciplined system for managing product development, ensuring that steps are not skipped, quality stays high, and technical and marketing risks are controlled by senior management.

Before risk can be managed it must be assessed. One way to quantify risk is to consider the impact (often the monetary value) of a risk event at stake and the uncertainties of events occurring. The relationship of the amount at stake and the uncertainties of events are illustrated in Figure 2.3.

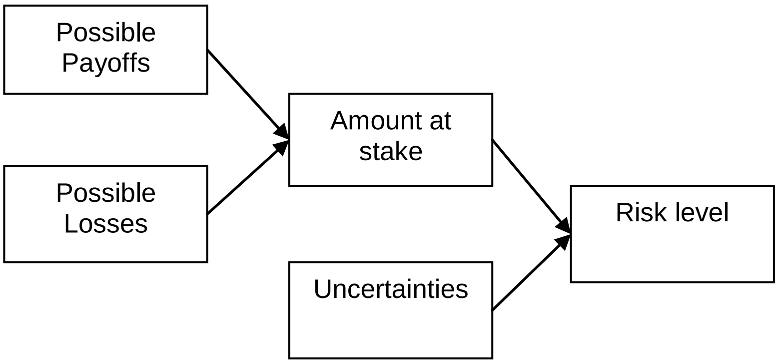

Figure 2.3: Adaptation of Cooper's (2001) view on risk

Combining possible monetary payoffs with possible monetary losses provides insight into the monetary value at stake. The uncertainties of the “amount at stake” monetary value must be ascertained to establish the level of risk of the project. This view on risk is similar to that of the PMBOK (2004) where risk is defined as the probability of an event occurring and consequence of such an event.

At a micro risk management level each phase/stage of a project should contribute to systematically reducing the risk associated with a project. This is briefly addressed by Anderson (1996) when he states that risk is managed by allocating development funds based on the successful completion of each phase/stage of development.

Despite the recognition of the contribution that phases/stages and gates make to empower senior management and other stakeholders to control the project, and despite the fact that the purpose of each phase should be to contribute to systematic risk reduction, the notion of phases/stages and gates is still much neglected in project management literature.

2.4 An exploratory case study to illustrate the risk management potential of stage/phase-gate models

An illustrative case study, based on Lotz (2006), is used to demonstrate the risk management potential of a stage/phase-gate project management approach. In this case study steel plates were to be manufactured by a new facility. Some of these steel plates could have had defects and the steel plates made with defects had to be scrapped.

The first option that the designers of the new facility had, was to use an existing control system on the market. This control system acted as a predictive model for identifying whether the steel plates were made to specification or not. The existing control system required twenty inputs to be measured from the manufacturing facility and had a guaranteed predictive performance of 73%.

The cost of the predictive control system available on the market was estimated at US$ 1,200,000. This included the installation and implementation of the complete control system as well as maintenance for three years.

The problem with the existing, available control system was that the predictive accuracy fell to zero if one of the required twenty inputs were not available to the control system. Ensuring that all twenty inputs from the manufacturing facility were available at all times was problematic. Furthermore, management, plant operators from similar facilities, and the design team of the new production facility had differing opinions regarding which variables had a larger impact.

It was known from other similar manufacturing plants that 5% of all steel plates manufactured had had defects. As stated, with the available predictive control system on the market 73% of all defects could be predicted. The result was that at least 1.35% of product with defects would be delivered to the clients as final product. Furthermore, if one also takes into account that the combined reliability of the twenty sensors required was 94.2% then the actual amount of defects passed on to the clients was 1.43%; the annual reliability of the twenty sensors was simply the product of the annual reliability to the power of the amount of sensors (see Appendix B for calculations).

The loss of revenue would have been the 1.43% of rejected product and as the annual revenue was estimated at US$100,000,000 then the loss of revenue would have been US$1,433,609.

The total three year cost would then have been the cost of the available predictive control system and the three year loss of revenue. The result was US$5,500,826 (see Appendix B). The cost of a newly developed predictive control system then had to be lower or at least had to be equal to this amount to be advantageous.

Management authorized a study to investigate whether the control system available on the market was the best possible solution or whether a new system should rather be developed from a financial risk perspective. This beckoned the following technical questions:

- Was it necessary to measure all twenty variables?
- If not, which variables had to be measured?
- Could a more optimized model be developed?

A further prerequisite of management, for the possibility whether a new model had to be derived, was that the model had to be human interpretable. The current predictive control system available on the market, at that stage, was considered to be a black box model. Management deemed that the derivation of another black box predictive model would have added little understanding of underlying process fundamentals even if it used less than twenty input variables.

A process consisting of stages/phases and gates was applied. A cross-functional and diverse project team was assembled consisting of:

- Project manager – Acting as the leader of the project team;
- Plant operator(s) – These individuals worked with the steel plate manufacturing equipment on a daily basis. Valuable input was provided by them, although these individuals could not be dedicated to the project team on a full time basis;
- Process engineer(s) – These individuals had extensive knowledge of the design of the steel plate manufacturing equipment, operation and broader plant operation; and

- Computer programming and data mining expert(s) – These individuals had experience in extracting underlying fundamentals from data and how to program this.

Members of the project team had the opportunity to come up with innovative approaches and ideas during the Discovery Stage. The plant operators gave valuable input from their plant experience. The process engineering staff and programming experts formulated technical approaches based on these inputs. Some of these ideas were eliminated during the first gate due to technical difficulty and time restrictions.

The first stage focussed mostly on refining some of the technical aspects of the Discovery Stage as “market place merits” of this project were not an applicable stage objective (see Appendix C for details). A budget of US$ 40,000 was allocated to this stage, which had to be used to search for new technologies that could be used.

During the second gate emphasis was placed on the “must meet” and “should meet” criteria of the project. Preliminary ideas were discussed with management to refine the project objectives and technical feasible options.
The second stage focussed on improving the technical aspects of the project and refining the estimated costs. A business case was developed, which specified the project costs compared to the estimated increase of income due to project implementation.

In this case study the issue of marketing of the product/newly developed predictive control system is not applicable as it is a system specifically developed for this project.

The second stage had limited resources and time for development. A budget of US$ 85,000 was allocated to this stage.

The third gate was executed as another meeting with all related parties including top management. The project definition and outcomes were fixed. Managerial approval and backing were obtained even though the project team could operate autonomously.

A laboratory-tested model was derived as the outcome of the third stage. The model used fewer variables than the original predictive model. The plant operators, process engineers and data mining experts all provided inputs during the development process.

The incremental improvements from stages one and two, together with the options eliminated during previous stages, implied that third stage progressed quite quickly. Expensive modelling software had to be purchased, which made this stage run over the allocated budget. The stage was budgeted at US$ 190,000 and came in at US$ 210,000. The budget overrun could be approved by the project manager because of the autonomous nature of the project team.

This model was tested (gate four) on real time data, but still in a laboratory environment.

Parallel model implementation (stage four) was done on a similar plant so that the same input was sent to the predictive control system and the newly derived model. The new model used less input variables to deliver comparable predictive accuracy to that of the old model.

The cost of stage four was kept low because the predictive control system derived in the previous stage could be applied as is. Furthermore, the single input used by the new predictive control system was already available as it was measured as an input to the predictive control system already in use. The cost of stage four was US$ 80,000.

The loss of revenue of the newly developed predictive control system was determined in exactly the same manner as was done in the case of the existing predictive control system available on the market. The overall reliability of the newly developed control system is higher due to the fact that the new system only requires one input parameter from one sensor. This increased reliability directly results in fewer losses due to send backs of the steel plates by clients.

Approval was given to install the newly developed predictive control system in the new plant (gate five) after all parties (project team, management, etc.) came to the conclusion that the system was ready for launching.

Stage five was then the implementation of the new predictive control system in the new production facility. The single sensor that will act as input parameter was installed. The specialized sensor and controls cost US$ 440,000 for the complete installation.

The phased/staged approach also limited the expenditure of the complete project. The result is that the capital for development, implementation and maintenance of the newly developed system was less than that of the available control system on the market. The cost was again worked out for a period of three years (see Appendix B).

A post-launch review took place, during which certain perceptions and views were raised by the project team and management. These perceptions and views were discussed and resolved where needed.

The results of the project were the following (Lotz 2006):

- An optimized predictive model was developed;
- This new predictive control system required only one input variable compared to the twenty variables of the old predictive model;
- The new predictive control system had comparable predictive accuracies to that of the old model;

- The singular model input resulted in a human interpretable model since it was known now that a specific variable had to be controlled precisely to ensure correct steel plate manufacturing; and
- The development and implementation of a new predictive control model cost came in 10.6% lower on a three-year payback basis as compared to the control system available on the market (the financial calculations are presented in Appendix B).

Figure 2.4 compares the financial implications of developing a newly developed control system with the application of the available control system. Figure 2.5 summarises the stage/phase-gate development of the case study as a binary decision tree.

The following advantages were observed in this project due to application of a stage/phase-gate project management model:

- The cross functional dedicated project team was completely responsible and empowered for the project - this led to project completion since separate departments did not have to wait for each other or miss-communicate requirements;
- The incremental addressing of all project aspects during each phase led to the identification of wrong project options quicker; and
- Financial project risk was controlled well due to the incremental cost incurred in the stage/phase-gate process.

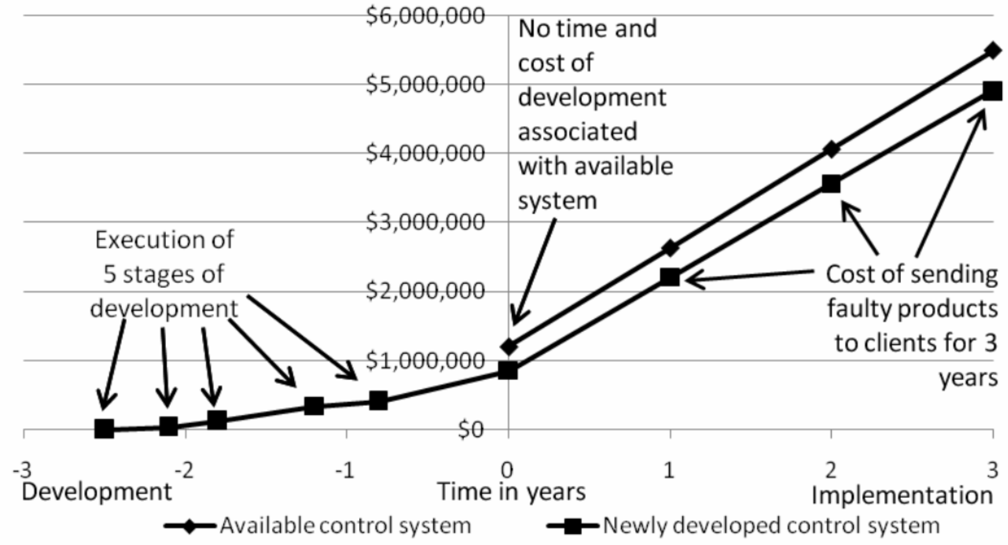

Figure 2.4: Comparing development and operational cost of a newly developed control system with the costs of an existing control system

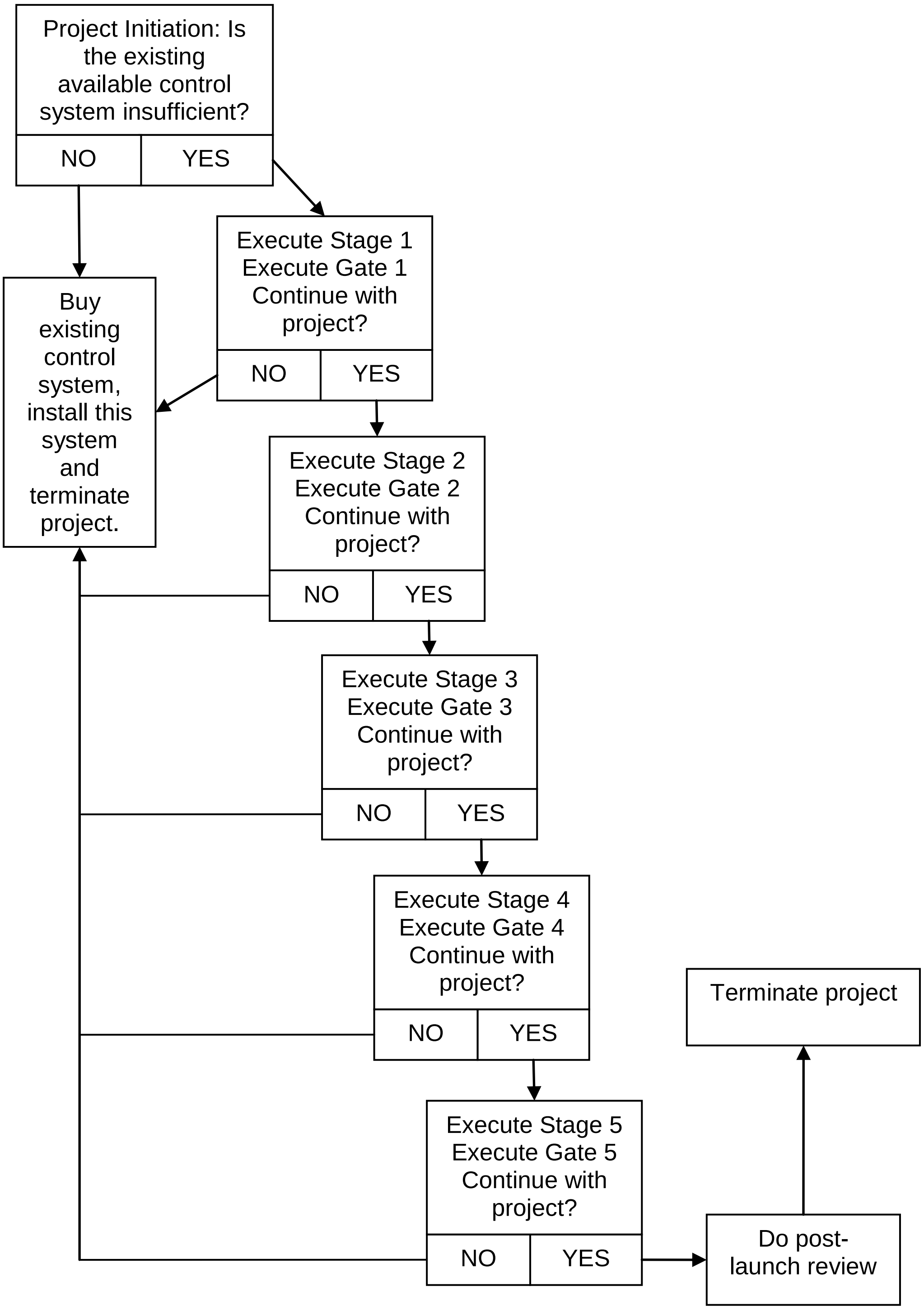

Figure 2.5: Binary decision tree representation of the case study

2.5 Chapter conclusions

The use of phases (or stages) and gates is a well established in literature and in industry. Phased project management approaches are used because of the risk management potential that it offers. The potential of a stage/phase-gate model was also established from literature. This chapter describes the relationship between risk management, project phases and rolling-wave planning. Risk management at the end of phases within a project is distinguished from the contribution that a phased approach can make to the management of a portfolio of projects if pre-project phases are included. The improved risk management potential of phases and gates was demonstrated by means of an illustrative case study.