Methods for Risk Assessment within the framework of Sustainable Development

Ronald Wennersten
Jan Fidler

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Department of Industrial Ecology
School of Industrial Engineering and Management
Royal Institute of Technology (KTH)
KTH, 100 44 Stockholm
www.ima.kth.se

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The photo (Åsa Larsson) on the cover of the report shows the Loudden oil port and it´s surroundings the Eco Park (Nationalstadsparken) and the busy ferry terminals.

All photos in the report are taken by Åsa Larsson, Ronald Wennersten, Jan Fidler.

Abstract

In a democracy we have to accept that decision processes are participatory in the way that they involve many stakeholders in the decision, not only experts. This is important because most of the decisions cannot only be based on facts but also values have to be included. It is thus important to have transparent information around the consequences of different alternatives and the concept of risk is here one of the most difficult concepts to evaluate.

This project has focused on a case study around the location of Loudden oil terminal in the central part of Stockholm. This case study was chosen because of its complexity regarding the decision-making process and stakeholder interests and because risk is an important parameter in the decision of the location of the oil harbour. The case study shows that land use planning is a delicate trade off between economic and social development and protection of environment and between the interests of different stakeholders. This planning process requires that information around risks of different types can be evaluated and presented in a transparent way for all the stakeholders involved. Risk is only one parameter among many in the decision process, but it is often an important one and one which is difficult to grasp.

One of the experiences in the project is that many of the stakeholders including politicians and the public, taking part in the planning processes have a consequence based approach more than a risk-based approach. This means that they do not take the low probabilities for mayor accidents into account but merely focus on possible worst case scenarios and if those can be handled. The safety reports for the installations however have a much more risk-based approach relying on different methods for estimating probabilities for accident scenarios. This makes it very difficult to communicate and agree upon the results from these safety reports which are actually the basis for decisions around the acceptance of the installations. Parts of the existing legislation also includes demand for estimation of probabilities or frequencies for accidents, but no recommendations how to calculate it. In connection to this there are also proposals to use acceptance criteria e.g. societal risk and individual risk in order to facilitate evaluation both for the companies and for the authorities. This project shows that this development is very doubtful because of the inherent large uncertainties in the estimation and also because of the problem to communicate the results in participatory decision processes.

As a result of this project we therefore argue that there should be a more consequence based approach for accidents and worst case scenarios in the safety reports where ‘real’ worst case scenarios are described. These can then be communicated to the stakeholders and also to the rescue service in order to decide if these worst case scenarios can be handled in a proper way and also how the risk can be reduced by robust barriers and emergency actions. The report should also include an extended summary which in a transparent way can communicate the results to all involved stakeholders. There should also be an overview of major accidents which have occurred internationally at similar installations.

From this project the recommendation for further research is that more detailed examples of guidelines for how to develop more consequence based approach for accidents and worst case scenarios should be developed both for industrial sites and transport of dangerous substances. These developed examples should then be discussed among a wide stakeholder group.

The result from the training package shows that this type of training course where different stakeholders have to argue from different standpoints is very valuable in order to widen the horizons and understanding different views on the concept of risk. There is not one objective way to evaluate risk, but many depending on values and preferences.

Sammanfattning

I en demokrati måste vi acceptera att beslutsprocesser involverar många intressenter inte bara experter. Det är också viktigt att förstå att de flesta beslut inte bara baseras på fakta utan också på olika typer av värderingar Av detta skäl är det väsentligt att alla har tillgång till transparent information om vilka konsekvenser olika beslut kan leda till. Begreppet risk är här ett av de svåraste att hantera på ett transparent och begripligt sätt.

Detta projekt har fokuserat på en fallstudie rörande alternativa placeringar av oljehamnen på Loudden i centrala Stockholm. Fallstudien valdes eftersom beslutsprocessen är komplex och att risk är en viktig parameter. Studien visar att fysisk planering är en känslig balansakt där hänsyn till ekonomiska, sociala och miljömässiga såväl som motstridiga intressen måste hanteras. Planeringsprocessen kräver att risker med olika alternativ kan utvärderas och beskrivas så att alla intressenter förstår. Risk är bara en parameter, men en viktig sådan i beslutsprocessen.

En av erfarenheterna från projektet är att många intressenter inbegripet politiker och allmänhet har ett uttalat konsekvensbaserat sätt att värdera risker. Detta betyder att man oroar sig främst för stora konsekvenser av olyckor och att man tar mindre hänsyn till att sannolikheten för olyckan kan vara liten. De säkerhetsrapporter som tas fram av företagen för olika installationer är däremot huvudsakligen riskbaserade där man tar hänsyn bara till olycksscenarier som inte har extremt låg sannolikhet. Detta leder till svårigheter då man skall besluta om huruvida dessa installationer skall vara tillåtna. Delar av gällande föreskrifter kräver också att man uppskattar sannolikheter eller frekvenser av identifierade olycksscenarier, men inga klara direktiv för hur dessa skall beräknas. I anslutning till detta så används också kriterier för att värdera risken som t ex samhällsrisk och individrisk, som anses kunna underlätta utvärderingen. I det här projektet drar vi slutsatsen att denna utveckling är mycket tveksam beroende på de stora osäkerheter som finns i beräkningen av sannolikheter och frekvenser, samt också på grund av svårigheten att kommunicera resultaten till olika intressenter.

Som ett resultat så anser vi att säkerhetsrapporterna bör bygga mer på en konsekvensbaserad riskvärdering där de största konsekvenserna som en olycka kan leda till beskrivs. Dessa är lättare att kommunicera till politiker, allmänhet och även till räddningstjänsten. Scenarierna utgör sedan en bas för en diskussion om olyckorna kan hanteras med hjälp av robusta barriärer och nödlägesplaner. I anslutning till detta bör mer arbete också läggas på att skriva en utvidgad sammanfattning av rapporten så att innehållet kan kommuniceras på ett transpartent sätt till berörda intressenter. Säkerhetsrapporten bör också innehålla en beskrivning av betydande olyckor som inträffat internationellt på liknande installationer.

Med utgångspunkt från resultaten i projekten rekommenderar vi ytterligare studier för att ta fram rekommendationer för hur mer konsekvensbaserade scenarier kan utvecklas för olika typer av verksamheter såsom industrianläggningar och farligtgodstransporter. Dessa förslag kan sedan diskuteras i bredare intressentgrupper.

Ett annat resultat från projektet är att utbildningar kan utformas så att de befordrar en ökad förståelse för hur olika intressenter värderar risker. Det finns inte en objektiv risk som kan beräknas med ingenjörsmässiga metoder och utvärderas mot fasta kriterier. Riskvärdering är i mångt och mycket en subjektiv process som måste hanteras på ett demokratiskt sätt.

Abbreviations

BSR	Baltic Sea Region
CAA	Clean Air Act
COASTMAN	Acronym for the INTEREG IIIB project Coastal Zone Management in the BSR
COMAH	Control of Major Accident Hazards
CZ	Coastal Zone
CZM	Coastal Zone Management
DPSIR	Driving force, Pressure, State, Impact, Response
ECHA	European Chemicals Agency
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ICZM	Integrated CZM
IMO	International Maritime Organisation
HSE	Health and Safety Executive
KTH	Royal Institute of Technology
LNG	Liquid Natural Gas
LUP	Land Use Planning
MAHB	Major Accident Hazard Bureau
MARS	Major Accident Reporting System
MBPP	Marine Biodiversity, Patterns and Processes
MSUO	Maritime Safety Umbrella Operation
PSSA	Particularly Sensitive Sea Area
PBA	Planning and Building Act
REACH	Registration, Evaluation, and Authorisation and restriction of Chemical substances

RMP	Risk Management Program
SD	Sustainable Development
SEC	Swedish Environmental Code
SEPA	Swedish Environmental Protection Agency
SPI	Swedish Petroleum Institute
SR	Safety Report
SRSA	Swedish Rescue Services Agency (Svenska Räddningsverket)
UNEP	United Nation Environmental Program
WCS	Worst Case Scenarios

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1. Introduction

In November 2002 the Prestige, a 26-year-old tanker loaded with heavy-grade oil, was damaged off the Spanish Atlantic Coast, sank and caused an ecological disaster. On its way this tanker had travelled through the Baltic Sea. There are no guarantees that a disaster like this cannot also happen in Swedish coastal waters. The volume of maritime oil transportation in the Baltic Sea has increased significantly during recent decades. It has been estimated that more than 130 million tons of oil will be transported through the Baltic Sea by 2015. The major driving force behind the current increase in oil transport in this area is the high price of oil in combination with Russian export ambitions, as well as increased economic activity in general in the former Soviet Union region. Several new ports have been constructed in the St. Petersburg area recently, while existing ports have been upgraded. This means that the overall export capacity from Russian Baltic Sea ports is increasing rapidly.

The environmental hazards of oil spills are of two different kinds. First, accidents during storage and transport can produce large and dramatic effects, requiring substantial and rapid responses by several different authorities in cooperation. Although most of the historical accidents in the Baltic Sea have been comparably small in size, the environmental effects are still substantial because of the ecological sensitivity of this brackish sea. This is why the Baltic Sea is classified by the International Maritime Organisation (IMO) as a 'particularly sensitive sea area' (PSSA). Second, it is a well-known fact that oily sludge or various forms of oil-contaminated residues from tank washing is discharged in open seas, despite regulations prohibiting this in all parts of the Baltic Sea. It was estimated by UNEP in 1990 that, globally, the extent of these two types of oil pollution were roughly of the same magnitude, although tanker operation emissions might have been somewhat larger than those directly related to accidents such as collisions or groundings. The cumulative result is that substantial volumes of ecologically hazardous substances are released into the sea. The environmental consequences of these diffuse emissions are not yet fully understood.

However the ocean, its coasts and surrounding regions also have great economic significance, which is why some risks always have to be accepted. The main problems are to set levels of acceptance and to resolve the conflict between risks and benefits. In many cases, nations and groups of people are exposed to risks arising from activities from which they derive no direct benefit. There are also conflicts between nations and between sectors such as oil companies, tourism and the fishing industry, which in different ways profit from the ocean but also affect it. Ecological problems are caused by oil pollution, sewage or aggressive fishing techniques. Environmental organisations and regional administrations also pursue their own aims for the ocean and its coast and it is not unusual for interest groups to be in conflict with each other. For example, the danger from oil terminals and oil transportation can have a negative influence on the tourist and fishing sectors. The interaction of activities between conflicting groups using the ocean and coastal parts of the Baltic Sea region (BSR) have until now not been given sufficient attention.

Land use planning (LUP) in coastal zones (CZ) is therefore a delicate trade-off between economic development and protection of the environment and between the interests of different stakeholders. Hence this planning process requires information about different types of risks that can be evaluated and presented in a transparent way for all stakeholders involved. In the end, the decision in the planning process is based on subjective evaluation of different alternatives but it is essential that transparent information is available.

Conflicts in the Baltic Sea Region arise not only from the problems of shipping of oil but also from other types of infrastructure, such as off-shore drilling for oil. A recent example of a conflict is the planned natural gas pipeline from Russia to Germany. The pipeline is called Nord Stream, which refers to the offshore section between Vyborg and Greifswald, but sometimes it may have a wider meaning, including the onshore section in Russia and further connections in Western Europe. The project is highly controversial for both environmental concerns and national security risks. The methods and cultures for assessing risks and using results in planning processes are very different in the countries around the Baltic Sea. It is thus obvious that it would be beneficial to start a process where these issues are discussed, not only on a high policy level, but also on a more practical level where different cases are illustrated. This was the general idea behind the COASTMAN project, which started in 2004 and ended in 2007.

This Swedish case study project forms part of the EU COASTMAN project within the INTERREG IIIB programme, with partners from several countries around the Baltic Sea Region (BSR).

Central objectives in the COASTMAN project were:

- To demonstrate the conditions under which spatial conflict resolution in coastal zone management can be handled in a bottom-up perspective, starting from concrete case studies covering the problem dimensions and different cultures around the Baltic Sea
- To identify legal, organisational, economic, methodological and cultural frameworks for Coastal Zone Management (CZM) in participating countries and to find out how differences in these frameworks influence strategies for conflict resolution on local and regional levels in CZM and what adaptations of methods are necessary for each participating country
- To promote sustainable development of coastal areas through an information exchange platform, information events and specialist workshops; exchange of experiences and best practice in conflict resolution in CZM, with related INTERREG projects
- Development of joint educational programme for CZM in the BSR, with the focus on conflict resolution in spatial planning
- Creation of awareness among the stakeholders in all BSR countries that problems to be solved contain a mixture of facts and values and that solutions very much have to be found in a participatory processes where all stakeholders are involved

The results from the COASTMAN project are based on work with practical case studies around the BSR. These case studies comprised oil terminals and a wastewater treatment plant. The main results from the project were:

- Descriptions of legal, organisational, economic, methodological and cultural frameworks for CZM in participating countries
- Set of recommended methods and guidelines for conflict resolution in CZM, with the methods tested on practical cases in the BSR
- Recommendations for conflict resolution in practical cases based on participatory processes
- Shared vision among participants on differences in the frameworks and how these differences influence strategies for conflict resolution in CZM
- Set of recommendations describing the adaptations of methods necessary for each participating country due to cultural and economic differences

- Published handbook with description of practical cases, evaluation of selected methods and recommendations on how to use methods to resolve conflicts in coastal zone management
- Internet-based course with on-line material focused on conflict resolution in CZM

The Swedish case study, which was the main focus for this project, involved the Loudden oil terminal in Stockholm. Loudden is one of several ports in Stockholm County and the biggest oil terminal in the region. It is situated in the eastern part of central Stockholm.

After several years of heated debates between a number of stakeholders, such as politicians, oil companies, municipalities and NGOs, the city of Stockholm finally took a decision in 1999 not to prolong the contracts with the oil companies after 2011. Important motives for the decision to close Loudden were to eliminate the transportation of petroleum products by tankers travelling through the city and the transportation of petroleum products in the archipelago. Another important motive was Stockholm City's strategy of building and expanding the city inwards, which means using as much existing land as possible, while at the same time using existing infrastructure for construction of residential areas and offices.

The many stakeholders involved in the case include the harbour company owned by the City, oil companies renting the oil harbour from the City, neighbours to the industrial area, city planners, tourists, NGOs, political parties, etc. It is important to recognise that the interactions between stakeholders have consequences for the decisions made. The risk aspects were important arguments in these discussions. The problem was to identify the risks and decide whether they were acceptable. The risk assessments carried out by the companies involved are generally not transparent enough to be understood by a wider stakeholder group.

The detailed objectives of the Swedish case study reported here were to:

- Compare the appropriateness of different risk assessment methods in a comprehensive assessment of different risks for storage and transport of petroleum products. An important criterion was that the results could be used in participatory decision processes, where a wide group of stakeholders takes part.
- Compare the appropriateness of tools for environmental system analysis and environmental impact in connection with storage and transport of petroleum products. Here too, an important criterion was that the results could be used in participatory decision processes, where a wide group of stakeholders takes part.
- Develop criteria, indicators and general methods for handling risk aspects as part of sustainable development.
- Develop models for decision-making processes in participatory decision processes, where a wide group of stakeholders takes part.
- Apply the models and methods developed to the Loudden case in Stockholm.
- On the basis of the results from the case, discuss guidelines for decision processes in land use planning with the focus on risk aspects within the framework of sustainable development.

This report is structured in a way that we first give an overview of the Swedish case study in Chapter 2. In Chapter 3 there is an international overview of one of the main issues in the project; How to develop scenarios for major accidents? In this chapter we can see that there is a different approach concerning consequence or risk-based scenario development, that is how much effort that should be spent on calculations of probabilities for accidents. In Chapter 4 these issues are studied more in detail in relation to the Swedish case study with some major

conclusions. In Chapter 5 there is a discussion how to evaluate environmental consequences in relation to accidents. In Chapter 6 participatory processes for risk assessment are discussed. Which stakeholders should take part and how in evaluation of risks for major accidents? In Chapter 7 risk is discussed in relation to other parameters in decision making from a standpoint of indicators. Indicators can be used to develop a set of parameters which can be used in participatory decision making processes. In Chapter 8 the pilot course in conflict management is described with an evaluation. The course turned out to be a good way for stakeholders to discuss and get a deeper insight in how other stakeholders values and standpoints I a part of the decision process. The project is than summarised in Chapter 9.

2. Oil terminals, Risks and Land Use Planning – The case study at Loudden in Stockholm

2.1 Background

Stockholm is built on the waterfront, which means that the harbour has always played an important role for the city. Until the 1950s, Stockholm harbour was the biggest import harbour in Sweden. The city flourished and traded with all parts of the world. After the Second World War the trade with the Baltic States ceased, while ferries to Finland increased in numbers.

Today the Stockholm harbour is the biggest harbour on the Swedish east coast and plays an important role in the provision of goods to the city and Mälardalen region and also for passenger ferries and cruising ships. The harbour is divided into several docks, the most important being Stadsgården, Frihamnen, Värtahamnen, Loudden and Masthamnen. Other docks of importance in the Stockholm area are the outports of Kapellskär (90 km north of Stockholm) and Nynäshamn (60 km south of Stockholm). In addition to Loudden, petroleum products are handled in the Södertälje harbour (40 km south of Stockholm) and the Berg oil terminal in Nacka.

The increased demand for oil caused by industrialisation resulted in the construction of the oil port at Loudden in 1926. Loudden is the biggest oil terminal in the region, with an area of 250 000 m^2. It is situated in east-central Stockholm, close to the Stockholm National City Park (Fig. 2.1). It comprises more than 100 storage tanks plus six underground storage cisterns with a capacity of 130 000 m^3 for holding petrol, diesel, heating oil and other substances such as lubricants and naphtha. Furthermore, underground tanks situated in the south-eastern area of the Loudden docks are available but currently not in use. Loudden is thus an important component of the regional supply of petroleum products to central parts of the Stockholm Region and for shipping traffic.

Fig. 2.1. The Loudden oil terminal in central Stockholm.

The organisational structure of the parent company Stockholm Harbours (Stockholms Hamnar) is presented in Figure 2.2. Stockholm Harbours is a subsidiary company and fully controlled by Stockholm city. The land is owned by the City of Stockholm.

The docks in central Stockholm, Kapellskär (north of Stockholm) and Nynäshamn (south of Stockholm) are important links in the regional supply chain, as well as for the sea traffic over the Baltic Sea.

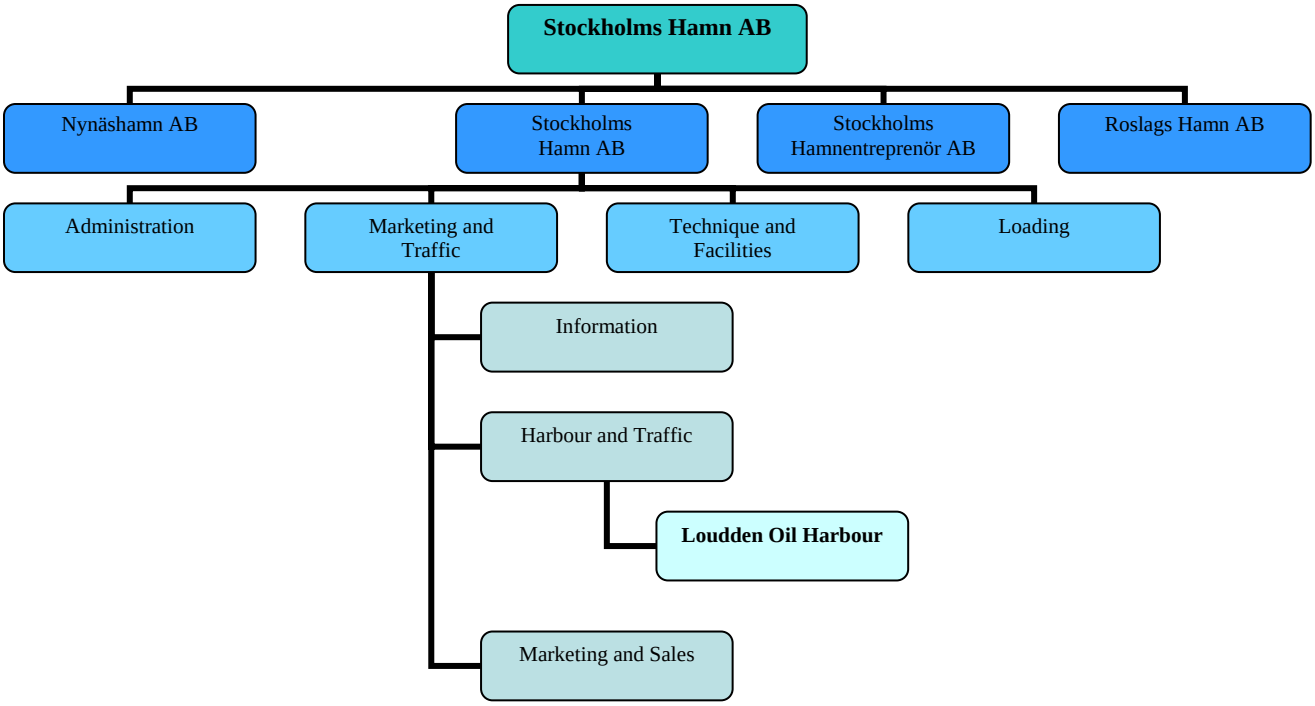

Fig. 2.2. Organisational diagram of Stockholms Hamn AB.

There are nine oil companies active at Loudden, two decontamination companies and one bunkering company situated in the area, including:

- Preem Petroleum AB
- Norsk Hydro Olje AB
- Univar AB
- Petrolia AB
- OK-Q8 AB
- Svenska Shell AB
- Reci Industri AB

Except for areas rented by the operating companies, Stockholms Hamn AB maintains common facilities such as piers, traffic routes and the gateway. Stockholms Hamn AB is responsible for safety and environmental reports on the harbour area.

Petroleum products such as diesel, gasoline and heating oil come in by ship from refineries in Finland, Norway, Sweden or Denmark through the archipelago, are unloaded and then stored in the Loudden cisterns and underground tanks. These 1.2 million tons of petroleum products and 170 000 tons of coal are mainly distributed by road traffic in the Stockholm Region. The Swedish Maritime Administration (Sjöfartsverket) has stipulated that the capacity and measures of oil tankers bound for Loudden should not exceed 20 000 tons, 11 m draught and 200 m visibility in daylight. Safety factors reduce these values for night-time or bad weather conditions. All ships handled at Loudden in 2002 were equipped with double hulls. This is not due to legal requirements, but to the introduction of financial bonuses for ships with higher safety and environmental standards. Sheet pile walls have been built along the coastline of the

harbour to prevent uncontrolled oil discharges from contaminating the land. Oil traps and sand filters have been installed to clean the rainwater run-off.

After several years of intensive debate between stakeholders such as politicians, oil companies, municipalities and NGOs, the city of Stockholm finally took a unilateral decision in 1999 not to prolong the contracts with the oil companies at Loudden after 2011. There was political consensus regarding this decision but no alternative site for the oil terminal has yet been identified. A solution for the region will affect not only the city of Stockholm, but also several other municipalities in the region. It is of course of central importance that a sustainable alternative solution to Loudden is presented and accepted by the stakeholders before Loudden is closed in 2011.

2.2 The case study around Loudden Docks

This case study was chosen because of its complexity regarding the decision-making process and stakeholder interest. The case study was mainly carried out in collaboration between the Royal Institute of Technology (KTH) in Stockholm and the City of Stockholm. Figure 2.3 shows Loudden Docks along the waterfront, almost embedded in National City Park which stretches through a large part of Stockholm. The area where Loudden Docks is situated is very close to the city centre and the Royal Institute of Technology (KTH). This location makes Loudden ideal for many purposes, such as a distribution node for petroleum products to the city but also potentially as residential area, recreation area etc.

Fig. 2.3. Location of Loudden Docks on the Stockholm waterfront.

The objectives of the case study were to:

- Study the decision-making process
- Determine the knowledge, information and data that should form the basis for a decision
- Reveal the interests and conflicts surrounding the process
- Investigate the role a university can play in the mediation process
- Identify conflict resolution methods that could be used in the process

It is important to understand that the decisions taken in the administrative and political processes of a city are not only the result of information and data. Even if the situation concerning information is effective and all stakeholders have access to the same knowledge and information, different stakeholders will have various opinions and will favour different decisions. The important thing is that the stakeholders have trust in each other. The degree to which one party trusts another is a measure of belief in the benevolence and competence of the other party. A failure in trust can be forgiven more easily if it is interpreted as a failure of competence rather than a lack of benevolence. Knowledge, information and data should form the basis for a decision but the decision can only be taken in a process where the stakeholders' values are revealed. We only know of one such effective

process, and that is the democratic process. The problem in practice with the democratic process is the real or experienced differences in power between the stakeholders and the different access to information.

Experiences from many cases, where conflicts or potential conflicts have been handled in different ways, show that it is always important to start early in a conflict resolution process. The money and time spent on handling problems before they turn into intractable conflicts provide a very high rate of return on investment. It is not always possible to reach consensus, but the important thing is that different opinions can be made visible and it is always much easier to establish a trustful communication process early. It is also advantageous if a third party can play an important role in the communication process. This third party should have an independent role in the process. From investigations of public confidence in different institutions, we know that universities are always perceived with a high degree of confidence, while politicians and industry are poorly rated. Universities should therefore strive to establish value-free platforms for discussions and develop scientifically-based evaluation tools.

One of the objectives in the present case study was thus to see how a university (KTH) could play the role of mediator in resolving conflicts such as that surrounding Loudden. This was achieved through the use of different methods, examples of which are:

- Creating an information base through a literature study
  Reports, books and newspapers were used to collect information needed in the case study.
- Workshops and hearings
  Workshops and one hearing were used to create platforms for discussion between different alternatives for Loudden and also around the decision-making process.
- Indicators were developed describing different aspects of sustainable development for different alternative locations of the docks.
- Risk assessment
  The aim here was to develop methods to assess risks so that the results could be communicated to all stakeholders in the process. The methods had to be based on knowledge from research in risk communication.
- Questionnaire
  A questionnaire survey was carried out in order to obtain information on how different stakeholders experienced the decision-making process and what changes they would have liked to make to it.

2.3 Administrative, political and legal framework

It is not possible to fully understand the decision-making process around Loudden Docks without understanding the administrative, political and legal framework in Sweden. The location of docks in Stockholm is part of an integrated coastal zone management (ICZM) process for the region. However, there is no overall national legislation or special agency or institution responsible for planning, implementation and evaluation of ICZM in Sweden. The main legal framework is the Swedish Environmental Code (SEC) and the Planning and Building Act (PBA), which apply to both terrestrial and marine areas. The inland and off-shore extent of the coastal zone is not explicitly defined in the SEC but the areas were comprehensively shown on maps connected with the PBA in which the regulations were proposed. According to the PBA, the more detailed definition of the various coastal zones is a task for municipal comprehensive (physical) planning. The extension off-shore is suggested to be 1-3 nautical miles from the baseline. A major part of the coastal zone has been identified as

an area of national interest. Many of the provisions in the SEC must be used when applying the PBA. The special management provisions in the SCE include regulations on siting new industrial installations, tourism and recreational functions and restrictions on summer cottage developments.

The central government ministries most relevant to coastal zone planning and management are the Ministry of the Environment and to some extent the Ministry of Agriculture, where issues concerning fisheries are handled. The National Boards and Agencies in Sweden also have great responsibilities regarding environmental issues and planning, since they produce guidelines and since some of them give permits to larger projects within their sector.

Most important are:

- The Swedish Environmental Protection Agency (SEPA)
- The National Board of Fisheries
- The National Board of Shipping and Administration
- The Swedish Board of Housing, Building and Planning
- The Planning Coast Guard

The municipalities in Sweden are responsible for physical planning at both the comprehensive and detailed level, although the County Administration Board can intervene if decisions by the municipalities threaten national interests. The Swedish government and some regional organisations support sustainable development in coastal regions. The Regional Environment and Management programmes are examples of the ambition to integrate ecological, economic and social aspects in regional development.

The immediate power of planning in Sweden lies at the local municipal level. There is a long and strong tradition in Sweden of local self-government, and the municipalities are strong compared to the situation in many other countries. However the government and its regional agency the County Administration Board have to monitor all planning and have the power to object in certain cases – mainly when national interests, health and security and inter-municipal interests are violated.

In contrast to the case in many other countries, the Government departments in Sweden are relatively small. The Ministry of Environment – responsible for the environment, planning and building – consists of 125 members of staff.

To support the government administration, there are a number of central authorities or boards, each responsible for a sector of the community. To support the Ministry of Environment there are six different major central authorities employing approximately 1 500 people. The Government can give the authorities instructions concerning their policies and activities, but according to the Swedish constitution the Government is not allowed to steer their decisions in individual cases. In this respect the authorities are independent of the Government. This is typical for the Swedish constitution, which dates back to the 17th century. The Swedish National Board of Housing, Building and Planning, with 165 employees, is one of these major central authorities.

On the regional level, Sweden is subdivided into 21 counties headed by county administrations linked to central authorities. The County Administration Board is a state agency operating under general directives issued by Parliament and the Government. The board is completely independent to take decisions within its own framework. In some cases the County Administration acts as a court. The head of the county is a Governor, appointed by

the Government for a period of six years. The Governor is chairman of a board of 14 people, to which the members are indirectly elected.

Parallel to the County Administrative Board, which is a government agency, there are on the regional level County Councils. These are elected by the people in general elections every four years. Their main purpose is to be responsible for healthcare. In Stockholm, the County Council is also responsible for regional planning and for public transport. The Regional Planning Office, which is an agency under the County Council with its own political board appointed by the Council, works with the regional planning issues. The company Storstockholms Lokaltrafik is owned by the County Council and operates the public transport network within the county.

The smallest political body is the municipality. Sweden has 288 municipalities, with populations varying in size from 3 000 to 750 000. The median size of a Swedish municipality is approx. 16 000 inhabitants and the median area approx. 700 km^2. Stockholm City is the biggest municipality of all, with 750 000 inhabitants.

The supreme decision-making body in a municipality is the Municipal Council, in the case of Stockholm the City Council. It is directly elected every four years and has in the case of Stockholm 101 seats. The Council appoints a number of delegations with about 15 local politicians, some of whom also have a seat on the Council. The most important delegation is the Executive Board. Another important and compulsory board is the City Planning Committee. In Stockholm other important boards are the Real Estate and Traffic Committee and the Environment and Health Committee. These committees have offices at their service, most interesting here are the City Planning Administration, the Traffic and Street Cleaning Administration, Stockholm City Development Administration and the Environmental Administration.

Stockholm City owns the Stockholms Hamnar AB, which operates the docks in Stockholm, Kapellskär (in the north-eastern part of the county) and Nynäshamn (in the southern part of the county). Loudden is located within the Stockholm Harbour area.

2.4 Description of the conflict and the decision-making process

The conflicts around the Stockholm docks are multidimensional and can be divided into three main areas:

- Protection of the environment and public health and safety
- Social aspects such as availability of residential apartments and job opportunities
- Economic aspects mainly for municipalities and companies

Examples of concrete conflicts within these areas are:

- The future need for docks
  This will be dependent on the development of the City of Stockholm, as well as the future demand for fuels.
- Economic interest from other stakeholders
  The companies that are active at Loudden have expressed their interest in staying at Loudden and even expanding some activities there. Other municipalities in the region have expressed their interest in taking over capacity from Loudden, mainly for reasons of economic development in their area.
- The future need for apartments and offices in central Stockholm

Part of the policy is to expand Stockholm inwards, and the area where the Loudden Docks is situated, would be then very attractive for the city of Stockholm to use for residential areas and offices.

- The protection of the Stockholm Eco Park, defended by several NGOs
- The risks connected to storage and transport of petroleum products
  Transports of concern were those through the city and those through the archipelago.

In 1999, Stockholm municipality decided that the Loudden oil terminal should be closed down in 2011. One motivation for the decision was to get rid of the transportation of petroleum products by trucks travelling through the city and the transportation of petroleum products in the archipelago. Before the City Council took the decision, there had been discussions around this issue for many years. Initially, the discussion focused on the supply of aviation fuel from Loudden to the Stockholm airports at Arlanda and Bromma. During the 1980s discussions were held about a pipeline as an alternative means of transportation of the fuel. In 1994 the City of Stockholm decided to guarantee the funding for such a pipeline. One of the conditions for such a guarantee was that the company responsible for the pipeline would have long-term contracts with the companies delivering aviation fuel to Arlanda. However the oil companies did not want to commit themselves to such a long-term agreement and this ended the discussions around the pipeline. This is a basic problem connected to right of disposition, where the city is often responsible for planning infrastructure but it does not have any control over the companies delivering products, e.g. petroleum products and energy.

The decision to close the Loudden Docks gradually developed up to 1998, when an accident occurred close to Loudden. The safety aspects can often radically change public opinion when an accident occurs. This happened when a truck containing 14 tonnes of propane was involved in an accident close to Loudden, in the central part of Stockholm in 1999. This accident did not lead to any severe consequences, but it could easily have caused a catastrophe. It had a great impact on the discussions about the risks associated with transport and led to a ban on the transport of propane from the harbour. One of the parties in the City Council, the Stockholm Party, used the accident for one of the matters close to its heart, namely to get rid of heavy transport from Loudden through the city and through the archipelago. The Stockholm Party formed an alliance with the non-Socialist parties to run the city, and the Stockholm City Council took the decision to close the Loudden Docks. When it came to signing new contracts with the oil companies, there was a new strategy. The previous contracts ran for 20 years in order to give the petroleum companies possibilities for long-term investment, but from now on the contracts were only for one year. In 2002 there was a new election when the power went over to the socialist parties and the environmental party. The new City Council opted to sign contracts with the oil companies up to 2008, with the possibility for prolongation to 2011.

The decision to close the Loudden Docks after 2011 has not been changed and there is now a process running for finding a new solution for the regional supply of petroleum products. During autumn 2006, the handling of aviation fuel was moved to the harbour in Gävle, a town 175 km north of Stockholm. Fuel is taken to the docks in Gävle and carried by railway to depots at Brista power station from where it is pumped through a pipeline to a depot at Arlanda airport.

Another important motive for closing the Loudden Docks was Stockholm City's comprehensive strategy to transform industrial land to build new housing. The Stockholm City Planning Committee is planning to build a new residential area on the property where

Loudden is located. In its comments on the decision of the City to close the Loudden Docks, the County Administrative Board has written:

'*The docks are of strategic importance for the region as the only full service docks and are in this role of national interest. How the docks' activities will develop in the long run is unclear. There is however much that indicates that the area will continue to be docks with surrounding activities in the foreseeable future. The area has an attractive situation in the city and can, when the docking activities decrease, be converted to a city development area. The possible phase-out of the docks must however be seen as a long term development*'.

Today the County Administrative Board of Stockholm is searching for an alternative solution for the petroleum docks in the Stockholm region. However, there are many questions that need to be addressed and many interests to be handled before a solution can possibly be accepted by all the stakeholders.

Some of these are:

- The strategic supply of petroleum products for the region
  How will the demand for the products develop in the next 10-20 years? Stockholm City has established the goal to be fossil fuel free by 2050. Do we need docks for petroleum products in the long run?
  How will a gradual switch to biofuels affect the situation?
- Interregional competition between the municipalities for employment opportunities, infrastructure development and economic growth. Docks would mean employment opportunities and economic growth for a municipality, but would also require adjustments of the infrastructure to support transport to and from the docks. What development is necessary and who will pay?
- Which aspects in sustainable development of the regions are most important, environmental impacts, risks, social aspects or culture aspects?
- Who will bear the costs for phasing out the docks, decontamination etc?
- Who is responsible for finding an acceptable solution for the oil companies? Their interest is that a change will not raise their costs.
- What should the land at Loudden be used for if the docks are closed? What consequences will a new residential area have for other activities in the area such as ferries etc? The area is also close to the National City Park.
- Who should take the final decision and what impact should the different stakeholders have on the final decision?

Many stakeholders are affected by the decisions but the actual decisions are always linked to the actual power to decide. In the planning process it is important to have an early exchange of thoughts around different solutions among the stakeholders. This can be classified as upstream conflict resolution. Before the decision was taken to close the Loudden Docks by Stockholm City Council, there had been a long period of discussion among the stakeholders. However these discussions had been diffuse and unstructured in many ways and the decision was finally taken with the Stockholm municipal interests in focus. The main problem connected with the decision was that no alternative for location of the docks had been decided. The decision was taken by Stockholm City Council as one of the stakeholders, but the one holding the decision-making power. However, the alternative locations will affect the other stakeholders, such as the petroleum companies and the other municipalities in the region. Thus the decision was not taken as a balanced decision among the different conflict

aspects and regional interests. The main problem with this kind of decision is that it tends to create intractable downstream conflicts, as in the case of Loudden.

For this reason it is important to look for conflict resolution methods that can be used to reveal information and values among the stakeholders as early as possible in the planning process. It is of course also important to identify at an early stage the stakeholders who will be affected by later decisions and plans.

2.5 Stakeholders involved in Loudden Docks relocation process

In Table 2.1, the stakeholders identified in the conflict are categorised into interest groups, individuals, organisations and authorities.

Table 2.1 Name and nature of stakeholders involved in the Loudden Docks relocation issue

Name of the stakeholder group	Interest groups	Com-panies	Organi-sations	Indivi-duals	Autho-rities
Stockholms Hamnar AB		X			
Oil companies	X	X			
Neighbours to industrial area				X	
Tourists			X	X	
Citizens	X			X	
Consumers	X		X		X
Swedish Government					X
Political Parties			X		

Stockholms Hamnar AB can be considered one of the most active groups in this conflict. This might be due to the fact that on the one hand the chairman of this company is actively driving the question of shutting down the oil terminal at Loudden and on the other hand the civil servants, managers and workers in the company do not want to move the facility. Many internal investigations about possible alternatives, risks and environmental impacts have been conducted and are presented in this paper. Stockholms Hamnar AB is part of the stakeholder group.

Oil companies (generic term for all companies operating at Loudden) are acting in a more defensive way. A few investigations have been carried out by e.g. OK/Q8 regarding the risk assessment of transportation of petroleum products. Due to increased occurrence of oil spill accidents in the Baltic Sea, the public awareness about the problem is omnipresent and the companies have to work on their environmental image.

On the other side there are the attempts of Preem Petroleum AB to increase the volume of petroleum products allowed to be handled at the Loudden oil terminal (from today's 229 000 up to 818 000 tonnes per year). This case is currently being discussed at the Environmental Court in Stockholm. Because of these arguments, the oil companies form one group of stakeholders in the target group.

Of course **neighbours** to industrial areas in general would preferably not live close to such a site, especially in the centre of the city. The Stockholm City Council is aware of this problem and is therefore declaring parts of the city to be environmentally protected areas, e.g. the National City Park in the direct neighbourhood of the Loudden oil terminal.

Neighbours are complaining about noise, smell and air pollution by traffic and would like the oil terminal to be moved to another place. People living along the access roads are also disturbed by trucks passing by and polluting the environment with noise and exhaust fumes and the residents are afraid of being seriously injured in the event of an accident occurring (explosion, fire etc.).

In addition, the level of sensitivity has been increasing in recent decades: people know about the health effects of 'dirty industries' and want to avoid harmful substances. On the other hand practically everybody is dependent on petroleum products: for example driving cars or using public transportation, using heating systems and electricity, as well as travelling by boat or plane.

Coming to the question of whether or not neighbours should be a part of the target group, the decision is based upon the assumption that political parties and organisations, such as the Organisation for Environment and Social Development, are generally represent the points of view of social groups such as neighbours and citizens, especially since no civil action groups have been established.

Tourists coming to the City of Stockholm by ship from other countries around the Baltic Sea land in the direct neighbourhood of the Loudden oil terminal. Other tourists will probably not come into contact with this area since no sightseeing attractions other than the National City Park and the Kaknäs Tornet, giving the view from above, are in the close surroundings of Loudden.

It is not very likely that the impression of Stockholm and Sweden would dramatically change from a tourist's point of view, if Loudden were to be moved in the future, but the City would definitely be able to create a new tourist magnet by building a new quarter with shops and museums.

The interests of **citizens** and neighbours in a democratic state are presumed to be represented by political parties or organisations, as long as no action groups are formed.

Within the group **consumers,** members of other groups are partly included, such as citizens using cars or public transport, neighbours using oil for their heating systems and also other industrial companies that are using these petroleum products in further production steps. These consumers are interested in this discussion because it might have an influence on the market prices for petroleum products in the event of the oil terminal being moved to a more distant location.

The **Swedish Government** is the stakeholder that aims to look at the national economic, environmental and social aspects of this conflict. This perspective allows and requires a thorough evaluation of the conflict. Even if there are lifelike different points of view towards this problem in different political parties, the government as an institution has certain regulations and guidelines. Because of this, the government is part of the target group as a representative of citizens and neighbours.

2.6 What type of information is needed in such a complex decision?

As has been described, the decision-making process around Loudden is very complex, involving many stakeholders and conflicting interests. To facilitate an effective decision-making process, there is a need for a comprehensive background material based on a holistic view and if possible a common vision or visions. The vision should be an integrated part of a

vision for sustainable development of the Stockholm region. This is also a central goal for the planning process in the City of Stockholm, to focus on sustainable development. Vision Stockholm 2030 states:

'*The City of Stockholm is working on a holistic and long-term vision in the project 'Vision Stockholm 2030'. The vision shall serve as inspiration and uniting force in the long-term development carried out in the City of Stockholm and other actors in the region. The work is founded on a broad cooperation and agreement around strategic questions for the Stockholm region.*'

In developing this vision the city strives to engage all stakeholders in the city in an active process of discussion. Sustainable development can be formulated in a general way, such as that in the Brundtland report from 1987:

'*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*.'

When it comes to practice, this general statement has to be broken down into more concrete objectives and goals. A vision has to develop some targets and goals and also indicators that will show how progress is achieved. Indicators can be formulated top-down as in the case of the Swedish Environmental Goals, which are broken down into different sector goals e.g. for energy and building sectors. However, sustainable development is a complex issue involving choices and values about what is more important or less important. These choices can only be made in a democratic process involving broad public participation. In this sense it is also important to formulate visions to develop indicators in a bottom-up process.

In creating the vision of a sustainable Stockholm region, there are several key components central for the development of the region in relation to the case study. Examples of these are:

- National transport political goals
  The Swedish government decided in 1998 around a general goal for transport policies in Sweden. The overall goal was formulated as 'To ensure a national economically effective and sustainable transport support for citizens and business in the whole country'.
- Scenario(s) for the development of the energy needs in Stockholm County
  In a recently published report, a prognosis for the future consumption of petroleum products in the Stockholm region was described. Stockholm County has the fastest increase in population in Sweden. The prognosis shows that the consumption of petrol and diesel in the Stockholm area will increase for the next 20 years. The consumption of diesel is expected to increase the most.
- Scenario(s) for how these needs are going to be met
  A change from fossil fuels to alternative fuels does not mean that docks will be redundant, since for example most of the ethanol used in Sweden is imported from Brazil. However the alternative fuels have a lower energy value and greater storage volumes are needed. A change to alternative fuels would thus require larger storage space and larger transportation capacity.
- Transport and depots – the planning of infrastructure for the coming 20-30 years
  Stockholm is a large region, with 40% of the petroleum products being consumed in the central part and the remainder divided between the north and south of the region. Several investigations propose that docks located north and south of the Stockholm region should replace Loudden, to avoid heavy oil transportation through Stockholm city centre. Several of the suggested harbour locations are situated far from Stockholm

and calculations show that transport distances will increase by 25% if Loudden is closed.

- Regional and municipal general plans
  In the Stockholm region there is a regional development plan called RUFS which describes the region's strengths and weaknesses. The plan is a strategic instrument to integrate continuing growth with long-term sustainable development. All communities in Sweden must have a comprehensive plan that describes how land and water resources should be used in the community.

In addition to these key components, the background material should include:

- **Environmental consequences**
  - Emissions to air

  At the docks, the petroleum products give rise to volatile hydrocarbon emissions when the petroleum products are pumped to the cisterns from the ships. When oil is transported by ships and trucks, the transport facilities generate emissions to air and the oil give rise to emissions during unloading. The emissions from the ships contain sulphur oxide, nitrogen oxides, carbon dioxide and particles. The consequences can be acidification, eutrophication, tropospheric ozone, greenhouse effects and depletion of the ozone layer.
  - Emissions to water

  Oil spillages can occur at different places in a dock area, for example at access ramps for trucks and railways, quays, pumps and tank locks. Contaminated water can also be released from the underground storage cisterns. The consequences of oil spills can be poisoned drinking water, contaminated nature and eutrophication.
  - Waste

  Waste in an oil terminal mainly consists of sludge from the oil sludge separation, cleaning residues from tanks, oil polluted matter from the ground, waste from the oil tanker engine house, flushing water and ballast water.
  - Protected areas

  It is important that sensitive areas and objects close to docks, depots, channels, roads and railways are mapped to determine how sensitive these areas are during standard operation and transportation and what the consequences would be if an accident occurred.
  - Erosion

  Erosion at coastlines, beaches and sea beds can be natural or generated by traffic. Erosion generated by ships depends on the speed, size and shape of the ship, the gradient of the beaches, the width and depth of the channel and the quality of the sea bed.
  - Noise

  Activities in harbours and depots can create noise that disturbs residential and recreation areas in the local environment. Noise from sea traffic is mainly generated when the ships are passing through the channel, lying in the quay and when the oil is being loaded and unloaded at the docks.
  - Vibrations

  Intensive transport by heavy traffic, e.g. trucks and railway, creates vibrations in the land and poses a high risk to buildings and nature.

- **Risk aspects**
  The risks in docks are mostly associated with handling of the oil products. The products are classified as highly inflammable or less inflammable. The products can catch fire if leaks and evaporation occur.
  Some docks and depots are located in industrial areas where other businesses can intensify the consequences if an accident happens in the oil terminal. The concerns connected to risks were that one could question the rational in having large storage facilities as well as transports of flammable products in the central part of Stockholm.

- **Transport**
  - Road transport

  Most accidents involving transportation of dangerous goods in Sweden affect nature and water resources, and the consequences are serious but fatalities are unusual. To make transportation safer, it is important to map dangerous road sections; bridges, tunnels, sections with very intense traffic and sections recommended for dangerous goods transportation.
  - Railway transport

  Railway accidents occur in different ways, for example level crossing accidents, sabotage and derailment. The standard of railways for dangerous goods transportation is important, for example number of level crossings and tunnels, how accidents affect roads and other railway lines nearby and whether different products should be transported in the same train.
  - Sea transport

  Discharge from oil tankers during normal operation consists of contaminated ballast water, cleaning water from the tanks, oil residues and water from the engine room and the keel. Grounding and collisions can lead to accidents with larger disasters. In the Baltic Sea, grounding is the most common accident and collision the next most common. Oil deliveries are limited by the quality of the harbour channels, quay berth access and road and railway capacity. The Swedish Maritime Administration is responsible for drawing up regulations regarding the types of ships permitted to traffic Swedish channels, depending on the width, depth and visibility in the channels.
  - Transport costs

  The price varies between different means of transportation for petroleum products. For example the price is 0.05 SEK/ton km for transportation with oil tanker and 0.10 SEK/ton km for transportation by rail in both directions.

- **The present standard and capacities of the harbours in the region**
  When Loudden is closed the Loudden national interest must be abolished and the environmental permits at the alternative docks must be consulted. The Swedish Maritime Administration decides which harbours and channels should be classified as national interest. The environmental permits regulate how much oil products each harbour is allowed to manage.

- **Costs of reconstruction and decontamination of Loudden when the docks close**
  Land and large investments are required to construct a new depot. In investigations concerning Loudden, calculations show that a new depot (500 000 m^3/year) would cost approx 300 mil. SEK and an inland depot (500 000 m^3/year) would cost approx the same.

Activities in the Loudden Docks have been going on for 80 years and the ground in the area is contaminated. Decontamination of the area can only begin when all activities that can cause contamination have ceased. The business companies in the Loudden Docks area are responsible for the decontamination. One of the specific problems with remediation of the area is that there are several bedrock storage systems. Remediation of these could require a long time (Larsson & Wennersten 2007).

As can be seen from this short summary, there is a need for an extensive background material in order to describe the complex issue around the Loudden case. Such a background material has to be in such a form that it can be communicated to the stakeholders in the decision-making process.

The decision-making process for this kind of regional problem is unclear. There is no regional forum for such processes and the decision taken by the City of Stockholm is a unilateral standpoint although many regional stakeholders are affected.

2.7 What methods can be used to facilitate the decision-making process and create platforms for discussions?

One of the central objectives in this project was to investigate how different methods can be used to create platforms for mediation between the stakeholders in the conflict. The outcome of the process is highly dependent on the willingness and commitment of the stakeholders to find a reasonable and practical solution. The parties have been involved in the processes and conservative in their opinions for a long time, and it could be necessary to involve a mediator in order to create a basis for a fruitful working environment. It is necessary that the stakeholders agree on such conflict assessment beforehand.

In this case study, different methods for conflict resolution were applied. The most important methods used were:

- Hearings, seminars and workshops
- Questionnaire survey
- Risk assessment
- Indicators for sustainable development

2.7.1 Hearings, seminars and workshops

Hearings are often used as part of a juridical process but can also be used as part of conflict resolution strategy where different stakeholders have the possibility to ask a committee questions. In this case, a hearing was held with the politicians in the municipal district committees and an energy company planning for a large storage facility of natural gas close to the Loudden area. The hearing was directed by KTH, which took the role of a neutral third party, and the focus in the hearing was safety issues. In order to get permission to construct the storage facility, the company had to include a written safety report in the permission application which was in a standard form. However these safety reports are very difficult to understand and evaluate for laymen and had been criticised by a local NGO. The hearing was held with around 15 participants without the obligation for any party to undertake any commitments. The aim was to create a more neutral platform for unbiased discussions in the presence of neutral experts from the university. The results of the hearing were very positive and a step forward in the communication process and in understanding the stakeholders'

arguments. An interesting result was that the role of the university as a third party was very appreciated by the participants in the hearing.

In order to collect information for the case study, two workshops were held. During these workshops different stakeholders had the possibility to give their opinions on the questions around a new harbour structure and also to comment on other stakeholders' opinions. The workshops were held by KTH, acting as the convener and also as the moderator creating a neutral ground for the discussions. In order to further develop the contacts with the stakeholders in the case study, a student has been working on her Master's thesis in parallel, on the theme 'Sustainable harbour infrastructures for the Stockholm region'. This work has created more regular contacts with the stakeholders during the case study.

2.7.2 Questionnaires

Questionnaires are a type of statistical survey handed out to a specific group of persons to gather information. Questionnaires have advantages over some types of surveys in that they are cheap, do not require as much effort from the questioner as verbal or telephone surveys and often have standardised answers that make it simple to compile the data.

In order to better understand how the different stakeholders viewed the decision-making process, in this case study a web-based questionnaire was sent out in 2006. The questionnaire was aimed at administrative (executive) officials within different stakeholder groups such as the County Administration, County Council, different municipalities, docks, oil companies and NGOs. The questionnaire was answered by around 70 officials (of approx. 200) mainly from county administration boards and municipalities. The results created an important discussion among the stakeholders around the need for a regional body handling these kinds of planning processes. One interesting result was that information from newspapers seemed to be one of the most important information sources for the officials. Another interesting result from the questionnaire was how the officials prioritised different aspects when planning a new structure for the docks area. The results showed that the officials gave transport opportunities to and from the docks together with environmental concerns as the highest priority, while employment was ranked lowest.

The results from the questionnaire also showed that it is mainly stakeholders from Stockholm that are taking part in the docks planning process and that these stakeholders think that the process affects a bigger region and that more stakeholders outside Stockholm should be active in the process.

Today there is no regional political organ that works together for finding a new solution for the docks. Of those stakeholders that responded to the questionnaire, 33% believed that a regional organ should take the final decision about how the oil deliveries for Stockholm region should be organised in the future when Loudden is closed.

The stakeholders want to replace Loudden with several docks located south and north of Stockholm to avoid long-distance oil deliveries by trucks through the city. In the planning process for the new docks structure, the most important factors to consider are the transport possibilities by sea, road and railway, environmental impacts, risks and regional development.

In the future, the stakeholders believe that the function of the oil terminal will change and other fuels will be delivered to the docks, for example biofuels. On the other hand, however, the majority of the stakeholders believe that the Stockholm region oil supply will always be an important question.

In 2006 a seminar was arranged by KTH and the results from the questionnaire were presented. Some topics in the questionnaire were discussed in more detail during the seminar, for example who should make the decisions about the future docks solution for oil supply in the region? Will we be using fossil fuel in Stockholm in 2050? At the seminar the stakeholders agreed that a special regional organ is needed in the docks planning process to deal with issues concerning land use, infrastructure and energy consumption.

2.7.3 Risk assessment

One of the main issues in our case was the possibility of a major accident e.g. during transport by trucks on the roads in the central part of Stockholm or oil spills in the archipelago. For many of the activities, there are existing risk assessments developed by the companies, but the general experience is that the results are difficult to communicate. Some stakeholders are very suspicious that the results are manipulated in order to favour the planned activities. In the case study, more robust methods for estimating risks and the general conclusions were discussed. In short the conclusions, described in other chapters in this report were:

- Describe real Worst Case Scenarios, not more probable but less catastrophic scenarios, and try to evaluate your ability to handle these Worst Case Scenarios.
- Do not underestimate the consequences in content and discussions. If one party focuses on probabilities, other interest groups will focus on consequences.

2.7.4 Indicators

The DPSIR (Driving force; Pressure; State; Impact; Response) framework is not a set of indicators but rather an approach often referred to in the context of sustainable development indicators. The concept underlying the DPSIR framework is cyclical: human activity exerts Pressures on the environment resulting in changes in its State; such changes will have an Impact on human and ecosystem health, which in turn may elicit a Response for corrective action and changing habits. In this case study, the DPSIR model was used to develop indicators for use in the discussions around the sustainability of different alternatives for dock relocation. From the set of indicators developed, a subset can be chosen in an evaluation process where the most relevant indicators for the docks structure are chosen. In earlier investigations for sustainable docks structure, the focus was more on the national economy and less on environmental consequences.

In the planning for a new docks structure, a number of issues have to be addressed, for example emissions, demand for oil products, political decisions etc. With the DPSIR model, both qualitative and quantitative indicators can be developed and the connections between them can also be visualised in order to decide which actions have to be taken in order to establish a more sustainable docks infrastructure. The development of indicators is described more in detail in Chapter 7.

2.8 Critical Summary

From the discussions above it can clearly be seen that the decision-making process around the Loudden Docks is complex, involving many stakeholders and conflicts of interest. The final decision will demand a comprehensive and extensive basis starting from a long-term vision, long-term planning horizon and in-depth consequence analysis. The answers from the stakeholders to the questionnaire clearly show that there is a need for a regional body that can take such strategic decisions, instead of decisions from single municipalities that affect the other actors and interest groups. The university can play an important role as mediator in

creating a neutral forum where the stakeholders can reveal and discuss conflicting interests. In such a process the university can use different methods to collect information and also to turn this information into a form that is understandable to the stakeholders. It is important to know that in the end, such decisions are political and should be taken in a democratic process. However a necessary requirement for a democratic process is that the stakeholders have access to a broad description of different alternatives and the consequences of whatever the alternative/s chosen.

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3. Analysing major accidents and accident scenarios – An international overview

3.1 Background

Legislation processes in Europe and North America have introduced a number of concepts to describe potential serious accidents in industrial activities. This chapter examines these concepts, e.g. a *major accident*, a *worst case*, a *major accident scenario*, a *worst case scenario* or an *alternative scenario*, and approaches to assess them. These concepts are an important part of the process of finding and describing a potential accident or accidents in order to mitigate negative consequences of industrial activities for humans and for the environment.

Requirements for finding and describing potential accidents as well as methods for their prevention/mitigation vary between countries due to varying national approaches and traditions. In principle, two approaches can be distinguished: a *risk-based approach* and a *consequence-based approach* (Christou & Porter 1999). In the literature, risk-based methods are sometimes called probabilistic and consequence-based methods deterministic.

The requirement to describe possible accidents is now included in the legislation of a number of countries and these requirements can be more or less precise. For potential major accidents operators of industrial sites have to produce reports that have to be approved by national authorities. A major accident can mean the 'greatest' conceivable accident – the real worst case, which has a low probability but very severe consequences (e.g. when the entire contents of a vessel blow up). A major accident can also mean a more 'realistic' accident, a more probable event with slightly less severe consequences than the worst case. This can vary between different countries.

The consequence-based approach focuses on assessment of the consequences of a number of possible scenarios. From the risk point of view, the scenarios are assessed using endpoints describing the consequences area resulting from the accessed scenarios, beyond which the harm to humans and the environment is acceptable. The risk-based approach focuses on assessment of both the consequences and probabilities of occurrence of the possible accident scenarios. The results can be expressed quantitatively in terms of individual risk[1] and societal risk[2] and are assessed from the risk point of view using various criteria. The results show an area within which there is a given probability of injury according to specific scenarios.

In the EU, the Seveso II Directive sets requirements on industrial operators handling dangerous substances to demonstrate that they have taken all necessary measures to prevent major accidents and limit their consequences for humans and the environment. In the USA, the Risk Management Program (RMP) issued by the Environmental Protection Agency (US EPA) provides these regulations.

The Seveso II Directive states that major accident scenarios can be described both quantitatively and qualitatively; they can be described by their probabilities *or* by the

[1] The risk to a person in the vicinity of a hazard. This includes the nature of the injury to the individual, the likelihood of the injury occurring, and the time period over which the injury might occur.
[2] A measure of risk to a group of people. It is most often expressed in terms of the frequency distribution of multiple causality events.

conditions under which they occur (Seveso II Directive, Annex II, IV, A). The Directive is flexible due to existing variation between national approaches and leaves it up to each member state to choose the presentation of major accident scenarios (Council Directive 96/82/EC – Agreed questions and answers 2007). The choice of either a qualitative or quantitative approach is influenced by the safety culture philosophy within each Member State (Fabbri et al 2005).

The U.S. Risk Management Program (RMP) requires interpretation of a major accident and major accident scenario as an accident/scenario which has the greatest consequences, even if its probability is very low. Clear guidance is provided on how to perform risk assessment (RMP, 1999). In the EU, the Directive states that a major accident means an occurrence of a 'major' event leading to serious danger to human health and/or the environment, but there is no definition of a major event comparable with the RMP description.

The investigation into the major accident at the Buncefield Storage Depot, close to London, in 2005, showed that the 'realistic' worst case scenario was used in the risk assessment but the event which later caused the incident was dismissed as having a very low probability (Buncefield Investigation 2006). The accident in Buncefield was caused by an alarm system failure during filling of a tank. Several levels of control did not show that the tank was full and petrol was leaking over the roof of a tank. After mixing with the air, a dense flammable cloud was formed and exploded. This operation is widely counted as one of the weakest parts in the chain, as was also stated in the Seveso reports from two oil companies.

The Buncefield disaster highlights some important questions about how risk assessments are carried out nowadays. For example, Emergency Planning and Spatial Planning are now discussed frequently in connection with similar establishments (Christou et al 2006). The likelihood of an accident such as that in Buncefield is very low according to quantitative risk assessment but the fact is that it happened, with devastating effects on the surrounding area. The importance of the Worst Case Scenario (WCS) approach is also stressed in other documents, e.g. OECD (Organization for Economic Co-operation and Development) Guiding Principles for Chemical Accident Prevention, Preparedness and Response (OECD 2003). This document recommends for emergency planning to identify possible impacts on the assumption of the worst case and the most probable accident scenarios.

3.2 The European Seveso Directives

The two major accidents in Europe in industrial plants at Flixborough in the UK in 1974 and Seveso in Italy in 1976 prompted the adaptation in 1982 of the legislation aimed at the prevention and control of such accidents - the EU 82/501/EEG Seveso Directive (Council Directive, 1982) (Wettig et al 1999). The future amendments as well as the new Seveso II Directive were driven mainly by further accidents; in 1984 at Bhopal, India (industrial plant) and in 1986 in Basel, Switzerland (Wettig et al 1999).

In 1996 the 82/501/EEG Seveso Directive was replaced by a new directive – 96/82/EG, the Seveso II (Council Directive 1996) and in December 2003 the Directive was amended with Directive 2003/105/EC (Council Directive 2003) which lists additional dangerous substances. Again the changes to the Directive were prompted by accidents; a cyanide spill into the Danube at Bai Mare in Romania in 2000, the fireworks storage accident in Enschede in the Netherlands in 2000 and the explosion at the fertiliser plant in Toulouse, France, in 2001 (Council Directive 2003). It is thus interesting to see that major accidents occur although their calculated probabilities are low and that there is an increasing tendency to take worst case

accidents into account. The experiences from the Enschede accident affected the discussion in the Netherlands, which is described in more detail below.

The Seveso II Directive is an example of European regulatory action affecting more than one country. The Directive is based on Article 130s of the Treaty (establishing the European Community) (Treaty, 1992). According to the Article, the Directive is a framework directive and the Member States can adopt stricter measures when enforcing the Directive in national legislation (Wetting et al 1999; Versluis 2003). The Directive does not cover military establishments, hazards created by ionising radiation, transport of dangerous substances e.g. on road, rail, loading and unloading, transport in pipelines, mining activities and waste landfill sites (Article 4), which are dealt with by separate legislation.

The Seveso II Directive is aimed at the 'prevention of major accidents that involve dangerous substances and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner' (Article 1). The Directive defines major accident hazard sites as those that store or could generate quantities of dangerous substances in excess of specified thresholds and such dangerous substances are listed. Threshold quantities are specified for substances that are toxic/flammable/explosive or dangerous for the environment, categories of substances and groups of categories. Sites are specified as low or top tier depending on whether the lower or upper thresholds are exceeded. The main difference between low and top tier sites is the requirement for top tier sites to notify the public within an agreed area and prepare a Safety Report (SR) and liaise with emergency services in preparation of an External Emergency Plan.

The following central parts of the Directive can be distinguished: the Domino Effect (Article 8), Safety Reports (Article 9), Emergency Plans (Article 11), Land-use Planning (Article 12) and Information on Safety Measures (Article 13). A central part of the Directive is a requirement for public information about major industrial hazards and appropriate safety measures in the event of an accident. It is based on recognition that industrial workers and the general public need to know about hazards that threaten them and about safety procedures. This is the first time that the principle of 'need to know' has been enshrined in European Community legislation (Mitchell et al 1996).

Industries that are covered by the Seveso II Directive have to produce a Safety Report, which must include description of major accident scenarios. The reason for the risk presentation in the Safety Report is to reveal the risks using reliable methods and to gather information for rational decision-making including physical planning and risk management. It is up to each Member State to choose whether the major accident scenarios should be described by their probabilities (risk-based approach) or the conditions under which they occur (consequence-based approach). The same flexibility is provided for interpretation of the major accident concept. If the Directive is to be effectively implemented, there is need for equal participation of three actors; operators (responsible for preparation of Safety Reports and Emergency Plans), authorities (responsible for control of implementation and enforcement) and the public, which should be consulted.

In order to meet the Seveso Directive requirements, the Major Accident Reporting System (MARS) databank has been established to store and retrieve accident information reported by the Member States. It is located at the Commission's Joint Research Centre, Institute of Systems Engineering and Informatics in Ispra, Italy. To promote safety-related knowledge further, a Community Documentation Centre on Industrial Risk (CDCIR) has also been

established at the same site. This Centre collects, classifies and reviews materials relevant to industrial risks and safety.

3.3 The Seveso Directive in EU Member States

3.3.1 Sweden

In Sweden, the Seveso II Directive was incorporated into national legislation in 1999 through a number of laws, decrees and regulations (see Swedish Rescue Services Agency (SRSA) website). The supplementary Directive 2003/105/EG was introduced in 2005. Supervising authorities for the Seveso legislation are County Administrative Boards (Länsstyrelserna), Municipalities (Kommuner) and the Working Environmental Agency (Arbetsmiljöverket).

According to the legislation (SRVFS 2005:2, 7§), a safety report shall include 'a risk assessment with detailed description of possible accident scenarios, description of circumstances under which those accidents can occur and estimation of possibilities and consequences'. A major accident is defined as in the Seveso Directive (SFS 1999:381; AFS 2005:19) and there is the possibility for both a qualitative and quantitative analysis (SFS 1999:381, 7§). No formal guidelines for risk assessments are provided. Both risk-based and consequence-based methods can be used. Guidance documents on risk assessment have also been issued by the Stockholm Fire Department, Stockholm County Administrative Board and by Gothenburg County Administrative Board. Branch organisations such as the Swedish Petroleum Institute have issued templates to guide risk assessment work (SPI 2000).

3.3.2 United Kingdom

The Seveso II Directive was implemented in the UK through the Control of Major Accident Hazards (COMAH) Regulations in 1999. The COMAH Regulations are enforced by a joint Competent Authority comprising the Health and Safety Executive (HSE) and Environmental Agency (EA) in England and Wales, and the Scottish Environmental Protection Agency. Under the COMAH Regulations, there is a requirement for the safety reports for major process and storage sites to include an analysis of major accidents. Guidelines from the HSE on preparing safety reports – The Safety Report Assessment Manual (SRAM) – describe what is meant by a major accident.

Risk assessments carried out by operators should be proportionate to the risk of the establishment. This proportionality is interpreted by the HSE as a function of the scale of the operations, the dangerous substances handled by the site and the nature of the surrounding area (including the population density). Guideline documents for risk assessment have been issued by the HSE and EA. These publications are not very detailed and do not specify whether a risk-based or quantitative approach should be followed or how scenarios should be selected and modelled.

The SRAM recommends adopting 'proportionality' – that is, a balance between the level of risk and the detail of the analysis:

'*A key principle of the Safety Report assessment process is that it is proportionate to the level of hazard and risk associated with the establishment to which the Safety Report relates. The proportionality of assessment of a Safety Report should broadly match the proportionality required of the operator's risk assessment for the establishment. This is essentially determined by the severity of the worst possible consequences should the worst case scenario occur, and the level of risk that remains after taking into accounts the prevention and mitigation measures that the operator has put in place*'(SRAM, p.118) .

Under the criterion 'The safety report should demonstrate that a systematic process has been used to identify all foreseeable major accidents' (SRAM, 10.3.1), the SRAM recommends that:

'*A systematic hazard identification process has been used to identify all major accident scenarios, including worst case and lesser events. A comprehensive process should have considered loss of containment derived from all reasonably foreseeable on-site operations and also external events that may impact upon site operations*'.

The SRAM defines the worst case scenario as a scenario '*usually associated with the loss of containment of the maximum inventory of the hazardous substance and the subsequent scenario that produces the worst outcome for people or the environment*'.

3.3.3 Ireland

The same procedures as in the UK are used in the Republic of Ireland (ARUP 2005).

3.3.4 Belgium

In Belgium, the federal and regional authorities have jointly published extensive guidelines about the content and structure of a federal safety report. This guideline suggests that the qualitative approach is the best way to implement the risk assessment. This model combines a detailed root cause analysis with consequence analyses. Additional guidance on risk assessment is given by the federal authority. The contents of these notes are not compulsory in nature.

The Belgian regions require a more quantified approach for risk assessments within the framework of operating permit applications (regional safety reports and safety studies). In Flanders, a full quantitative risk assessment (QRA) is requested, including the calculation of 'individual risk contours' and 'societal risk curves'. Specific guidelines for the elaboration of this QRA have been issued by the Cell Safety Reporting of the Flemish Environmental Administration. These guidelines are compulsory in nature. The damage and probability calculations can also take into account other literature references, such as the Dutch CPR documents. In particular the 'Purple Book' (CPR 18E), the 'Yellow Book' (CPR 14), the 'Green Book' (CPR 16) and the 'Red Book' (CPR 12) are generally accepted as references. In the Walloon region, the quantitative approach requires the calculation of damage zones and probabilities of occurrence. However, no individual risk and societal risk parameters are calculated. The methodology for risk assessments has been defined by a guideline 'Vademecum' of the Walloon Cell on Major Accident Risks (Environmental Risk Management in Belgium). According to guidelines issued by the Belgian authorities (Administration of Labour Safety), a major accident is an accident which shall be reported to the EU authorities. Several criteria have been defined for such accidents (Royal Decree, Appendix V).

A should be studied and following comment is made:

'*In determining the worst case scenarios, little or no account should be taken of the probability of their occurrence. Nor should account be taken of the control and safety systems that have been installed or will be installed to prevent such situations. After all, the worst-case scenarios serve to determine how reliable those measures must be. For example, if it appears that a worst-case scenario cannot be dealt with by releasing pressure, the measures to prevent the worst-case conditions are naturally much more important than if releasing pressure were indeed possible. Usually the improbable worst-case reactions are easier to*

identify and easier to assess than more realistic cases. But if it is found that for these 'easy' worst-case conditions the hazard potential is small or can be controlled with a pressure-release safety device, this would hold good all the more so for the 'more difficult, more realistic scenarios' (PPS, p.48).

This can be interpreted as meaning that the main purpose is to analyse the efficiency of safety measures, not a scale of consequences themselves, as is the case in the United States. Present safety systems are excluded from the calculations. After the consequence evaluation the scenario serves as a measure of effort, which should be done to install safety measures to prevent such kind of situations. It is usually easier to identify the most improbable scenarios, which worst-case scenarios are, in comparison to more realistic cases. However the measures needed for improving safety against worst-case scenarios must be shown to be useful in improving the safety of more realistic scenarios. In other words, measures sufficient to cope with the worst scenarios should be capable of dealing with the less than worst scenarios.

3.3.5 Netherlands

In the Netherlands, the Hazards of Major Accidents Decree 1999 (BRZO 1999) and various other decrees and amendments implement the Seveso II Directive on the control of major accident hazards involving dangerous substances. The risk-based approach is used. The BRZO defines two quantities for external safety, namely the individual risk and the societal risk.

The individual risk is visualised by risk contours on a map and the societal risk is visualised by a FN curve. The BRZO defines a major accident in the exactly same way as the Seveso II Directive (RIP 1999) and stipulates that the Safety Report shall include description of the major accidents and measures taken to reduce the likelihood of these accidents and to mitigate their effects.

As it is stated in the information sheet about external safety policy issued by Housing, Spatial Planning and the Environment (VROM) the disaster in Enschede led to an intensification of external safety policy. One of these objectives related to addressing the so-called 'societal risks'. This led between others to the following conclusions:

- Insufficient priority is given to the possibility of major disasters.
- There is a conflict between external safety policy and spatial development priorities concerning societal risks.
- The definition of acceptable levels of risk is viable in relation to the personal safety of individuals, but not in relation to disasters.
- Policy needs to be more flexible, to enable greater account to be taken of variance and dynamics.
- The traditional emphasis on technical matters has led to the question of awareness being somewhat neglected. Societal risk is therefore perceived to be too technocratic a concept and too difficult to communicate

To deal with these problems the Ministry of Housing, Spatial Planning and the Environment (VROM) in 2003 defined several improvement objectives, which were subsequently translated into practical policies:

- The authorities should make more transparent risk assessments and there should be greater clarity regarding the feasibility and affordability of risk reduction measures

- The system for calculating societal risk should do more to identify the potential social disruption of any prospective disaster.
- Emergency and disaster response services should be involved in the process from the beginning

The interesting development in the Netherlands is that the authorities have selected one particular computer programme (SAFETI-NL) to be used for risk-based assessment computations (Haag, 2007). This was due to observations made during a benchmarking study showing that large differences existed between the different calculations produced by different consultants. The limit value for location-based risk could vary between 50 and 700 metres, depending on the consultant and the computer model used. As the limit value for the location-based risk now has force of law, there is an urgent need for the risk calculation to be robust. Therefore, the Dutch government decided to select one specific computer model for calculations (Ale et al 2001).

3.3.6 France

In France, a consequence-based approach in the control of major accident hazards is used (Christou & Porter 1999). The major accidents that are accessed in the risk assessment process are pre-defined and considered independently of their likelihood, which is not accessed. The underlying philosophy is based on the idea that if measures exist sufficient to protect the population from the worst accident, sufficient protection will also be available for any less serious incident. The deterministic approach gives a first importance of the limitation of the consequences of possible accidents (Salvi et al 2005).

3.3.7 Switzerland

In Switzerland, the handling of hazardous chemical substances and materials is regulated in the Ordinance on Major Accidents (OMA). The Swiss Agency of Environment, Forest and Landscape (SAEFL) delegates the executive powers to the cantonal authorities. In the Canton of Geneva, the Geneva Labour Inspectorate (OCIRT) is in charge of the enforcement, in the Canton of Zürich the relevant authority is the Office of Waste, Water, Energy and Air, Section for Industrial Safety and Environmental Protection (AWEL) (Hansen et al 2006).

The Switzerland procedure to control and assess relevant hazard potentials and risks consists of two steps. In the first step, the operator submits a summary report containing an assessment of hazards. If, in the first assessment step, the enforcement authority concludes that serious damage to the public or to the environment from major accidents must be expected, it orders a quantitative risk assessment to be performed. If serious damage is not to be expected, the assessment procedure is completed after the first step (Gmünder et al 2006).

3.3.8 Poland

Appropriate detailed regulations were introduced in mid-2002 in Poland and according to an approved formal timescale; all Polish operators under SEVESO II had to submit appropriate documents to the Competent Authorities by the end of September 2003. There is no approved framework/guidelines for risk assessment methodology and the Polish Seveso II regulations do not require the use of risk-based assessment or any other risk assessment methods that are available (Markowski 2005).

3.4 Other countries

3.4.1 Canada

The relevant Canadian authority CRAIM (Council for Reducing Major Industrial Accidents/ Conseil pour la réduction des accidents industriels majeurs) has developed a management guide for major industrial accidents intended for municipalities and industry.

In the guide there is a clear definition of a worst case realise scenario as 'the emission of the greatest quantity of a hazardous substance, held in the largest container, whose impact distance is the greatest. Whether the hazardous material consists of toxic or flammable substances, conditions are pre-established to help understand the worst-case scenarios. These standard conditions concern the meteorological conditions, the duration of the loss of containment, the quantities of the product to consider, the physical conditions of the accident site, etc.

3.4.2 USA

In the United States, regulatory monitoring was codified in 1990, when the U.S. Congress passed the Clean Air Act (CAA) in the wake of the Bhopal incident in 1984. The legislation gave authority to the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) to regulate the industry. The CAA directed the EPA to create its Risk Management Program (RMP) rule. The RMP rule was promulgated in 1996 and requires industrial facilities with a threshold amount (usually 10,000 pounds) of specified chemicals to submit a Risk Management (RM) Plan to the EPA every five years.

The RM Plan includes a five-year accident history, an offsite consequence analysis (OCA), an accident prevention plan, and an emergency plan. The RM Plan is available to federal, state and local government agencies and the public, with some restrictions on the availability of the OCA. States may impose more detailed requirements, regulations and environmental laws that parallel, enhance and extend Federal regulations (California and New Jersey).

The EPA has issued detailed information in 'Risk Management Program Guidance for Offsite Consequence Analysis' (US EPA 1999). The offsite consequence analysis consists of two elements: a 'worst case release scenario' and 'alternative release scenarios'. To simplify the analysis and ensure comparability, US EPA defines the worst-case as a release:

- The release of the largest quantity of a regulated substance from a vessel or process line failure
- The release that results in the greatest distance to the endpoint for the regulated toxic or flammable substance

In broad terms, the distance to the endpoint is the distance a toxic vapour cloud, heat from a fire or blast waves from an explosion will travel before dissipating to the point that serious injuries from short-term exposure will no longer occur. Alternative release scenarios are scenarios that are more likely to occur than the worst case scenario and that will reach an endpoint offsite, unless no such scenario exists. They should be based on accident history or the operator's risk analysis.

Within these two parameters, the operator has the flexibility to choose alternative release scenarios that are appropriate for the site. The methodology and reference tables of distances presented by the EPA are optional. Hence the operator is not required to use this guidance. The EPA has developed guidelines for industry-specific risk management programmes for the

following industries: propane storage facilities; warehouses, chemical distributors, ammonia refrigeration, wastewater treatment plants and small propane retailers and users.

When describing the worst case release scenario, an owner or operator must assume the worst possible conditions with respect to wind speed and atmospheric stability, ambient temperature, height of release and temperature of the released substance. For example, a facility must assume that a substance is released at ground level and in a very short time, and that the weather is very hot (which makes chemicals volatilise or evaporate faster). A facility must assume that a container holding a hazardous substance is completely full (or that it holds the maximum quantity, if there are administrative controls that limit the quantity).

Both worst case and alternative release scenarios may take passive mitigation systems into consideration. Passive mitigation systems comprise equipment, devices or technologies that work without human, mechanical or other energy input to capture or control released substances. Dikes, building enclosures and containment walls are examples of passive mitigation systems. Active mitigation systems include fire sprinkler systems, water curtains, valves, scrubbers and flares, which use human, mechanical or energy input. Only alternative release scenarios may take active mitigation systems into consideration.

3.4.3 South Korea

Terms such as worst case scenario and alternative case scenario can be seen in documents published by organisations such as KISCO (Korean Industrial Safety Corporation) and Labour Department. Definitions of these terms repeat those proposed by the EPA in the United States. Korean scientists widely use GIS for estimation of accident consequences in their practice, which is also common practice in both the USA and the EU (OECD 2003).

3.5 Critical Summary

There are some interesting differences between the EU and the USA regarding the assessment of major accidents. The Seveso II Directive states that major accident scenarios can be described by their probabilities or by the conditions under which they occur. The EU Directive is flexible due to existing variation between national approaches and leaves it up to each member state to choose the presentation of major accident scenarios. The US RMP requires interpretation of a major accident and major accident scenario as an accident/scenario which has the greatest consequences, even if the probability of it occurring is very low. The EU Directive simply states that a major accident shall mean an occurrence of a ‘major’ event, without defining what a major event is.

Looking at the practical application of the Seveso Directive in different member states, it can be seen that some countries favour a more consequence-based approach (France), while others favour a more risk-based approach (the Netherlands). However in the case of the Netherlands, it is obvious that the Enschede disaster has raised criticism towards this approach. The Seveso II Directive states what should be done but lacks the methodology to accomplish it.

This reactive way of looking at worst case can also be seen in the Buncefield Storage Depot investigation, which verified that the ‘realistic’ worst case scenario was used in the risk assessment but the event which later caused the incident was dismissed as having a very low probability. The Buncefield report recommends emergency planning to identify possible impacts on assumption of the worst case and the most probable accident scenarios.

It is important to develop more practical guidelines for WCS and for worst possible, taking into account the prevention and mitigation measures that the operator has put in place. It is

usually easier to identify the most improbable scenarios, which worst-case scenarios are, in comparison to more realistic cases.

To simplify the analysis and ensure comparability, the US EPA defines the worst case as a release of the largest quantity of a regulated substance from a vessel or process line failure or that results in the greatest distance to the endpoint for the regulated toxic or flammable substance. When describing the worst case release scenario, an owner or operator must assume the worst possible conditions with respect to factors that could promote the spread of the substance and must also assume that the amount released is the maximum quantity available.

If the Seveso Directive is to be effectively implemented in EU Member States, there is a need for equal participation by all actors; operators (responsible for preparation of compulsory Safety Reports and Emergency Plans), authorities (responsible for control of implementation and enforcement), rescue services and the public.

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Environment Canada, www.ec.gc.ca

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4. Case studies of major accident scenarios and land use planning

This chapter presents three case studies on SEVESO installations with the focus on consequence-based analysis of Worst Case Scenarios (WCS). These three cases were chosen with respect to their position in the coastal zone (sensitivity) and their close interaction with neighbouring residential areas (risk zones). A position in a coastal zone such as the Stockholm archipelago makes transportation a significant part of risk assessment due to the increased likelihood of an accident with considerable consequences for the environment and for the population.

The cases illustrate difficulties associated with coastal zone management and the complexity of land use planning activities (LUP) in this area (storage and transportation) and comprise a planned LNG establishment in Värtan and two operating oil terminals, one in Loudden (Preem) and one in Nacka-Bergs (Statoil). These cases serve to show the importance of appropriate and transparent risk communication, which if not handled correctly can lead to conflicts and lock-in situations.

4.1 Proposed LNG establishment in Värtan, Stockholm

The LNG establishment in Värtan was proposed to form part of the Loudden Energy Dock in Stockholm. The proposed location is close to the Hjorthagen residential area and the Ropsten underground train station. The risk analysis for the planned LNG establishment was carried out by Scandpower Risk Management AB for AB Fortum Värme as part of the Safety Report (SR) according to the Seveso Directive. The risk analysis was completed in February 2005 (LNG Värtan 2005).

The risk analysis was performed using a specialist software package (Trace), which according to Scandpower is an internationally acknowledged technique. The frequencies and identification of consequences were derived from the classification originating from the Norwegian oil and gas industry. European standard EN 1473 plays a major role, as the proposed AB Fortum LNG station in Värtan was designed according to the standards in this document. Another foreign standard mentioned in the SR and acting as a foundation for the project in general is American NFPA standard (National Fire Protection Association) 59A. Finally, special control has to be undertaken at the station according to Swedish law 1988:868 regarding flammable and explosive substances.

4.1.1 Structure of the analysis

The area of the LNG establishment is subdivided into sections according to the ‘process drawing’ and sections are divided into smaller sub-units. Division according to the process drawing means that sections are chosen according to activities at the establishment, e.g. unloading in docks + pipeline to storage dock, storage tanks + pumps, trunk tank, etc. Each section is marked as to whether there is LNG or gas.

The sections are chosen in order to calculate leakage probabilities. Three types of leakages are defined; small, medium, big/burst. Using the Scandpower dossier, based on experience in the LNG field, each type of leakage is assigned a probability. These leakages are internal hazards; there are also external hazards such as oil fire (coming from nearby oil tanks), collision with fuel pipeline and accident during unloading. For each defined leakage, there are frequencies assigned for events: no ignition, immediate ignition and delayed ignition. The consequences of these events are assessed using the Trace software.

For each section, probabilities and consequences of LNG/gas leakages are produced with the help of data obtained from a template (probabilities) and software (consequences). Consequences are assessed independently of probabilities. All data are collated on a single table from which it is possible to read probabilities and consequences for each section. In the end, a risk matrix with five frequency ranks and six consequence ranks is produced in order to assess and visualise risk levels.

From the probability analyses, it emerges that there are two events which can give rise to critical consequences – ignition in the dike after leakage and a large jet fire. Serious consequences are associated with a medium or large pool fire, jet fire or flash burn in a number of sections, together with some external events.

Thus a fire in the dike after leakage and a large jet fire are the worst case events and a medium or large pool fire, jet fire and flash burn are the worst case consequences. According to the analyses, this gives a total of 37 different WCS. When transferred into a risk matrix, these 37 WCS are classified as significantly risky. However, none of them is classified as unacceptably risky.

The conclusion drawn in the safety analysis is that any unwanted events that can be expected in the planned LNG establishment with a 'large certainty will not influence the establishment's surroundings and in that meaning the establishment is a safe one'. For the persons working within the establishment, the focus must be on competence and emergency preparedness. The general criterion for risk acceptability is based on the policy of 'no raised risk on the other side of the fence'. This is quantified according to following:

- The heat in the event of an accident is not higher than 1.5 kW per m^2
- No gas clouds develop with concentration higher than ½ LEL (lower explosive limit), which corresponds to 2.5% natural gas in the air

The active and passive barriers are implicitly included in the analyses because they are taken into consideration when describing consequences with the help of the computer software. For example, the closing time of valves in a section which limits the amount of LNG coming out after leakage (e.g. broken pipe) is included when computing consequences. The Domino Effect is discussed extensively in the SR with a statement that such an effect cannot possibly occur if the establishment is designed according to the plans. An act of terror is assessed as 'impossible to quantify' with reference to accepted practice in the branch.

4.2 The two operating oil terminals in Stockholm area: Loudden (Preem) and Nacka-Bergs (Statoil)

In this case, the SR for two oil terminals (Preem Petroleum AB and Svenska Statoil AB) in the Stockholm area were examined together with risk analyses carried out later for Nacka-Bergs. The SR were produced using the same templates to estimate probabilities and consequences. These templates are based on experiences and data from the Swedish Petroleum Institute and the Swedish Oil Ports Forum (SPI 2000). The SR for the Statoil terminal was prepared by the manager of that oil terminal, while the SR for the Preem terminal was prepared by the consultancy firm Sweco Viak.

4.2.1 Structure of the analysis

The templates identify different work components; boat unloading, storage, oil pumping, etc. Each work component in turn is divided into different events which 'cover conditions under

normal operation and include technical systems faults, operator error and deviation from routines'. For each event there are 'basic' probabilities assigned which correspond to the 'situation in an average oil terminal'. When analysing a specific establishment, these basic probabilities are adjusted to a particular situation by evaluating different factors. The factors can be procedures, instructions, equipment, working environment, etc. Possible passive and active barriers are also assessed here. The results of the risk analyses are probabilities of events in work components. An event with negative consequences can lead to oil discharge. Discharges are divided into four different classes according to amount of oil discharged.

In consequence-based analyses, several scenarios are chosen based on probabilities. According to SPI recommendations, the effects of different scenarios, both in the case of ignition and no ignition, can be either described or counted with a help of a computer programme. In the case of description, consequences are evaluated with the help of diagrams for spill dimension, heat radiation, etc. The template also recommends identifying the potential impact on any residential areas, source of drinking water supply etc. in the vicinity of the proposed establishment. Finally, a risk matrix is produced to describe and help assess the risk level. Even if the templates are same, there are differences in how they are applied in the following cases.

Fig. 4.1. The Loudden oil terminal

4.2.2 Loudden oil terminal (Preem)

The SR was completed in November 2005. The establishment is divided into two parts – I and III. The analyses have been carried out for the following products; heavy oil, Jet-A1 fuel, fuel oil, aviation petrol and ethanol. The risk matrix for each product is produced with five frequency classes and five consequence classes; consequence classes are separated into consequences on humans, the environment and property. The consequences were calculated using 'PIPA' from Shell Global Solutions. The event of overfilling during unloading was estimated as having a high probability but less serious consequences. Events involving fire in connection with pipe leakage during loading or unloading and overfilling during loading were considered to be serious events with a low probability.

Fig. 4.2. The Nacka-Bergs oil terminal

4.2.3 Nacka-Bergs oil terminal (Statoil)

In the case of the Statoil SR, the consequences are described using the diagrams method recommended in the SPI template. In the Statoil Safety Report there are three scenarios identified as having the highest risk potential; loss of petrol during loading a petrol truck, leakage in the pipe system and overfilling of a tank. In the report, overfilling is

chosen as a worst case scenario, the actual words ‘worst case scenario’ being used. The consequences are assessed using a diagram method suggested by the SPI template.

4.2.4 Assessment of smoke emission in the Nacka-Bergs oil terminal

At the request of Svenska Statoil AB, SP Brandteknik carried out a consequence-based study of uncontrolled fire and resulting smoke emission for one of the tanks in the Nacka-Bergs terminal. The motivation for this study was to gather knowledge about the extent to which the risk information about possible consequences should be disseminated to nearby residential areas.

The study concerned one of the tanks and the consequences were calculated using ALOFT software developed by the US National Institute of Standards and Technology. The software calculates concentrations of particles of PM10, CO and SO2 but the programme does not take into consideration the topography, which is an important factor in the case of Nacka-Bergs. The results from the study show that the impact area in the event of fire depends on weather conditions, with more turbulent weather conditions giving a greater impact on nearby residential areas. This was also the experience from the Buncefield accident in the UK (Buncefield Investigation 2006)

4.3 Discussion of methodology for evaluation severe accident scenarios

The conclusion which can be drawn from examination of the three safety reports discussed above is that they are not in compliance with the purpose for which they were produced; i.e. if the key objectives of the EU Seveso Directive are protection of population (LUP) from possible accidents, protection of the environment, and good risk communication to all parties involved, which should enable acceptance, mitigation of conflicts or reasonable decision-making. The implementation of the Seveso Directive in different Member States is under development and this process is more than just a simple transfer of the Directive into national legislation. There is a need for discussion, consultancy and understanding of the Directive’s objectives among all stakeholders in a society.

In Sweden there is no tradition of establishing the law in a form of control by commands of regulation and detailed guidance for how to perform e.g. risk analyses. This means that the development of the chemical legislation is driven by practical needs, e.g. by pressure from authorities or by bodies using SR outcomes (e.g. Emergency Units in the vicinity of establishments). Other drivers for developing the law are accidents (Enschede, Toulouse, Buncefield, see chapter 3).

Sweden is not an exception, as this process is ongoing in many Member States and is also being driven by the EU Commission through e.g. MAHB. One example of this process is discussion about the kind of scenarios that can be used for LUP. For example, Christou et al. (2006) include recommendations on using WCS for Emergency Planning but not for LUP. Another conceptually more difficult task is how to integrate the objectives of the Directive with the concept of Sustainable Development, which is a complex issue.

The Scandpower analysis for the LNG establishment is an extensive and, from the engineering point of view, well-structured report. The question is how accessible the language is for people who are not familiar with the technical expressions but who should be the target of SR (Emergency Units, Special Planners). The quantitative methods used in the SR might seen scientifically correct but they are basically ambiguous in chosing scenarios and data. The results are also in a form which maket it very difficult to use in communication to other

stakeholders. Simplicity and transparency in description of risk would most likely improve the communication but there is a lack of guidance on how to carry out risk assessment, which is essential for risk management.

The planned LNG establishment raised an energetic debate around the appropriateness of the location of the plant in central Stockholm. As a result of this debate, a hearing was arranged where politicians from Stockholm could ask questions concerning the content of the Safety Report to a panel consisting of experts from the company behind the Safety Report and from KTH. The hearing clearly showed the weakness of the Safety Report as part of the communication process to stakeholders. The questions mainly focused on WCS and their consequences for the surrounding areas (see chapter 6).

It is not sufficient to convince stakeholders about the safety of an establishment simply by showing that the probability of accidents is low, particularly since it appears that calculations are carried out in reverse – first the boundaries are set (no harm outside the establishment) and then the calculations are made. A better approach would perhaps be to view the aim of risk/safety assessment as a search for cause-effect chains which could lead to an accident and to improve mitigation methods for potential accidents, i.e. using effective passive barriers.

In the methodology used for the proposed LNG establishment, it is impossible to separate the influence of passive barriers or active barriers in the calculations. This can be compared with the USA Risk Management Program Guidance (RMP 1999) according to which the risk management should be assessed by developing a Worst Case Scenario, which includes only passive barriers, and alternative scenarios, which can include both passive and active barriers. The failure of active barriers was in fact the cause of the Buncefield accident, as this scenario was ignored as having low probability (Buncefield Investigation 2005).

The safety report for the oil terminals can be criticised from the same perspective as the LNG report regarding how well these reports comply with the objectives of the Seveso Directive. An interesting aspect is the consequences study of emissions from fire in one of the tanks. The reason for this study was that the Directive demands that information about the possible hazards be passed on to the public. The results of the consequence study in question make the decision about who should be informed difficult. In the event of high weather turbulence, the entire neighbouring area would be affected, while in the case of low turbulence the smoke would spread quite a long way from the establishment, so the question is who should be informed, and how.

The reports emphasise that the highest risk is related to the movement of flammable substances, both within and outside the facilities. This occurs due to large volumes of oil and fuels passing through a limited pipe diameter, and is a logical conclusion. An important observation is that alarm systems do not seem to be given a great deal of attention in the SR. The possibility of a terror act is also given little attention. It is almost impossible to estimate their likelihood and suggest effective measures to decrease related risks. Improvement of the external and internal security systems sounds like a positive initiative, but is too general.

The central problem in all safety reports is that they are mainly risk-based. i.e. they identify scenarios which might have severe consequences but where the calculated probability is low. Several research projects have shown that calculated probabilities for accident scenarios are highly uncertain and that scenarios used are ambiguous. In one such research project, seven teams performed risk analyses for the same chemical facility, an ammonia storage depot (Lauridsen et al 2002). The abstract to this report states:

'*The results of the project point to an increased awareness of the potential uncertainties in risk analyses and highlight a number of important sources of such uncertainties. In the hazard identification phase it was revealed that the ranking of hazardous scenarios by probabilistic and deterministic approaches could result in completely different conclusions. On the other hand, despite a large difference in frequency assessments of the same hazardous scenarios, there was good consensus on the ranking among the adherents of the probabilistic approach. Breaking down the modelling of both frequency and consequence assessments into suitably small elements and conducting case studies allowed root causes of uncertainty in the final risk assessments to be identified. Large differences were found in both the frequency assessments and the assessment of consequences. The report gives a qualitative assessment of the importance to the final calculated risk of uncertainties in assumptions made, in the data and the calculation methods used. This assessment can serve as a guide to areas where, in particular, caution must be taken when performing risk analyses.*'

It is interesting that the report points out the high uncertainties while at the same time maintaining a strong belief in the probabilistic approach. It is important to point out that the example the group looked at was quite well described and rather limited in complexity. The reality is somewhat different. The calculations of probabilities in all three safety reports studied in the present project are much less elaborated and built on very uncertain data. In many safety reports the probabilities are just taken from rough guesses and put into a scale from 1-5 in a risk matrix.

A serious probabilistic approach for determining Worst Case Scenarios in safety reports would require a set of data which in the majority of cases is non-existent. The efforts to evaluate all scenarios in a probabilistic way would also be prohibitive. It is also important to state that Worst Case Scenarios are not stochastic in their nature. 'Impossible' accidents occur frequently and show that low probabilities are often more dependent on lack of knowledge than knowledge of probability. The belief in probabilistic approaches also reflects a strong engineering tradition, which can be highly questioned. However, probabilistic approaches can and should be used for restricted systems in the internal work of companies for studying system integrity and raising the safety level.

The safety reports somewhat reflects the rather vague instructions in the Swedish legislation around these topics. In the regulation SRVFS 2004:8 which includes guidelines for handling hazardous activities one can read:

For estimating severe consequences on environment the following parameter should be considered (Short translation from Swedish):

- The inherent hazard of the substance
- The amount of the handled substances
- The dispersion conditions
- The sensitivity and protection value of the area

The risk analysis should include a calculation or other description of probability (or frequency) of identified accidents.

It is thus obvious that the legislation demands a risk-based approach. However when choosing method for risk analysis the legislation states that one should consider the objectives, the activities at the site and the need for communication of the results from the analysis. It should also be described how the risk analysis is carried out and how it is updated.

When it comes to evaluating the safety reports it is interesting to study a judgment from the court of appeal concerning an appeal from the Stockholm Municipality to reject an application from Preem Petroleum Company to increase the amount of petroleum products handled it is stated (Svea hovrätt, Dom 2003-04-03 i mål nr M 6068-02, translation from Swedish):

'Even though the risk for an accident is estimated to be low the consequences of an accident at Valhallavägen with adjacent city buildings and the entrances to the Metro could be severe.'

The concept risk is here used as synonymous to probability. Here we have a clear consequence based approach where the court states that the severe consequence is more important than the low probability.

When it comes to evaluation of severe accidents for dangerous transports the risk-based approach is dominating. One of them has been developed by the Swedish National Road and Transport Research Institute (VTI) (Vägverket 2005). The VTI-method describes how to estimate the risks in connection to transports of dangerous goods. In principle the method consists of the following steps:

- Estimate a general probability for accidents from national statistics. The figure can be given as accidents/transport kilometre
- Estimate the length of the road part being analysed
- Calculate the frequency of accidents of the chosen road part from 1 and 2. The statistics could be adjusted for special circumstances.
- Calculate the consequences of an accident

The method can be used to calculate societal risk as well as individual risk. It is obvious that if we use average statistics for accidents to calculate the probability for an accident at a certain part of a road the probability will be very low and thus the societal risk as well as individual risk will be low. Is this a reasonable approach? If a lot of short road parts is analysed in this way every analysis will show low probabilities for accidents. The method has been analysed by researchers (Ingvarson et al 2003) who concluded:

'*The Analysis of the VTI-method shows that the method can be questioned for risk- and vulnerability analysis because the formula and index for calculation of accident frequency, both for road and railroad, are not well-founded and its combination is not motivated.'*

One can thus conclude that for road and railway transports the risk-based approach can be questioned. It might also here be more reasonable to use a more consequence based approach when it comes to land use planning.

4.4 Recommendations for safety reports concerning Worst Case Scenarios

Below we present a list of recommendations for accident scenario analysis which could be used in participatory processes involving different stakeholders.

Recommended principles for description and management of possible accidents

- Develop a transparent and realistic emergency plan which is easy to communicate. The capacity to handle a potential accident is of the utmost importance. Do not hide possible uncertainties!

- Choose the worst case scenario with the worst conceivable consequences as an accident scenario, not that with lesser consequences, just because circumstances and/or calculations show that the worst case scenario seems too unrealistic.
- Do not underestimate the information gained from the WCS. When deciding upon different accident scenarios, do not underestimate the worst. If the potential worst case is neglected as unrealistic due to low probabilities, other stakeholders can focus on consequences.
- Bear in mind that a quantitative risk assessment is not a certain method and that the potential worst accident is not a stochastic variable. This means that the worst accident will happen, the only question being when.
- Do not underestimate a human factor or an act of terror.
- Devote more time to mitigating eventual consequences and emergency planning by improving preventative measures such as passive barriers rather than to calculating possibilities.
- If stakeholders raise questions about possible consequences and emergency planning, give them credit for this and let them be involved in planning and communication.
- The aim of risk management is to understand possible circumstances which could lead to the worst possible accident at a particular site and to prevent these. Be aware of complexity. The better the circumstances leading to a possible accident are understood, the better the risk management will be.

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5. Environmental consequences of major accidents

5.1 Environmental Impact Analysis

The major instrument for assessing the environmental impacts of industrial activities is Environmental Impact Assessment (EIA).

Environmental Impact Assessment is a key instrument of European Union environmental policy. Since passage of the first EIA Directive in 1985 (Directive 85/337/EEC), both the law and the practice of EIA have evolved, and an amending Directive was published in 1997 (Directive 97/11/EC) (European Commission, 2001).

The EIA Directive covers a broad range of activities ranging from industrial to infrastructure projects. It introduces procedural elements to be followed, such as the provision of an environmental impact statement and consultation with the public and environmental authorities within the framework of development consent procedures for the activities covered. Member States may regulate the EIA procedure as a permitting procedure or by adding it to existing permitting procedures under other pieces of Community (or national) legislation. The results of the EIA procedure have to be taken into consideration in the development consent procedure (IMPEL Network, 1998).

According to Directive 97/11/EC, the environmental impact assessment shall identify, describe and assess in an appropriate manner, in the light of each individual case and the direct and indirect effects of a project on the following factors:

- Human beings, fauna and flora
- Soil, water, air, climate and the landscape
- Material assets and the cultural heritage
- Interactions between the factors mentioned in these three categories

Some corrections and supplements have been introduced into Directive 97/11/EC. Member States shall take the necessary measures to ensure that, if the developer so requests before submitting an application for development consent, the competent authority shall give an opinion on the information to be supplied by the developer. The competent authority shall consult the developer and authorities before it gives its opinion. The fact that the authority has given an opinion shall not preclude it from subsequently requiring the developer to submit further information.

The information to be provided by the developer shall include at least:

- A description of the project comprising information on the site, design and size of the project
- A description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects
- The data required to identify and assess the main effects which the project is likely to have on the environment
- An outline of the main alternatives studied by the developer and an indication of the main reasons for their choice, taking into account the environmental effects
- A non-technical summary of the information mentioned in the previous points (97/11/EC)

5.2 Swedish legislation governing the EIA process

In Sweden, the EIA Directive is mainly implemented by Chapter 6 of the Swedish Environmental Code (Miljöbalken), which was adopted in 1998 and entered into force on 1 January 1999, and a support Ordinance on EIA (1998:905). This Environmental Code brings together legislation that was previously contained within 15 Acts and includes environmental regulations of general importance, with more detailed supporting provisions being laid down in Government Ordinances. However EIA is also required under other legislation, e.g. the Roads Act, the Construction of Railways Act, the Minerals Act, the Certain Pipelines Act, the Certain Peat Deposits Act, the Electricity Act and the Planning and Building Act. For most of this legislation the EIA requirements are wholly/partly compatible with the general EIA provisions in the Environmental Code. An exception was the EIA provision in the Planning and Building Act, which related to certain detailed development plans that were distinct from the requirements in the Environmental Code. However, the Planning and Building Act has now been amended to link these EIA requirements to those in the Environmental Code (through implementation the SEA Directive) (Sheate et al 2005).

According to the Swedish Environmental Code, an EIA report shall be included in the project permit application as regards operations with environmental impact. Before the Environmental Code came into force, the EIA decree and the Law on Environmental Protection stipulated the rules for the Swedish EIA system (Severinsson 2004).

Today, the EIA is conducted to describe an operation's impact on the environment and the economic administration of resources. The law not only refers to nature but moreover to the environment for human beings, the landscape frame and the cultural environment (Severinsson 2004).

Resources taken into consideration are:

- Land
- Water
- The rest of the physical environment
- Raw material
- Energy

5.3 EIA report on the Preem Petroleum AB oil terminal at Loudden

Preem Petroleum AB is asking permission to expand its activities at Loudden docks. Initially Preem wants to handle 490 000 tonnes of petroleum products (compared with the 302 600 tonnes handled in 2004) and after the removal of 'aviation fuel' the total amount of petroleum products will be 380 000 tonnes. The amount of aviation fuel handled today at Preem's facilities at Loudden is 238 000 tonnes.

This increased handling of petroleum products is only planned to go on for a limited time. In 2006 the handling of aviation fuel will move from Loudden to Gävle harbour. When the transfer of aviation fuel handling has been realised, Preem wants to transfer some of the handling of other petroleum products (a total of 125 000 tonnes) from Bergs harbour to Loudden. As a result, the planned activities of these two transfers will be about 380 000 tonnes in total. The application includes the receipt, storage and delivery of petroleum products at the oil terminal in Loudden harbour.

The reason behind the proposed expansion at Loudden is the increased market demand for Preem's products among its customers. There are mainly logistical reasons for transferring the handling of some petroleum products from Bergs to Loudden (shorter transport distances etc).

According to the Swedish Environmental Code, environmental impact assessment analysis should be carried out for storage of petroleum products. In this case the EIA report was prepared by SWECO VIAK AB and the EIA documentation was submitted on 16 March 2005. Complementary additions to the EIA report were submitted on 29 November 2005.

5.4 Environmental impacts associated with accidental releases

The structure of the Environmental Impact Assessment report very much resembles that of the SEVESO report. In general, both reports have to describe the activity from a physical and organisational point of view and also the potential impacts the activity could have and measures to avoid these impacts. The main difference is that the EIA has its main focus on the continuous impact on the environment from the normal operation of the industrial activity, while the SEVESO report focuses on impacts from accidents.

The EIA should also contain an analysis of potential accidental releases but the methodology for doing this is usually very primitive. In the SEVESO report, this methodology should be more developed in accordance with the EU Directive. However neither the Directive for EIA nor the SEVESO Directive contains recommendations on which specific methods should be used to assess risks, stating only that 'recognised methods' should be used. When it comes to evaluating the accidental risks of an industrial activity on the environment, both methods thus leave a more or less blank space for subjective interpretation.

When discussing risk assessment in connection with major accidents, the main consequences taken into consideration are those for people, the environment and property. All these potential consequences are important for land use planning.

The risks for the environment are associated with many uncertainties, two of the main categories being:

- Uncertainties in how different substances handled in a specified industrial activity will affect the environment in the short-term and long-term. This risk is connected with the inherent hazards of chemicals.
- Uncertainties in the amounts of the substances that can be released to the environment. In the case of transport, some uncertainty is also related to where the release occurs.

The effect of chemicals on the environment is complicated and is one of the important issues handled in REACH, the new European Community Regulation on chemicals and their safe use (EC 1907/2006), which deals with the Registration, Evaluation, Authorisation and restriction of CHemical substances. The new law entered into force on 1 June 2007.

The aim of REACH is to improve the protection of human health and the environment through better and earlier identification of the intrinsic properties of chemical substances. The REACH legislation places greater responsibility on industry to manage the risks from chemicals and to provide safety information on the substances. Manufacturers and importers will be required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database run by the European Chemicals Agency (ECHA) in Helsinki. The ECHA will act as the central point in the REACH system. It will manage the databases necessary to operate the system, co-ordinate

the in-depth evaluation of suspect chemicals and run a public database in which consumers and professionals can find hazard information.

5.5 Alternative approaches to environmental risk assessment

In this project we mainly focused on the uncertainties concerning the probability of accidental releases to the environment. If we can evaluate this in a robust and transparent manner, we can connect it to the information on inherent hazards from chemicals in the REACH system in order to have a more comprehensive evaluation of the risks and use it in land use planning.

Taking these considerations into account illustrates the complexity in assessing environmental risks for e.g. a municipality, where there can be risk sources from both transport and industrial sites with different environmental surroundings. One common way of assessing the environmental risk is built on the estimated amount released and the possibility of cleaning up. The main problem with this approach is that the possibility of cleaning up is very dependent on the characteristics of the specific ecosystem where the accident occurs. There are examples of methods that try to take this complexity into account, but the result is usually that any such method has such a complexity and need for data that it is very difficult to use in practice. One example of such an approach is the Environment-Accident Index (EAI) (Scott Andersson 2004). EAI has been proposed as a planning tool created as an equation in which chemical properties (variables describing the chemical involved) are combined with site-specific properties (variables describing the accident site). The EAI is intended to facilitate assessment of the environmental effects related to chemical accident scenarios and hence assist in the organisation of preventative programmes. The problem with this method is that it is very complicated to specify the site-specific properties, especially when it comes to transport of hazardous substances for which it is difficult to find data for all the places along a transport route. A more realistic approach would be to try to map the sensitivity of areas around industrial activities and transport routes. This idea is developed further below.

Relating to the discussion on worst cases in the previous chapter, it is very doubtful if these scenarios should be restricted in magnitude due to calculations showing low probability for the real worst case. It is also very doubtful if positive decisions concerning acceptance of transport of hazardous substances on land or water should be taken when statistics show low probabilities of accidents. The probabilities for transport accidents are calculated from general statistics, and all that is known is that accidents occur but that it is not possible to know beforehand where they will occur. The only thing known for sure is that those accidents will occur somewhere along the traffic routes.

In this project we chose another approach, which is based more on the precautionary principle and the ability to handle an accident, disregarding the fact that a low probability for such an accident has been estimated. The proposed method is based on the previous discussion on how to estimate the Worst Case Scenario (WCS). In this case the WCS is essential ‘loss of containment’, i.e. everything in a tank is released. The next question is then whether such a release can be handled in an acceptable way. To answer that question, we can assume that different areas can be given a certain protection value. For different industrial activities including transport, real WCS can be described and the acceptance criteria can then be based on the ability to handle these situations in different areas with different protection values. This reasoning then ends up with a method consisting of two parts:

- Estimation of the maximum amount that can be released using real WCS.

- Development of a map for the area of interest e.g. a municipality, a transport route where areas with different protection values can be estimated using some method. The estimated amount that can be released, the type of chemical and a figure for the protection value can be used to develop a semi-quantitative way of estimating the risk.

Using the principles in the previous chapter for WCS, i.e. in principle 'loss of containment', the next step in the methodology is a way to define protection values for the areas of interest. One way to do this is to use the concept of 'Sensitivity Mapping'. Several methods have been proposed for this and those studied in this project are described below.

5.6 Methods for sensitivity mapping

5.6.1 Sensitivity mapping of land-based areas

This method (Wallblom 2006) is based on description of preconditions and protection value of the surroundings/recipients in risk assessment. Motala municipality has developed a risk analysis for those accidents that can bring about an effort by the rescue services according to the Regulation on Prevention of Accidents (SFS 2003:778). The risk analysis includes health and safety consequences for people, where traffic accidents followed by fire turned out to pose the largest risk. Accidents with serious consequences for the environment have not yet been analysed due to lack of appropriate methods. The existing method considers only the amount released and the efforts to it clean up. In order to get a more comprehensive risk analysis for environmental consequences, the sensitivity of the physical area has to be taken into consideration. The proposed method is built on the protection values of the surroundings/ recipients. The method includes a risk table which can be used for larger areas and where several 'protection' areas and risk factors are included. This facilitates a ranking process of areas with the largest need for protective actions, both preventive and in case of an actual accident. It also points out the need for more in-depth risk analysis.

This method could be used together with the principles developed for WCS in this project. The protection values could then be combined with the largest amounts of chemicals that could be released in the area from industrial activities or transport.

5.6.2 Sensitivity mapping of coastal zones

In the event of an accident, there are several factors that have to be taken into account in order to evaluate a sensitive marine habitat. The three most important factors are (Kuikka et al 2005):

- Vulnerability of populations to pollutants
- Uniqueness of populations (genetic specificity of the population to the given environment)
- Recovery potential of populations

The Baltic Sea is one of the world's largest brackish water bodies and is therefore ecologically unique and highly sensitive to environmental impacts. Shallow and narrow straits connect the Baltic Sea with the North Sea and thus the exchange of water is very limited, so it can take more than 25 years for the water to be replaced and any contaminants persist in the Baltic for a long time (HELCOM 2005). The Baltic Sea is also a geologically young sea and the present conditions have existed for only 8 000-10 000 years. The Baltic Sea ecosystems have had very little time to adapt and develop after the last Ice Age.

The Baltic Sea is characterised by strong vertical and horizontal salinity and temperature gradients that affect the biota. The salinity varies from 20 ppt in the Kattegatt area to only 1-2 ppt in the inner parts of the Gulf of Finland (HELCOM 2005). Low water temperature and ice cover slow down the degradation processes and enhance the effects of contaminants in the Baltic Sea (Furman et al 1998).

The biodiversity of ecosystems is largely shaped by the environmental variables, e.g. salinity and temperature. Due to the variable conditions in the Baltic Sea, specific biotopes and a flora and fauna consisting of few but specially adapted species have developed. A unique mixture of both marine and freshwater species that have adapted to the brackish water conditions can be found. The number of species declines from south to north and west to east. In the Gulf of Finland in particular, species are living close to their tolerance limits and habitats are dominated by freshwater species (Kuikka et al 2005).

The Gulf of Finland ecosystem is so different compared with other ecosystems that it is likely that many species have genetically adapted to the specific environment. If conditions in the Gulf of Finland area change radically, a number of unique populations that have developed since the last Ice Age will become extinct. Similar losses are not likely to happen in larger sea areas, where environmental gradients are not so strong or expressed over such short distances (Kuikka et al 2005).

The uniqueness of the Baltic Sea has been recognised by the International Maritime Organisation (IMO), which designated the Baltic Sea a Particular Sensitive Sea Area (PSSA) in 2004. PSSA are areas of the sea that need special protection through action by the IMO because of their vulnerability to harmful impacts from shipping activities (IMO 2005).

During a research seminar arranged by the COASTAM project at Kristineberg Marine Research Station in Fiskebäckskil on the Swedish west coast in September 2006, three different methods to measure sensitivity in marine ecosystems, from Sweden, Finland/Estonia and Russia respectively, were presented and discussed.

5.6.3 MARBIPP (Sweden)

The method from Sweden was developed through a project entitled Marine Biodiversity, Patterns and Processes (MARBIPP). This project was funded by the Swedish Environmental Protection Agency.

The overall aims of MARBIPP were to:

- Estimate the importance of biodiversity in marine coastal ecosystems
- Develop ways to monitor biodiversity changes and to predict levels of biodiversity from environmental factors
- Advise managers on how marine coastal biodiversity should be conserved.

Swedish and Baltic Sea coastal ecosystems are very unusual and complex because of their distribution along a salinity gradient. The MARBIPP project compared patterns and processes of biodiversity between two or more areas along the salinity gradient in order to gain knowledge about the biodiversity relationships that were general and the types of relationships that were area-specific.

A main issue for estimating biodiversity is to find ways of assessment that are not too costly or too complex. The traditional way of assessing biodiversity by sorting, defining and

counting species is very resource-demanding, as is analysis of biodiversity at the genetic level. One task of the MARBIPP project was to investigate whether habitat-forming species or habitat characteristics correlated sufficiently well to biodiversity to be useful as indicators of biodiversity. The salinity gradient along the Swedish coast creates a tremendous challenge in trying to make generalisations among areas. It means in practice that most knowledge relevant in one area is at risk of being irrelevant (or even erroneous) in another. Thus, most scientific studies and advice to managers have to be area-specific. Another problem is that the entire Swedish coast and the Baltic Sea are under environmental stress and that it may be very difficult to find an area without anthropogenic stress in order to characterise a habitat.

The entire Swedish coastline has been monitored, with the exception of the Bay of Bothnia and very few studies from the Bothnian Sea, and marine habitats have been classified. The different parts of the coastline have been classified based on different key species or habitat-forming species, e.g. eelgrass (Zostera marina) or bladder wrack (Fucus vesiculousus). A database has been published on the internet in which different stakeholders can find information about different biotopes and their sensitivity towards different kinds of anthropogenic effects, e.g. oil spills and organic pollutants. The information is based on published scientific material and the information sources are also cited in the database.

The MARBIPP project also provided some experiences about the problems involved in communicating complex scientific information from scientists to non-experts and politicians. The conclusion was that it is necessary to meet face-to-face and that much time must be spent on personal meetings. Transfer of information via the internet or by e-mail proved not to be fruitful.

5.6.4 OILECO (Finland and Estonia)

The method from Finland was developed in an INTERREG project between Finland and Estonia entitled OILECO. The aim of OILECO was to identify different parts of the Gulf of Finland that should be prioritised in case of an oil accident. The reason is the limited number of oil booms and thus the capacity to handle a major oil spill in the Gulf of Finland. The method used was based on red-listed species and the ability of the different species to re-colonise a habitat after an oil spill. The project also worked with different scenario methods looking at how an oil spill would behave and spread under different wind conditions. The conclusion drawn was that it is not always the most conspicuous and well-known species such as seals and birds that should be saved in the event of an oil accident, but rather less well-known species such as beetles and rare plants. The method will be used in the event of an oil spillage in Finnish waters and is based on scientific rather than emotional values.

5.6.5 Russian experiences

The Russian method was based on Geographical Information Systems (GIS), which gather ecological information about different marine habitats in the Russian part of the Gulf of Finland. Several different ecological expert groups were involved during the process. The information collected was used to compile an atlas that gives information about sensitive ecosystems both on land and in the sea. The atlas includes information about e.g. currents, fish spawning areas, birds, seals and different marine biotopes. The information may be used for example when planning the routes of the oil tankers transporting oil from the Primorsk oil terminal. The atlas has been produced in both Russian and in English.

5.7 Critical Summary

Assessing the risks of impacts on the environment from industrial activities is complicated for several reasons. One is that the effects of chemicals on ecosystems are difficult to evaluate, especially long-term effects and cumulative effects from small releases and releases of different chemicals. Another problem is to assess the magnitude of a potential accident in terms of the amounts of chemicals that can be released and where. Present assessments in Environmental Impact Assessment and SEVESO reports are dubious in their use of methods. These reports are often written by consultants and the aim is mainly to fulfil legal requirements, partially due to the current legislation lacking more precise descriptions of methods that should be used. The outcome from the reports also has a very low transparency, which means that they can scarcely be used in decision-making processes where wider stakeholder groups are involved.

Methods used by municipalities to assess the risks of accidents with consequences for the environment usually involve a simplified way to estimate such risk. These methods are built on rough estimates of the probability of a release, the amount released and the efforts to clean up. Following the reasoning in this report, the estimation of probabilities for a release is very uncertain and there are no reliable methods for this estimation. It would be better to assume that the total amount of chemicals in a container can be released and to study the capacity to handle this situation. This capacity is dependent on where the release takes place. Depending on the sensitivity or protection values of the area, the consequences will be more or less serious. This requires that municipalities develop maps with factors describing the sensitivity and/or protection value of areas.

This method could also be used for supervision of activities by the authorities. If an activity handles a large amount of a chemical that can affect the environment in a negative way and the activity is situated in an area with high protection value, inspections should be carried out more often. The ranking of activities in this way could also be combined with a simple way to estimate the level of risk management in the company. Simplicity in methodology is of primary importance if supervision is to be effective and reliable.

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6. Risk in participatory decision processes

6.1 The concept of risk in Land Use Planning

As described in previous chapters, risk and safety are important topics in many decision-making processes concerning land use planning (LUP). The real meaning of risk presentations in safety reports is to reveal risks using reliable methods and to gather information for rational decision-making including physical planning and risk management.

There is a belief that by making risk assessments and producing safety reports, it is possible to manage risks in a better way. Another belief is that risk estimation works with reliable methods because mathematical statistics are used. However, there are several difficulties associated with the current use of these methods. One of the difficulties is uncertainties in the estimation of probabilities calculated in quantitative risk assessment methods. Other difficulties include unclear guidelines for the worst possible event and consequences of an accident.

Several concepts have been introduced to describe a potential serious accident occurring during industrial activities. Examples of these concepts are the WCS, more likely but less catastrophic scenarios, most credible scenarios, major accident scenario, etc. The worst case scenario should be a sequence of events/actions/accidents for a certain industrial site and time that causes the worst magnitude of an accident and consequences. These kinds of accidents are often regarded as having very low probability, so a basis for planning more likely, but less catastrophic, scenarios is used. However, clear definitions and guidelines for developing these scenarios are lacking.

In this project we argue that the ‘major accident’ approach, as it should be used according to the EU Seveso Directive, should not be based on the notion of probability, but rather on the accumulation of worst case assumptions and yields; in theory, the maximum loss level. The chosen worst case and following worst loss should sufficiently support any democratic decision-making process, for example spatial planning.

6.2 Public participation in the decision-making process

One of the basic questions regarding the decision-making process in land use planning and risk issues concerns which stakeholders should be invited to take part in the process. Many researchers believe that those stakeholders who are affected by the decision should have the possibility to influence the process (Stern & Fineberg 1996; US CCR 1997). As value judgements are an integral part of risk assessment, it is reasonable to integrate values from concerned stakeholders.

The picture of strictly objective experts taking care of risk assessment has gradually changed and there are actually arguments that it is not possible to separate experienced and real risks. Many researchers argue that concerned stakeholders should take part in the whole process of risk assessment including risk evaluation (Eduljee 2000). The idea of participatory processes originated from alternative methods for conflict resolution that emerged in the 1970s and 1980s (Bier 2001).

There are three main important arguments favouring participatory processes:

- In a democracy, citizens have the right to take part in decisions affecting them and to obtain information regarding the basis for these decisions.
- Participation by all stakeholders can contribute to increasing the quality of information for both decision-makers and other stakeholders. Non-specialists can contribute a picture reflecting ethical, social and political values.
- Through the discussion, stakeholders get insights into their own values and those of others, which raises confidence and minimises the risks of intractable conflicts (Anex & Focht 2002). This was also one of the basic ideas behind the pilot course described in chapter 8.

However, some researchers have called for caution when it comes to participatory processes concerning decisions relating to risk. Increasing opportunities for participation can make the decision-making process more ineffective, with an overabundance of information that can lead to poor analysis and certain alternatives not being investigated in depth. Some studies highlight the need for higher quality among the participants, not for less participation (Anex & Focht 2002).

Decisions concerning the environment are political as well as scientific, which means that they have to be based on technical methods as well as interests and values among the public. Some people argue that participatory decision-making tends to shift environment-related decisions too much towards politics. A systematic analysis to investigate how participation has affected the quality of environment-related decisions in the USA during the last 30 years examined 239 cases describing a large variety of participatory processes with different intensities (Beierle 2002). Intensity here referred to less focus on collecting information from the wider public and a higher focus on reaching agreement between smaller groups of stakeholders. The quality was evaluated in terms of four issues:

- Are participatory decisions more cost-effective?
- Do decisions with high stakeholder participation increase the common benefits for the stakeholders?
- Do the participants contribute innovative ideas, useful information or new information?
- Do the stakeholders have access to scientific information and expertise?

Taken together, the results show that the more intensive forms of participatory decision-making processes have more prospect of resulting in high quality decisions (Beierle 2002).

Cross (1998) analysed the subjective factors that are usually indicated as important for public risk perception and drew the conclusion that caution is required concerning values in the decision-making process. The picture of public risk perception is usually not based on correct statistical selection, since it is often those with the greatest resources that have the greatest say. It is also difficult to define the concept ‘value’. Cross (1978) investigated what are thought to be the four most prominent sets of values in public risk perception:

- *Dread* is above all linked to what is unfamiliar. The public fear of the unknown has often led to peripheral groups being disadvantaged. Groups with strong resources are heard more and poor minorities are treated unfairly. When the pesticide DDT was abandoned in USA it was replaced by organophosphorus compounds with higher acute toxicity, causing many deaths among farm workers.

- *Voluntariness* can be hard to define. What at first glance might appear voluntary e.g. driving a car, is often necessary in work, shopping etc. The same goes for risks at work. The choice of occupation can be regarded as voluntary, but that might not be the case for unemployed people.
- *Catastrophic* consequences. Research shows that the public especially fears events that have severe consequences for many people at the same time. This fear is not unambiguous. Public fear in this sense relates more to technological catastrophes than natural. This indicates that technology is more important for the risk perception than the catastrophe in itself.
- *Control*. When people experience control of a situation they also perceive the risk as smaller. When driving a car many people experience less risk compared with when they are passengers. This can be attributed to the fact that most people think that they are better drivers than the average.

Cross (1998) is of the opinion that those factors are essentially not values or opinions and should not be considered important in decision-making processes relating to risks.

6.3 Democracy and the concept of risk

Some researchers dismiss the idea of decisions relating to risk taken by experts and involving stakeholders. Decisions on risk should be treated as any other decisions within a representative democracy. There is no reason for changing a decision simply because some people are displeased with the decision (Sjöberg 2001).

The different arguments for and against public participation mainly fall back on different conceptions of *democracy* as well as the basic *concept of risk*.

The concept *democracy* has often been expressed in the form of different models. In practice, these models can be reduced to three different ways to view democracy:

- Representative democracy.
  This is our traditional model where elections are the central mechanism for ensuring democracy. The citizen can affect the development through their choice of politicians.

- Participatory democracy.
  In this perception there is a need for public participation not only in elections, but also in different decisions in society. In Sweden there is actually legislation for the support of this participation, e.g. in Environmental Impact Analysis, Seveso reports, etc.

- Deliberative democracy.
  In this form of democracy there is a more in-depth participatory process, with dialogues and discussion carrying the process of decision-making forward. An important document here is ‘Understanding risk’ from the US National Research Council.

In practice, all these forms of democracy exist at the same time in Swedish society. In principle, Sweden has a representative democracy, but the decision-making processes are run by civil servants and members of the public have many opportunities to interact in the decision-making process.

If there is rigid acceptance that the principles of representative democracy should rule, there is a risk for expert rule especially when it comes to decisions involving risks. This is a problem

because of the different ways to interpret this concept. The basic concept of risk is interpreted in very different ways in different scientific disciplines. Engineers working with risk assessment often have a firm belief that risk is an objective factor that can be calculated and that better methods and data bring them closer to the truth concerning the risk. This is expressed clearly in a report by Bergstrand (2005) discussing another central document about how to carry out risk evaluation (Davidsson et al 1997). The summary to the Bergstrand report states (free translation from Swedish):

'*If we in Sweden were to follow the example of Holland and introduce quantitative risk criteria, according to Davidsson et al (1997) we will need well-defined methods for QRA. This is so that risk analysis can be compared with chosen criteria and examined by authorities. It is important that the reasoning in the risk analysis can be tracked and that uncertainties are visible. Davidsson et al. also believe that the method must include a standard for how generic values should be handled. The method for representing scenarios presented in the work primarily fulfils the demand that the risk analysis becomes a good foundation for comparison. In the report, a simple statistical reasoning is also presented for preparation and summing-up of generic values. The systematic should also simplify the examination by the authorities*.'

However, social scientists often argue that risk can never be a purely objective factor but more a social construction. Examples of these opinions are:

'*In a risk society, we want to argue, even the most restrained and moderate-objectivist account of risk implications involves a hidden politics, ethics and morality*.'
(Adam et al 2000, p.1).

'*… risk is not reducible to the product of probability of occurrence multiplied with the intensity and scope of potential harm.*'
(Adam et al 2000, p. 7)

From the discussion above we can conclude that there is no simple way to carry out participatory decision-making processes relating to risk. However, one important conclusion is that we in Sweden in practice have to take public participation into account and that the elected politicians are often on the level of the public in understanding traditional risk analysis. This became very obvious during a hearing held with politicians during the course of this project (see chapter 4). It is also obvious that non-experts have a tendency to be more consequence-orientated when evaluating risks and that experts tend to be more risk-orientated, i.e. take both probability and consequence into account. There are probably a number of reasons for the consequence-based reasoning among non-experts. One more mentally deep-rooted reason is that the public is especially fearful of events that have severe consequences for many people at the same time, disregarding the low probability of such events. Another reason could be mistrust of probabilities calculated by experts. The latter fear is highly justified, as we have shown in this report.

6.4 Conclusions

Approaches to risk assessment and risk management now have to acknowledge the fact that the results obtained must be communicated to various groups of stakeholders. The communication aspect is stressed because of the recognised importance of public participation during decision-making processes. A high level of public acceptance also mitigates future conflicts. Experience tells us that the overuse of quantitative risk assessment methods leads to difficulties in communication rather than clarity; the probability concept is difficult to

understand and accept and also highly uncertain. Therefore an important demand on the outcomes from a risk assessment should be its capacity to provide functional knowledge understandable to all parties involved.

One question is how to distinguish between 'worst case' and 'more likely but less catastrophic' events. If the worst case were to be used all the way through an event tree, the calculated probabilities would be difficult to grasp – especially when communicating results to different stakeholders. An observed conclusion from conflict resolution concerning industrial sites is that involved stakeholders who derive no benefit from potential risks emphasise safety issues and are afraid of risks with low probabilities but large consequences. They are not interested in higher probability, more credible scenarios. A solution for this is to actually choose WCS as a starting point and then discuss how to handle such scenarios.

Another question is who is really a user of information gathered from safety reports. Is it an authority with responsibility for supervision, a municipality where the site is located, or third parties affected by new hazards? All these stakeholders need different kinds of information, both in content and depth. This is something that people performing accident scenario analysis should keep in mind. An additional question concerns the purposes for which risk estimations are produced – for emergency planning, decision making, or safety? Safety reports are often produced by consultant companies in a rather standardised way and the real purpose is only to fulfil legal requirements.

One of the common mistakes made during risk assessments is that the possible accidents are approached using statistical methods, i.e. are perceived as stochastic. We argue that possible accidents should not be assessed using statistical methods. The worst case approach as it is used in the USA gives a better starting point for emergency planning, spatial planning and mitigating possible effects – for example using effective passive barriers. The worst case approach is also easier to communicate and mediate to stakeholders due to its transparency – it is more useful in democratic decision-making processes.

The conclusion that can be drawn from examination of the three safety reports mentioned earlier (chapter 4) is that they are not in compliance with the purpose for which they were produced. The LNG safety report in particular led to even greater suspicion between stakeholders. The aim of risk/safety assessment should be to find cause-effect chains which could lead to an accident and to improve mitigation methods for potential accidents, i.e. using effective passive barriers.

The general experience is that areas of potential conflict in decisions involving risks should be handled as early as possible and with great openness. If information is concealed in order to avoid discussions, the road to results might turn out to be much longer, not shorter. There is usually a general eagerness to get the process underway, but the time needed for information and discussions must be set aside at an early stage. This tends to let stakeholders feel that their opinions have been taken into account, even if the final solution is somewhat different from what they would have wished. The argument that participatory processes slow down the whole process is therefore often not valid. One negative example of conflict resolution strategies is the planned gas pipeline at the bottom of the Baltic Sea, which Russia is planning to build to Germany. The information about the project came out late and many stakeholders feel that the information process is not very open. If the information around the project had started much earlier, the opposition to the project would probably have been much weaker and the project group could have taken care of important stakeholder opinions. Exploration of energy sources might turn out to be one of the most difficult areas for conflicts in the Baltic Sea Region. In order to solve these conflicts, there will be a need for platforms for

information exchange and open discussions at early stages. One such platform could be joint Baltic Sea Region courses in conflict resolution strategies, such as that developed in the COASTMAN project. Another experience is the importance of a third party in the conflict resolution process. This third party could be a university who should play a neutral role and establish platforms for conflict resolutions.

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7. Indicators for sustainable development with the focus on integration of the risk perspective

7.1 Models for developing indicators

Communication is the main function of indicators and communication demands simplicity. Indicators always simplify a complex reality. They focus on certain aspects that are regarded as relevant and on which data are available, but their significance goes beyond that obtained directly from the observed properties. Sustainability indicators communicate those aspects regarded as critical or typical for the complex interrelation between economics, social aspects and environmental effects. In addition, sustainability indicators may be used as a powerful tool to raise public awareness on sustainability issues. Providing information on driving forces, impacts and policy responses is a common strategy to strengthen public support for policy measures.

The indicators developed can be top-down or bottom-up. Top-down indicators can be used by authorities to follow up developments in e.g. an environmental programme. Bottom-up indicators can be used to strengthen public support in e.g. developing more sustainable pathways for society. It is important that there is broad participation in choosing the set of indicators so that there is public recognition that these indicators are important for measuring sustainable development. Choosing and aggregating indicators is always a subjective process, which has to be deeply rooted among the stakeholders taking part in the development.

Many types of indicators for sustainable development have been developed, both on a national and international level. It is not within the scope of this project to review that work. However, on a national level the Swedish Environmental Protection Agency (SEPA) has published several reports covering indicators on both national level (Naturvårdsverket 1999) and international level (Naturvårdsverket 2002). These indicators serve to support the work of achieving Sweden's environmental objectives. The method used by SEPA to develop the indicators and when selecting follow-up measurements for the environmental quality objectives was the internationally accepted DPSIR model, where DSPIR stands for Driving forces and the resulting environmental Pressures, on the State of the Environment and Impacts resulting from changes in environmental quality and on the societal Response to these changes in the environment.

The DPSIR framework is useful in describing the relationships between the origins and consequences of environmental problems, but in order to understand their dynamics it is also useful to focus on the links between DPSIR elements. For instance, the relationship between the Driving force and the Pressures through economic activities is a function of the eco-efficiency of the technology and related systems in use, with less Pressure coming from more Driving force if eco-efficiency is improving. Similarly, the relationship between the Impacts on humans or eco-systems and the State of the environment depends on the carrying capacities and thresholds for these systems. The Response of society to Impacts depends on how these Impacts are perceived and evaluated; and the results of the Response on the Driving force depend on the effectiveness of the Response.

Stockholm City has followed the principles of SEPA in using DSPIR to support the development and follow-up of their environmental programme (Miljöutredning - Stockholms miljöprogram 2003).

In the COASTMAN project, the DSPIR model was used to develop indicators to support a vision for more sustainable infrastructure for storage and transport of petroleum products. The choice of the DSPIR model was partly based on the fact that Stockholm City is using the model in their environmental programme. The model can also illustrate the cause and effect chain in the complex planning process. In this process for new infrastructure, a set of issues has to be handled, e.g. emissions, demand for petroleum products, political decisions. The indicators describing the connections have to be of both a qualitative and quantitative nature. In the DSPIR model, both quantitative and qualitative indicators can be used and the relationships between them evaluated in order to get a better understanding of which actions can be taken to develop more sustainable infrastructure.

7.2 DSPIR model applied in the Loudden case

The Loudden case study was used to analyse how sustainable development affected the planning process for a new harbour structure for Stockholm oil handling. The following questions were raised:

- How does the vision of sustainable development affect the planning process for a new oil harbour structure?
- Can the DPSIR model be used to create indicators that describe how the vision of sustainable development can affect the planning process for a new oil harbour structure?

The DPSIR model was used to create and describe indicators for sustainable development and to make simplified descriptions of the oil harbour structure. Examples of indicators with the focus on risk were:

Driving force (D)
- Energy consumption and population increase
- Depots and infrastructure

State (S)
- Capacity of rescue service
- Protected areas

Pressure (P)

Normal operation and accidents resulting in:
- Emissions to air and water
- Waste

Consequences (I)
- Environmental consequences
- Economic consequences

Response (R)
- Transportation
- Regional planning
- Community planning
- Stakeholder participation

7.3 Critical Summary

Four criteria were created that define a sustainable oil harbour structure and the indicators were connected to each criterion. These criteria ensure: secure oil deliveries of high quality, positive regional development, and a secure oil harbour structure which takes the environment into consideration and also the possibility of stakeholders participating in the planning process for the harbour structure. A questionnaire was sent to administrators to illustrate the possibility of stakeholders participating in the planning process for the new harbour structure for oil deliveries in Stockholm. Thirty-three percent of the stakeholders who responded to the questionnaire believed that a regional organ should take the final decision on future oil deliveries for the Stockholm region when Loudden is closed. This opinion strengthens the view that all stakeholders who are affected by a major decision like this need to formulate common indicators for a sustainable harbour structure. Distinct criteria are essential in getting the right support from all stakeholders in the final decision-making process. To make this possible, a regional organ must be created that is responsible for the future harbour structure planning.

Finally, many of the factors involved in the concept of sustainable development have been used in previous harbour investigations, but no investigations have used the actual concept of sustainable development. In incorporating sustainable development into the planning process for a new oil harbour structure, the DPSIR model can be used to underline important relationships and to ensure that no important details and issues are overlooked in the planning process.

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8. Training stakeholders in conflict resolution in land use planning with the focus on risk

8.1 Introduction

The pilot course on 'Conflict resolution applied to coastal zone management in the Baltic Sea region' was developed and implemented during the autumn of 2006. The aim of this pilot course was to provide deeper knowledge and understanding of problems connected with developing activities in coastal zones, such as building new harbours or expanding existing facilities. These activities involve different risk factors that can lead to conflicts. The aim of the course was to practise, train and give suggestions to participants about complexity connected with decision-making from the sustainable development (SD) perspective. Particular attention was devoted to integration of the risk aspect in the overall land use planning process. Risk was one of the criteria used to assess different locations and to evaluate SD. The course was also used as a method to study how the participants handled the concept of risk in a decision-making process and how the perception of risk changed during the course.

The basic idea when constructing the course was to collect and share experiences gathered in the case studies carried out in the COASTMAN project and to provide participants with the potential to exchange knowledge and experiences and to improve their practical skills and develop their understanding of conflict resolution methods. This was mainly achieved through studies and discussions of different methods, tools and experiences of conflict resolution around the Baltic Sea Region (BSR).

The participants in the course consisted of project partners and a variety of invited stakeholders from different countries around the BSR. There were 35 course participants in total, with diverse backgrounds and experiences such as scientists, politicians, municipal officials, harbour officials, government employees and students. Some of these were directly involved in the project case studies carried out in the different countries, while others were purposely invited to take part in order to create a desirable mix of experience and knowledge among course participants.

Scientists came from: Tallinn University of Technology, TuTech Innovation GmbH in Hamburg, University of Latvia, Klaipeda University, The Royal Institute of Technology, Commission for Nature Protection of the Russian Geographical Society, Russian State Hydro meteorological University.

Officials came from: Municipal Government of Haapsalu (Estonia), Riga City Local Agenda 21 Office (Latvia), SIA (Regionalie projekti, Latvia), Ventspils Port Authority (Latvia), Port Infrastructure Office (Lithuania), Primorsk Urban Municipality (Russia).

Government employees came from: Nacka Municipality (Sweden), Free and Hanseatic City of Hamburg Department, Environmental Emergency Response Unit (Germany), Ventspils City Council Environmental Department (Latvia), Territory Development and Planning Group Property and Territory Development Department (Lithuania), Stockholm City Planning Committee.

8.2 Background information

8.2.1 Pedagogical ideas behind the course

When constructing the course, the following pedagogic concepts and ideas were included:

- The pilot course was built around a virtual case study and a role play, both based on the same decision-making situation connected with land use management - where to build a new oil harbour. Using this approach, the course participants were given the potential to reason around the idea of SD, experience unavoidable conflicts and learn about methods to mitigate them, all without having self-interest in the conflict.
- Role play was chosen as a suitable learning method because it provides the opportunity to reflect on the complexity of social or environmental issues and has the potential to facilitate learning processes in these fields (Henriksen 2004). Land use planning in coastal areas is a good example illustrating the complexity of such a process.
- The pilot course was not constructed as a university course for higher education students but was rather a course based on the knowledge and values of different types of stakeholders. This meant that a very important part of the knowledge and experiences came from the participants themselves, supplemented with lectures and discussions of different methods, tools and experiences of conflict resolution around the Baltic Sea Region.
- Due to the international character of the course, a website was developed to serve as an information and communication platform – providing study materials, course results, links and a discussion forum (http://www.webforum.com/pilotcourse).

8.2.2 Course structure

The course was divided into two seminars held over a three-month period. The seminars included individual assessment, lectures, work in groups and discussions. Between the seminars the website served as a contact link. There were thus three essential components of the course: the virtual case study, the role play and the course website.

Seminar 1 began with a block of lectures, after which participants were divided into smaller groups to discuss what SD means in general and to attempt to reach consensus about the criteria that should be used to evaluate SD in a harbour planning process. These criteria were used to compare four harbour locations suggested in the virtual case, together with analysis of possible conflicts. The last task was to choose the best possible harbour location and suggest methods and procedures for the decision-making process. Results from the group work were documented and presented during the final joint discussion.

Seminar 2 centred on role play. The role play simulated a decision-making process, and the course participants played the roles of different stakeholders, practising negotiation and workshop techniques. The role play storyline was based on the virtual case. Two groups performed the same role play, discussing several topics and trying to reach agreement about each of them. At the end of the seminar, both groups reconvened and presented their results.

8.2.3 Virtual case

The virtual case study developed for the pilot course simulated the possible geographical, environmental, historical and political situation between two countries. To illustrate this

situation, a storyline and a map were used. The storyline described the current situation between the two countries and the dynamics of their relationship, while the map visualised the storyline. Both the storyline and the map were presented in a way that left spaces for course participants to fill with their own ideas.

The storyline described two neighbouring countries that were both experiencing rapid economic growth and that had decided to collaborate in building a new port for oil imports to their two largest cities. The countries were situated by the sea and separated by a bay. A bridge with good transportation capacity connected the two countries. The coastline and the water were used for different purposes, for example tourism, fishing, water supply and natural habitats. Four different harbour locations were presented as possible locations (Figure 8.1).

This virtual case was used during both seminars but with different approaches. During Seminar 1, the main task was to choose one location as a possible future harbour from four suggested locations, after analysing the four locations according to SD criteria and possible conflicts. None of the suggested locations was an optimal choice. During Seminar 2 the same map was used but the storyline was rewritten in order to suit the purposes of the role play.

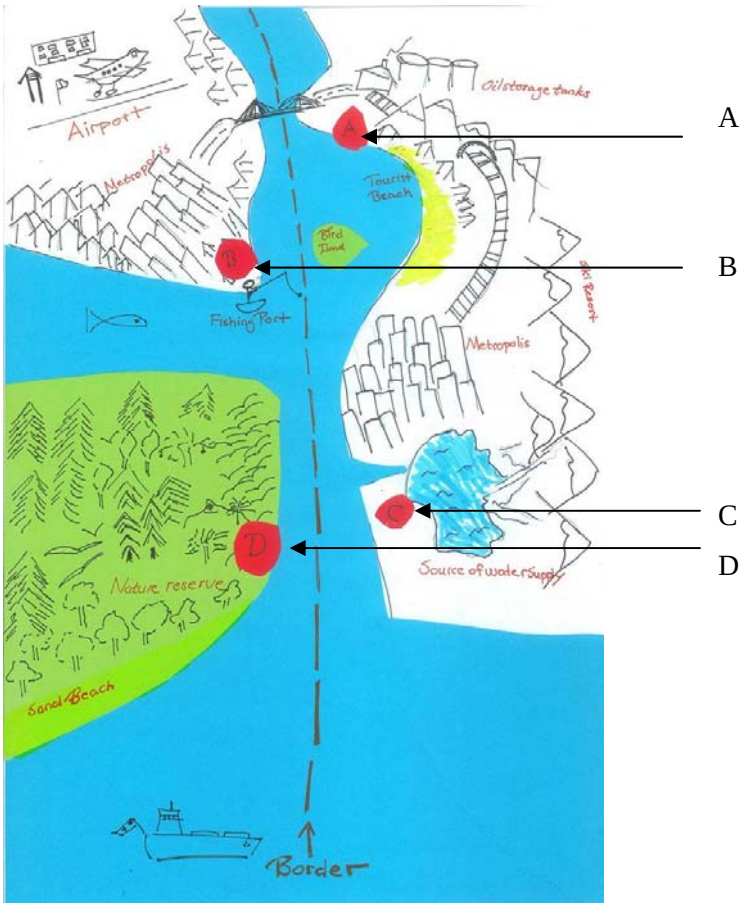

Fig. 8.1. The map used in the virtual study case with four suggested harbour locations (A, B, C, D).

8.2.4 Website

As mentioned above, a website with different functions was developed for the course. Without these functions it would not have been possible to carry out a distance learning course such as this.

The website was divided into two parts; a restricted site with detailed information for the course participants and a public site with a general description of the course and contact information for people interested in receiving more information about the course.

The following information was made available on the restricted site:

- Logistical information; course programme, timetable for seminars
- Virtual case description; map and storyline
- Material for the role play
- Library with study materials
- Material from the lectures
- Results from group work during the seminars

The course website also contained useful functions such as:

- Information & exchange forum
- Sharing of documents and other materials
- Discussion forum
- Personal profile

The course participants were introduced to the website by filling in their own profile and by uploading a short reflection about how they wished to relate their professional work to sustainable development (SD).

During the entire course, all information about course content, timetables and logistical information was distributed through the website. On the website, the course participants could find information about each other and keep in contact.

Before the virtual case seminar in Riga and the role play seminar in Stockholm, questions for the group work and role play instructions were published on the website. After the seminars, the course participants presented their group work and the results of the role play in the website library.

8.3 Seminar outcomes and lessons learned

8.3.1 Seminar 1: Riga. The virtual case – choosing the best possible harbour location

The seminar in Riga lasted one and a half days and began with lectures, after which the participants worked with the virtual case in groups. There were five working groups consisting of 6/7 individuals. The seminar finished with a joint plenary session where group work results were presented and discussed.

The main focus during the seminar was on sustainable development (SD) and conflict resolution. The work was divided into the tasks listed below and participants were asked to

keep a record of their work in order to make presentations during the plenary session and to produce a written report.

- Write a personal reflection about how to relate your professional work to the concept of SD
- Discuss SD, develop and agree upon criteria for SD
- Create a table that compares four given harbour locations according to the criteria
- Analyse the four harbour locations according to possible conflicts
- Choose one harbour location as a result of your analyses; motivate your choice
- Suggest how the decision-making process associated with the chosen harbour location should be carried out and list the methods that could be used

The first day started with a welcome speech by the Latvian Minister of the Environment, followed by opening information about the course structure. The subsequent block of lectures covered different subjects relating to the planning processes, stakeholder participation and conflict resolution and analyses. The first lecture was an introduction to a method of framework analysis, with the applications and experiences from studies in Guanabara Bay, Brazil. The next lecture informed participants about planning and decision-making processes in Swedish municipalities, with an example from Nacka municipality. The last two lectures of the first day were about ideas and concepts of SD and methods for conflict resolution and decision-making processes. A lecture given during the second day described the opinions of a Latvian NGO concerning harbour expansion in Riga. All lectures given during the seminar were later made available on the course website.

In order to prepare the participants for the course, they were asked to submit an assessment before the seminar. Participants were asked to write a short reflection about how they would like to relate their professional work to the concept of SD and upload it onto the course website. These reflections were also briefly presented by participants when the group work started.

The work in groups started with a discussion about concepts of SD; participants presented their personal opinions and the first task was to reach consensus about the criteria that should be used when evaluating SD in a harbour planning process. The next step was to analyse the suggested harbour locations in the virtual case according to the SD criteria. The participants had to choose one location that best fulfilled the criteria for SD. The last task was to discuss and devise suggestions regarding how to carry out a decision-making process in connection with the chosen harbour location and the methods that should be used for this.

The participants were asked to record all results and write a short summary of the discussion. The closing part of the seminar comprised a plenary session during which the groups presented their results and discussed them together. Finally there was an open vote where all groups decided the best location for the proposed harbour. After the seminar, groups had two weeks to complete their reports and upload them onto the website.

8.3.2 Results of Seminar 1

All working groups succeeded in completing the tasks assigned and chose a harbour location according to suggested methodology. However the results differed between groups. This was a good result because the virtual case was created so as not to have one optimal solution.

During the work with the virtual case, participants found that the virtual case storyline was written in quite a general way. This approach created confusion in the beginning but also encouraged participants to use their imagination and initiated discussions in groups. Participants were asked to fill out the storyline with their own ideas and suggestions.

There were no disputes as regards SD consisting of three aspects; economic, social and environmental. The discussions arose when different groups had to decide what criteria should be used to evaluate harbour locations and whether the criteria should be positioned under the different aspects (economic, social and environmental) or handled all together. The argument for not grouping criteria under different aspects was that some of the criteria could be added to all groups. The risk as a criterion was highlighted by all five groups; both as a risk of accidents and as risk of environmental damage. In addition, the importance of economic risks such as destroying local fishing communities or tourism enterprises was stressed.

After analysing the harbour locations according to the SD criteria and possible conflicts in all four locations, consensus had to be reached about where to locate the new harbour. The results from the groups were not those anticipated when the virtual case was being constructed. When comparing harbour locations according to the SD criteria, groups used different approaches. Some groups made a more quantitative assessment, evaluating locations according to SD criteria using a grading system, e.g. 1-5 or labelling locations with plus and minus points and then adding these together. Two groups completed their analysis with additional criteria: one group suggested WCS and other group legal circumstances as additional criteria for the final harbour choice.

After choosing a harbour location, the groups gave examples of decision-making processes that could be used, e.g. SWOT analyses (Strengths, Weakness, Opportunities, Treats) logical framework analyses, hearings, interviews, downstream conflict resolution processes. At the end of the seminar all groups gathered together and presented and discussed their results in the final plenary session. In the open vote about harbour location, locations A and C got the most votes, followed by location B as the best for the future harbour. None of the participants voted for location D (Figure 8.2).

8.3.3 Seminar 2: Stockholm. The role play – decision/negotiation process simulation

The seminar in Stockholm lasted two days. Participants performed the same role play in two separate groups, each consisting of over 15 participants. The role play simulated a decision-making and negotiation process, which was divided into two different parts - a pre-negotiation part and a formal negotiation. The participants acted as stakeholders negotiating about the status and responsibilities of a future harbour commission.

The role play storyline was based on the virtual case, rewritten for this purpose. The storyline now concerned a negotiation process in which two countries agreed that a Permanent Harbour Commission (PHC) should plan a new oil harbour. Before the PHC could start its work, a Temporary Commission (TC) had to meet to discuss and decide on several issues that were essential for the PHC work.

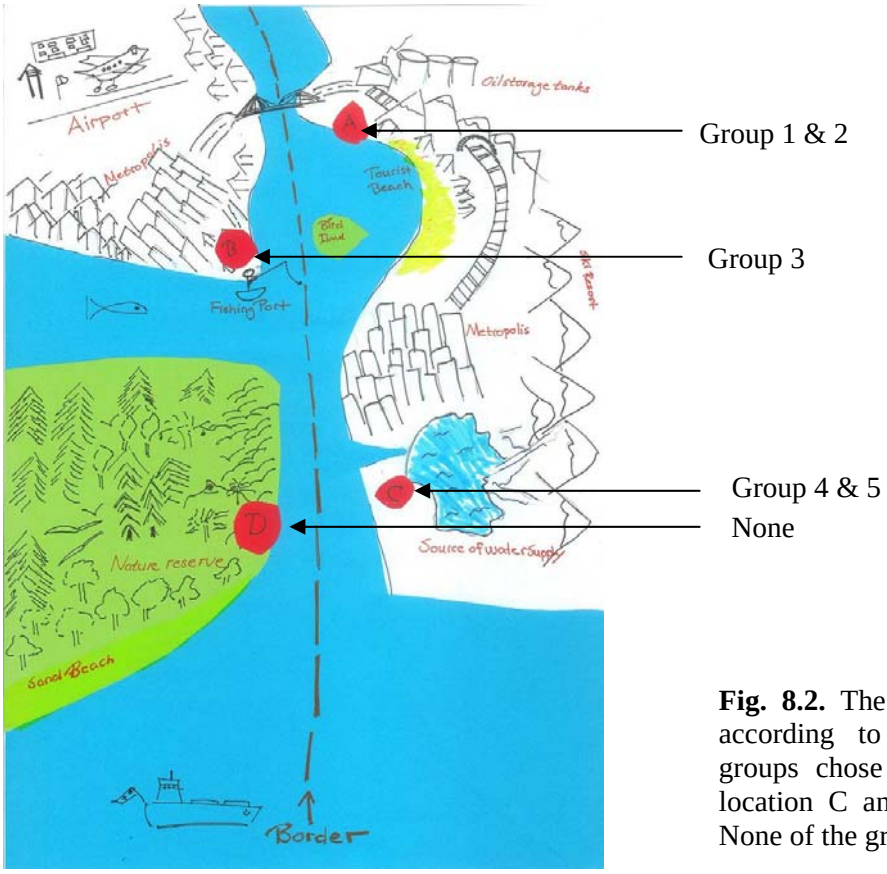

Fig. 8.2. The chosen harbour location according to the five groups. Two groups chose location A, two groups location C and one group location B. None of the groups chose location D.

The central issue for the whole negotiation process was to reach agreement about the following topics, which were chosen to reflect the aims of the course:

- Procedures of the PHC (members and chairman)
- Guiding principles of the PHC
- Defining mandate of the PHC
- Securing financial resources for harbour construction, location and impact
- Defining procedures for establishing broad support in the process of finding and deciding the new harbour location
- Assessing environmental consequences of the new harbour

The TC consisted of the following stakeholders:

- Ministries; trade and environment
- Small businesses; tourism organisations, smaller fishing industries
- Large businesses; petroleum industries, harbour associations
- NGOs; nature protection organisations, birdwatchers
- Chairman (leader of the negotiation in the role play)
- Local authorities
- Scientists representing universities

Before the seminar, participants were issued with role instructions, which gave them suggestions about what positions and opinions a particular role should have, in order to help them act out. The roles were distributed between participants according to their background;

for example a person working in local authority played the local authority role. Through this, participants were given the possibility to use their own experience from their daily work.

To prepare the course participants for the role play, a general storyline and negotiation instructions for each role were also distributed before the seminar. The general story included the following SD policy, which participants had to discuss during the negotiation process:

- SD involves three main sectors, social, economic and environmental, and a balance must exist between these three sectors
- SD is development that meets the needs of the present without compromising the ability of future generations to meet their own needs
- Harbour structures should be planned from a SD perspective
- In the harbour planning process, the factors that civilians in the country/countries believe to be the most important must be taken into consideration

The first seminar day started with a brief introduction to familiarise the participants with the role play storyline and structure. The pre-negotiation part then began. During this, there were bilateral discussions and participants had to find out as much as possible about each other's opinions on different topics and create alliances. In the formal negotiation phase, there were six topics on the agenda to be negotiated. Participants were expected to present their own ideas about the topics and to reach agreement/consensus about the topics; a two-thirds vote was required for approval. The role play finished with a presentation of the group results, the differences between the results were discussed and the participants shared their opinions about the role play as a whole.

8.3.4 Results of Seminar 2

Group 1

Group 1 agreed that the members of the PHC should be similar to the TC, all members should have the same voting rights and the chairman of the commission should be on a rotating basis between all TC members. It was also agreed that the PHC guiding principles should be based on the harbour SD policy but some extra principles were added and underlined:

- The harbour should not be located in the drinking water supply or in the fishing areas
- Recreation areas for future generations, the nature reserve and the bird island had to be protected
- New energy sources had to be studied

The PHC would make the final decision about harbour location and the governments of both states would ensure that the harbour was constructed according to the guiding principles and future operation.

To secure the financial resources, the costs of harbour infrastructure and ownership would be shared between both states and the commercial companies would pay for the superstructure. In the event of an accident, the polluter pays principle would be used and a fund established.

To establish broad support in the process of finding and deciding the new harbour location, the public would be involved by hearings and giving feedback. The documents of the PHC would be published on the internet before the decision about the harbour was made by the PHC and the PHC would take public needs into account.

Before the PHC could decide about the harbour location, an environmental impact assessment (EIA) would be needed and both governments and the businesses concerned would have to cover the costs of the EIA and further environmental monitoring.

Group 2

Group 2 established restrictions concerning membership and chairing of the PHC. Members should be similar to the TC but with only one member representing small businesses and one member representing NGOs. The chairmanship would change on a rotating basis between local authorities.

The PHC guiding principles would be based on the harbour SD policy. The PHC would be responsible for investigating the harbour location and the government would make the final decision. Public opinion would be important but would not be the only factor in the decision-making process.

The government and local authorities would have to secure and control the financial resources for the harbour construction and make a risk agreement to secure financial resources in the event of an accident.

A referendum about the harbour location would not be necessary for establishing broad support in deciding about the new harbour location because the documentation for the harbour decision-making process would be made public. The PHC would decide about the structure of the information campaign (why the harbour is needed and how it should be constructed) and which documents should be made public and when.

The location of the harbour with the smallest impact on the environment would have to be chosen or special measures would have to be introduced to minimise the impacts or to compensate for them. All investigations, for example EIA, would have to be carried out by specialists (scientists). The government and the local authorities would have to decide who would pay for these investigations.

8.3.5 Questionnaire

To study whether the opinions of the course participants about SD and stakeholders changed during the course, a questionnaire was used during both seminars. In the questionnaire the participants ranked the factors they thought were important in a harbour planning process (see below). According to the results of this questionnaire, there was no obvious change in the opinions regarding SD. However, a significant finding was that the risk of accidents was listed as the most important factor to be taken into account during both seminars. Figure 8.3 shows that 80% of the respondents ranked the risk of accidents as the most significant factor.

Factors

1. Risk of accidents.
2. Emissions to water.
3. Transport facilities.
4. Regional sustainable development.
5. Regional development.
6. Near to source of drinking water supply (when planning a new harbour, attention should be paid to how close the drinking water supply is).
7. Near nature reserve (when planning a new harbour, attention should be paid to distance to the nature reserve).

8. Energy consumption.
9. Employment.
10. Distance to oil consumers.
11. Opinions from oil companies.
12. Opinions from NGO.
13. Opinions from harbour companies.
14. Noise.
15. Unsightly appearance.
16. Opinions from politicians.

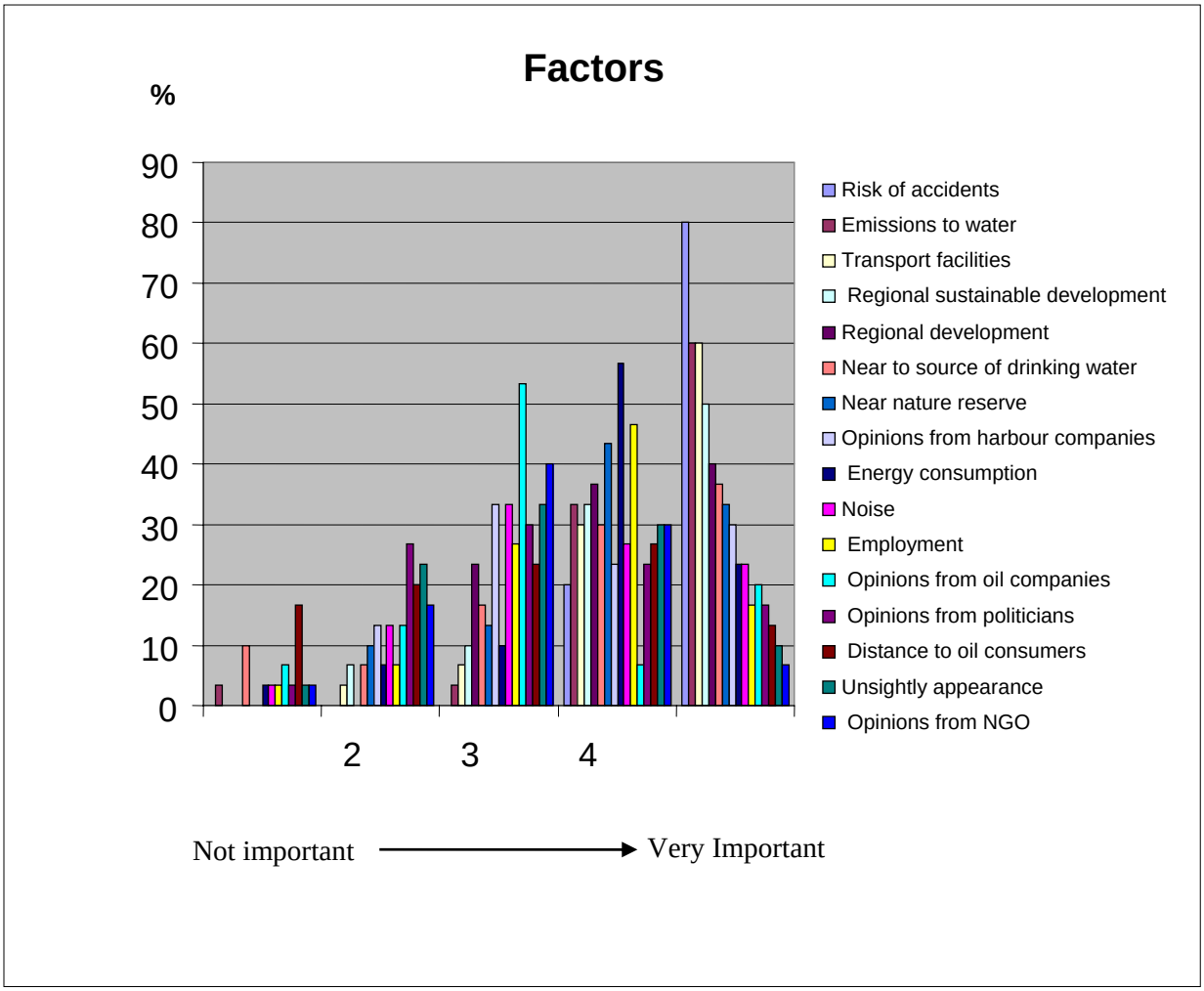

Fig. 8.3. Ranking the factors important to take into account for land use management in coastal zones.

8.4 Critical Summary

Several interesting aspects emerged during the discussion about the concept of SD at the first seminar in Riga. The participants had no difficulties in defining the concept of SD as a common vision, but there were disputes regarding what kind of SD criteria should be used specifically in a harbour planning process. The risks to people and to the environment emerged as an important factor that can trigger conflicts, e.g. risk of polluting water resources.

The task for the five groups during Seminar 1 was to choose one harbour location from four alternatives given using their own SD criteria and conflict analyses. Despite the fact that the groups used a similar methodology, the results differed. Of the four possibilities given in the virtual case, all groups avoided alternative D (nature reserve), two groups chose alternative A, two alternative C and one alternative B. One group used 'worst case' as a start before they looked at different criteria.

The results from the role play during Seminar 2 were also interesting. Two groups enacted the same role play in parallel but reached different outcomes. The task was to decide the structure and tasks of the proposed permanent harbour commission (PHC). The results showed how different aspects and values can come into expression during a negotiation process, as shown in the group reports. For example:

The idea of democracy
Group 1 decided that all stakeholders who were members of the original commission should also be members of the permanent commission, and all of them should have the same voting rights and share the chairmanship. They gave the permanent commission the right to make the final decision. Group 1 also decided that all material should be made public and published on the internet. Group 2 excluded some of the stakeholders representing NGOs and smaller companies from the permanent commission and delegated the chairmanship to the local authorities and the decision-making rights to the government. They also thought that the permanent commission should decide which documents should be made public.

The vision about SD
Group 1 expressed an ambition to develop the SD harbour policy and concretised what SD meant for their region (virtual case study), in other words they tried to use the general vision of SD in a more local way. Group 2 adhered to the suggested general SD harbour policy given to them in the beginning of the role play.

Future accidents
There was also a distinct difference concerning the topic of who should pay in the event of an accident. Group 1 assumed the polluter pays principle, while Group 2 decided that the government, the local authorities and investors should take the economic responsibility for any future accidents.

Several interesting features about conflict resolution emerged during seminar discussions. When working with the task of locating a new harbour, the strengths and weaknesses of the SD concept/approach were visualised. The strengths were identified as the vision of SD and a feeling of working in the same direction, which does not create any greater conflicts. The weaknesses were visualised when trying to apply SD ideas in a tangible case, a local planning process. During the discussions, stakeholders' values affected the results regarding e.g. what interests should be prioritised, how local and regional conflicts were described and understood, etc.

The ambition of the course was to visualise differences (natural, cultural, etc.) between stakeholders, opinions about legal and market aspects, democracy, political systems and gender. Awareness of these differences was expected to have positive effects on people's understanding of each other and in that meaning contribute to conflict mitigation.

The exercise during Seminar 1, when the participants were forced to establish a common position about one of four suggested harbour locations, clearly showed participants that the

decision-making process is not only based on facts and science but in fact on values, attitudes and the ability to handle these. This became even clearer during the role play, where the ideas of democracy, transparency and stakeholder participation in the decision-making process were reviewed. In our opinion, this shows how discussions and participation are important parts of the democratic process for SD and conflict resolution applied to coastal zone management of land and water.

We believe that the structure of the course and the pedagogic exercises, with one virtual case and one role play, increased participants' knowledge and awareness about conflict resolution and SD. It visualised different values and attitudes to central questions for SD and conflict resolution, such as democracy, publicity and stakeholders' possibilities to participate in and influence the planning process.

The specific results of the group discussions and negotiations in the role play and the results of the group work during Seminar 1 naturally reflected a number of important conditions linked to the course implementation, such as group composition as regards nationality, knowledge of languages, profession, gender, age and experience in this subject area. The course had a heterogeneous composition of participants reflecting all these different perspectives (companies, planners, genders, nationalities etc.), which is important in a course such as this, because it creates a dynamic process. The heterogeneous composition of groups was also the driving force in visualising different values and attitudes, which are often important reasons behind conflicts about the use of land and water in the coastal zones. This makes it possible to apply the course in areas with the focus on other conflicts.

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The Course website is available at http://www.webforum.com/pilotcourse
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9. Summary and discussion

In a democracy, we have to accept that decision-making processes are participatory in the sense that they involve many stakeholders in the decision, not only experts. This is important because most of the decisions cannot simply be based on facts, as values also have to be included. These decision-making processes are not only based on the principles of representative democracy, but also the fact that stakeholders can and will affect the decision in more direct ways. It is thus important to have transparent information concerning the consequences of different alternatives and in this regard, the concept of risk is one of the most difficult concepts to evaluate.

This COASTMAN project focused on a case study around the Loudden oil terminal in Stockholm. Loudden is one of several harbours in Stockholm County and the biggest oil terminal in the region. It is situated in central Stockholm. After several years of inflamed debates between stakeholders (chapter 2) such as politicians, oil companies, municipalities and NGOs, Stockholm City finally took a decision in 1999 not to prolong the contracts with the oil companies after 2011. Important motives for the decision to close Loudden were to eliminate the transportation of petroleum products via roads through the city and the transportation of petroleum products in the archipelago. Another important motive was Stockholm City's strategy to build and expand the city inwards, which means using as much existing land as possible and using existing infrastructure for building residential areas and offices.

This case study was chosen because of its complexity regarding the decision-making process and stakeholder interest. It was mainly carried out in collaboration between the Royal Institute of Technology (KTH) in Stockholm and the City of Stockholm. The area where Loudden Docks is situated is very close to the city centre and the Royal Institute of Technology (KTH). This location makes Loudden ideal for many purposes, such as a distribution node for petroleum products to the city but also potentially as a residential area, recreation area, etc.

The case study revealed that land use planning is a delicate trade-off between economic and social development and protection of the environment and between the interests of different stakeholders. This planning process requires that information concerning risks of different types can be evaluated and presented in a transparent way for all the stakeholders involved. Risk is only one parameter among many in the decision-making process, but it is often an important parameter and one which is difficult to grasp.

One of the experiences in the project is that many of the stakeholders taking part in the planning processes, including politicians and the public, have a consequence-based approach more than a risk-based approach. This means that they do not take the low probabilities of major accidents into account but merely focus on possible WCS and whether those can be handled. However, the safety reports for actual installations (chapter 4) have a much more risk-based approach relying on different methods for estimating probabilities for accident scenarios. This makes it very difficult to communicate and agree upon the results from these safety reports, which are actually the basis for decisions around the acceptance of the installations. Parts of the existing legislation also include demands for estimation of probabilities or frequencies for accidents, but no recommendations on how to calculate these. In this context, there are also proposals to use acceptance criteria e.g. societal risk and individual risk, in order to facilitate evaluation both for commercial companies and for the authorities. This project shows that this proposed approach is very doubtful because of the

inherent large uncertainties in the estimation and also because of the problem of communicating the results in participatory decision-making processes. The uncertainties are not just the result of poorly developed methods, but are actually an intrinsic property of the methodology.

As a result of this project, we therefore argue that there should be a more consequence-based approach for accidents and WCS in the safety reports where 'real' WCS are described. These can then be communicated to the stakeholders and also to the rescue services in order to decide if these WCS can be handled in a proper way and also how the risk can be reduced by robust barriers and emergency actions. Another question is who is really a user of information gathered from safety reports (the authority with responsibility for supervision, the municipality where the site is located, third parties affected by new hazards). All these stakeholders need different kinds of information in terms of both content and depth and this is something that people performing accident scenario analysis should bear in mind. The other main question concerns the reasons for producing risk estimations - emergency planning, decision making, or safety.

Safety reports should perhaps be required to produce an analysis of an accident which has the 'greatest' conceivable impact – the worst case (e.g. the entire contents of a vessel exploding). Such requirements could also be formulated in a way that leaves this question open, so that the analyses are carried out for more 'realistic' accidents – more probable accidents with slightly lesser consequences than the worst case. The reports should also include an international overview of occurred accidents at similar installations

One of the mistakes made during risk assessments is to approach possible accidents with statistical methods, i.e. to perceive such accidents as stochastic. This report argues that such an approach is flawed. The worst case approach as used in the USA gives a better starting point for emergency planning, spatial planning, and for mitigating possible effects – for example using effective passive barriers. The worst case approach is also easier to communicate and mediate to stakeholders due to its transparency – it is more useful in democratic decision-making processes.

The conclusion drawn from examination of the three safety reports in chapter 4 was that they were not fit for purpose. The LNG safety report in particular actually increased the level of suspicion between stakeholders. The aim of risk/safety assessment should be to find cause and effect chains which could lead to an accident and to improve mitigation methods for potential accidents, i.e. using effective passive barriers. Different quantitative and qualitative methods for estimation of probabilities can be used internally in companies in order to evaluate the safety and integrity of sub-systems. However, the way these methods are used in safety reports is highly unreliable.

The recommendation for further research from the COASTMAN project is that detailed guidelines should be developed for a more consequence-based approach for accidents and WCS, both for industrial sites and transport of dangerous substances. These guidelines should then be discussed among a wide stakeholder group. There should be a development towards more transparent safety reports with extended summaries which could be an important part in communication to all stakeholders in participatory decision making processes.

The results from the training package (chapter 8) showed that this type of training course where different stakeholders have to argue from different standpoints is very valuable in widening stakeholders' horizons and understanding different views and values on the concept

of risk. There is not one objective way to evaluate risk, but many depending on values and preferences.

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