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Transmitted by the experts from Norway and Sweden

## FIRE SAFETY IN BUSES

### Bus and coach fires in Sweden and Norway

Note: The text reproduced below was prepared by the experts from Norway and Sweden in order to inform about the progress of the project FIRE SAFETY IN BUSES.

# Fire Safety in Buses

## WP1 report: Bus and coach fires in Sweden and Norway



**Statens vegvesen**

Norwegian Public  
Roads Administration



**Vägverket**

Swedish Road  
Administration



SP Swedish  
National Testing and  
Research Institute

## Abstract

This report describes an investigation into bus and coach fires in Norway and Sweden during the period 1996 – 2004. In addition to straightforward information on actual numbers of fires, the work has included an investigation of the causes of fires, where they occurred and their consequences. The material has been obtained from a wide range of sources, including insurance companies, fire and rescue services, bus and coach manufacturers and bus and coach operators. The results show that the number of fires in such vehicles is high in relation to the number of fires in other categories of vehicles, such as private cars or commercial vehicles, but that they seldom resulted in injuries. Most of the more severe fires have been caused by electrical faults or by leakage of flammable liquids in the engine compartment. However, many of the source reports have not been very detailed, with the result that, in many cases, it has not been possible to assign a definite cause of fire.

**Key words:** Bus, coach, fire, statistics, risk, safety

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## **Preface**

This report forms part of a larger project concerned with the safety of buses and coaches in fires, initiated and financed by the Norwegian Public Roads Administration in Norway and by the National Road Administration in Sweden. It presents a summary and review of bus and coach fires in Norway and Sweden during the period 1996 – 2004.

## Summary

This report presents a collation and analysis of bus and coach fires in Sweden and Norway over a ten-year period, 1996-2004.

Between 1999 and 2004, an average of 49 bus and coach fires were reported each year in Norway, and 122 per year in Sweden. However, it can be assumed that the actual number of fires is considerably higher than this, as a large number of fires are not reported. This means that about 1.0-1.4 % of all buses and coaches in service are involved in fires each year. The mass media have drawn attention to the problem, and the insurance sector, together with the bus and coach industry, has taken steps to break the rising trend. Nevertheless, the number of fires is still at an unacceptably high level as, in percentage terms, about 5-10 times as many buses and coaches catch fire as do heavy goods vehicles.

Fortunately, despite the surprisingly high number of fires, injuries to persons have been very limited. However, the potential risk of a catastrophe is high, if a fire should occur in a situation where escape was difficult. An example of such a case occurred in Poland in 2005, when 13 persons died. Sweden has seen several examples that have nearly turned into catastrophes, such as the Fjärdhundra accident in 1998 and that in Arboga in 2006, which would have had very much more serious consequences in the event of a fire.

Both Norway and Sweden have seen a noticeable rise in the number of bus and coach fires between 1998 and 2001. The level in Sweden then stabilised, while the number of bus and coach fires in Norway shows a slightly declining trend. The reason for the rise over the 1998-2001 period is strongly linked with the more stringent noise regulations that were introduced on 1<sup>st</sup> October 1996.

Information for this report has been collected from other reports, internet searches and contact with other sources and public authorities such as insurance companies, bus and coach builders and operators, and the National Board of Civil Defence, Rescue and Fire Services. A recurring feature throughout the process of information acquisition was that of poor documentation, with the result that, in most cases, there are many unknown aspects of each fires. The main causes of fires in buses and coaches have shown themselves to be electrical faults and leakage of flammable liquids.

The actual number of fires per year is an estimate, based on material from the reported cases and on information from those responsible for insurance assessment of fires in vehicles. The unreported cases can, for example, consist of incidents below the insurance excess values, or of cases dealt with under the manufacturer's or builder's warranty.



# 1 Introduction

## 1.1 The background to the project

The Norwegian Public Roads Administration in Norway and the National Road Administration in Sweden wish to investigate the circumstances connected with fires in buses and coaches. The materials, designs and construction of buses and coaches as used today do not provide an acceptable level of safety against fires, and so a research project was started in order to investigate the situation in more detail. The project was divided up into eight sub-projects:

1. Collation and presentation of bus and coach fires over the last 10 years.
2. Identification and presentation of present-day interior materials.
3. Risk assessment of bus and coach designs and uses.
4. Evaluation of fire walls between engine compartment and passenger space.
5. Development of test methods for water-based extinguishing systems in small engine compartments.
6. Simulation of fires in passenger spaces using CFD models.
7. Full-scale trials.
8. Suggestions for changes in the fire safety design aspects of buses and coaches.

This report presents the results of sub-project 1. As far as Norway is concerned, there is already a report from SINTEF<sup>1</sup> covering bus and coach fires over the period 1997-2000, which means that, in this report, the Norwegian situation is covered only for the period 2001-2004.

The question of fire safety in buses and coaches is very much of current interest, not least bearing in mind the recent accident in Sweden when a coach went off the road near Arboga. If the accident had resulted in a fire, the results would have been catastrophic. The subsequent reaction is well characterised by the following report in Göteborgsposten on 2006-01-31:

On 2006-01-27, a coach drove off the road and down into a ravine outside Arboga, resulting in severe damage. The fire and rescue service was soon at the crash site, and took steps to prevent a fire. A few days later, on Monday 30<sup>th</sup> January, traffic police in Gothenburg stopped and inspected 23 buses. The operation lasted two hours, between 09.00 and 11.00. *15 buses were found to have oil leaks in their engine compartments, of which one was so serious that the vehicle was served with a notice requiring it to be resubmitted for full road safety inspection. Two buses had defective fire-fighting equipment.*

“The bus company manager blames lack of money, but this is not an acceptable argument as far as traffic safety is concerned”, says health and safety representative Gunilla Ohlin.

The work on sub-project 3 (Risk assessment of bus and coach designs and uses) has also shown that cost plays an increasingly important part in all aspects of bus transport, with a specific effect on vehicle maintenance. There is also a considerable difference between the amount of maintenance as recommended by manufacturers and the amount that is actually performed by users.



## **1.2 The objective of the project**

The objective of this sub-project is to provide better understanding of the causes of fires, and of their progress, in buses and coaches, thus contributing to a reduction in the number of such fires and in their seriousness. The intention has been to produce as comprehensive a survey as possible, concentrating in particular on:

- The number of bus and coach fires, and their causes.
- The damage caused by fires, and the resulting costs.
- Injuries resulting from fires.

## **2 Definitions**

### **2.1 What is a bus or coach fire?**

In order to simplify interpretation of the results, and to prevent any misunderstandings arising, we should start by defining the concept of a bus and coach fire. This is necessary because the various information providers can have different interpretations of what they regard as a fire.

The insurance companies' main concern is with claims for damage caused by fires. Therefore, they employ a definition which, in addition to fire itself, includes other events that could have resulted in a fire. Events other than a fire itself, covered by fire insurance, and therefore included in the concept of fire, include lightning strike, explosions and also *short-circuiting of electric wires, i.e., there does not need to be a visible fire.*

Fire and rescue services are seldom called out to minor incidents such as short circuits in electrical systems, and therefore have no classification for this in their statistics.

In collecting our information, we have not been able to distinguish between these different views, but have had to accept each particular information provider's definition of a fire, treating them all together in order to provide as comprehensive a basis as possible.

### **2.2 What types of vehicles are included in the investigation?**

This investigation has been concerned with coaches on regular routes or tourist coaches, carrying more than 22 persons (Classes I, II and III). Local buses in regular urban traffic are also included. In a few individual cases, it would have been possible to include larger buses or coaches used for other purposes in the investigation. However, these are vehicles that could have been included in the category described above. Minibuses have not been included in the investigation.

## **3 Information sources and data collection**

### **3.1 General**

Fires in vehicles are always sensitive. As buses and coaches are part of the mass transport system, they form a particularly high-profile group. In the event of a more severe fire, manufacturers, operators and even organizations are often severely criticised in the mass media.

In order to obtain as much information on bus and coach fires as possible, and to be able to conduct an open dialogue with all concerned, we have therefore chosen not to provide specific details of persons, manufacturers, operators or organisations without their approval. Most of the parties whom we have contacted have been generous and helpful with information, although some instances of reticence have been found.

### **3.2 Information sources**

Most of the information in this report has come from insurance companies, DSB (Direktoratet for Samfunnsikkerhet & Beredskap, brann- og eksplosjonsvern) and SCB (Statistics Sweden), as well as from the previous SINTEF investigation<sup>1</sup>. However, we have also received valuable information from bus and coach builders and from certain operators/bus companies.

Although not all parties holding information on bus and coach fires have participated, the quantity of information was sufficient to enable us to make a good estimate of the total number of such fires. It is estimated that 90-95 % of all reported fires in Sweden are included, and that about 90 % of those occurring in Norway are included. In addition to the reported fires, there is naturally a certain unknown quantity of fires that have not been reported. See Section 4.1.1 for a discussion of the possible number of such fires.

The Norwegian and Swedish police forces do not have any common data base for vehicle investigations, and so it would have been very resource intensive to attempt to collect such data. We have, therefore, refrained from using police reports. However, a lot of the police's information is indirectly included, as it is often reported to the fire and rescue services and/or public authorities.

### **3.3 Information content**

The content of present-day data bases concerning bus or coach fires varies in extent, although information from recent years is usually more comprehensive than older information. In some of the data bases, it is only in the last few years that buses and coaches have been identified as a special group, which has introduced a greater degree of uncertainty into the results. Private cars and goods vehicles, on the other hand, of which numbers are considerably greater, have been identified in separate groups for many years.

Due to capacity limitations, the insurance companies do not have particularly detailed information going back further than five years.

For both Norway and Sweden, much of the information is based on post-event reports from the fire and rescue services. These reports are in the form of standard forms (generally digital), which have certain limitations. The time available at the site of an accident is seldom sufficient to allow personnel to carry out a more detailed investigation

of the cause of a fire. In general, judgements are based on experience as to whether a fire has been deliberately set or whether it has been due to a technical fault. In some cases, technical faults have been broken down into areas such as electrical faults, leakage of flammable liquids or friction.

As the tendency to investigate fires in vehicles, and also the necessary skills for doing so, are relatively limited in the fire and rescue services, information of this type needs to be treated with some caution. The police investigate fires only if they suspect a crime (arson). However, information on the number of reported fires is reasonably reliable.

### 3.3.1 Insurance companies

The insurance sector has a vested interest in investigating the reason for each fire. There is also a strong link between costs and the type of events, one of the effects of which is to provide a good indication of the extent of a fire. However, many buses or coaches are not covered by fire insurance, and are therefore not included in the companies' statistics.

Table 1 and Table 2 show figures from the largest insurance companies in Norway and Sweden, together with approximate indications of their market shares. Despite very overlapping information from SCB and DSB, we have been able to avoid duplication as a result of information on the time and place of fires, and also in certain cases on the vehicle registration number.

**Table 1. Swedish insurance companies that have provided data for the investigation.**

Company, Sweden	Market share (%)
Trygg Hansa <sup>2</sup>	> 65
Länsförsäkringar <sup>3</sup>	About 20
IF <sup>4</sup>	5 - 10
Other	< 5

Most of the information for Norway has been provided by the country's largest insurance company, Gjensidige.

**Table 2. Norwegian insurance companies that have provided data for the investigation.**

Company, Norway	Market share (%)
Gjensidige <sup>5</sup>	> 50
Vesta <sup>6</sup>	> 30
IF <sup>7</sup>	> 10
Other	< 5

### 3.3.2 DSB

DSB, the Directorate for Civil Defence and Emergency Planning, holds the official statistics for bus and coach fires in Norway<sup>8</sup>. Its data base is based mainly on reports from the police and fire and rescue services, and includes information on time, place and, to some extent, the probable cause of the fire. However, the cause of the fire is seldom documented with much detail, but is indicated merely by a code. Many bus and coach fires are simply classified as 'Other', which means that they may not show up in a search. It is estimated that the police attend about 75 % of all bus or coach fires in Norway.

### **3.3.3 SCB**

SCB, Statistics Sweden, is the central administrative authority for the official statistics of bus or coach fires in Sweden. Its material, too, generally includes information on the time, place and, to some extent, the reason for the fire. SCB receives its information primarily from event reports from the fire and rescue services. Until 2005, these event report forms did not indicate Bus/Coach as a specific group, which meant that a number of bus or coach fires were simply classified as 'Other', and were not always included in the statistics<sup>9</sup>.

### **3.3.4 Manufacturers**

Bus and coach manufacturers have an obvious interest in finding the cause of every fire, and often perform very thorough fire investigations in order to do so. We have been able to obtain information from this source on the number of fires and some information concerning their causes.<sup>10, 11</sup>

### **3.3.5 Bus and coach operators**

Bus and coach operators very seldom possess the necessary skills to investigate fires, but leave investigation to insurance companies, manufacturers or independent investigators. However, many of the companies do have excellent documentation of fire incidents, from which some of them have been able to provide us with information on individual fires, times, places and sometimes also the causes of fires.

### **3.3.6 The bus and coach sector**

Organisations for the bus and coach sector are the Federation of Norwegian Transport Companies (TL) and the Swedish Bus and Coach Federation (BR). Both organisations attach great importance to traffic safety, with the aim of ensuring that bus and coach travel not only is, but is also seen to be, the safest form of road travel. In both countries, the organisations have left the provision of information on bus and coach fires to others, and refer to their insurance companies.

## 4 Results

### 4.1 General

The sources of the information on which the data in this chapter are based are presented in detail in Chapter 3.

#### 4.1.1 Unreported fires

The material previously described in this report relates to reported fires. However, there is also a relatively large proportion of bus or coach fires that is not reported, and which is not included in the statistics. These are fires of which DSB, SCB and/or the insurance companies are not notified for various reasons, such as:

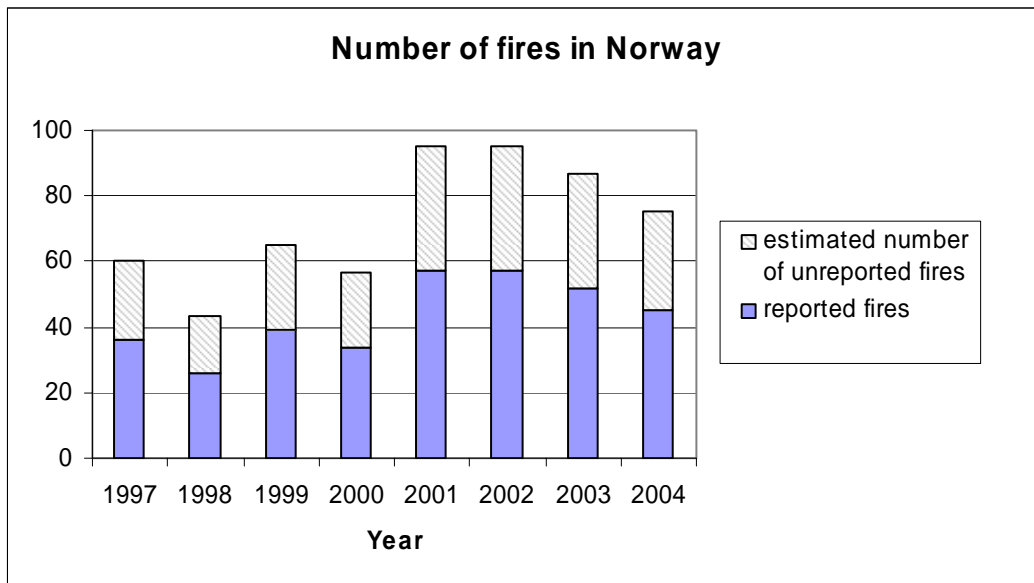
1. The vehicle is not insured against fire.
2. The excess payable in the event of a claim exceeds the amount of the claim.
3. Police or fire and rescue services were not called out, and/or did not assist in extinguishing the fire.
4. The cost of the damage is covered by the manufacturer's warranty.
5. Other reasons that we do not know.

The vehicle manufacturers, too, may not receive information on all fires or incidents (as defined in Section 2.1 above), due to shortcomings in reporting procedures etc. Generally only larger fires that are reported back to the manufacturers. A fire investigation usually takes about a day to perform and so, in order to reduce their standstill times, operators may not bother to submit a report. It is difficult to put an exact figure on the number of undocumented fires in this shadow zone. We have therefore tried to estimate the number of such fires by interviewing persons in the insurance and automotive sectors with considerable experience of bus and coach fires. Many of them feel that the number of unreported fires is about the same as the number of those that are reported. A realistic assessment is therefore that the number of unreported fires probably amounts to about two-thirds of the number of reported fires.

### 4.2 The number of fires in Norway and Sweden

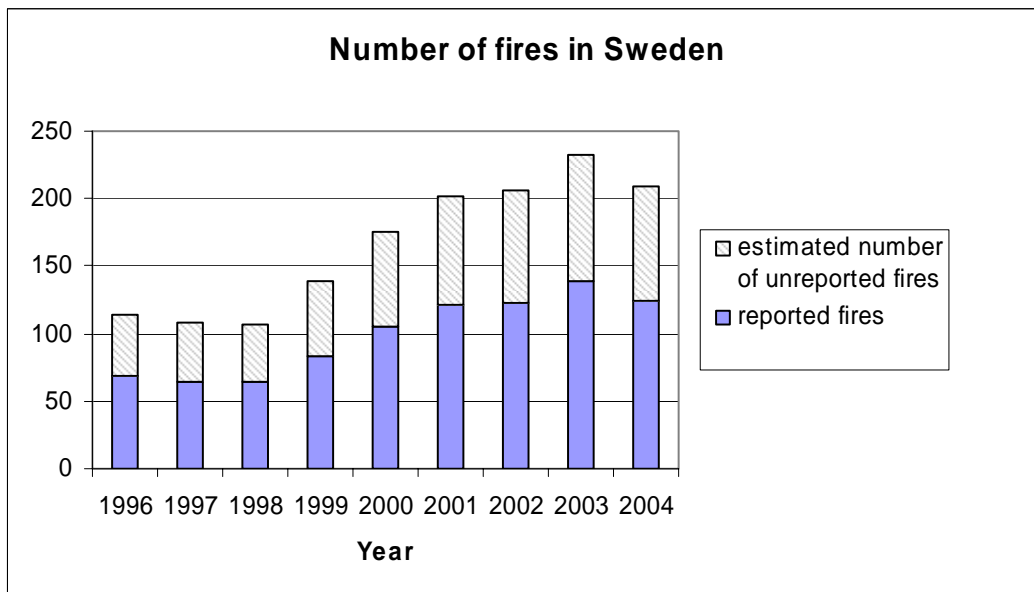
This section describes the number of reported bus and coach fires in Norway and Sweden, with the estimated number of unreported fires also indicated in the results.

Figure 1 shows the number of such fires in Norway between 1997 and 2004. The shaded parts of the columns show the number of fires estimated to have occurred, but not shown in the statistics. Data for the period 1997-2000 has been taken from SINTEF's report<sup>1</sup>.



**Figure 1. The number of bus or coach fires in Norway, 1997-2004.**

Figure 2 shows the number of reported bus or coach fires in Sweden over the period 1996–2004. The shaded parts of the columns show the number of fires estimated to have occurred, but not shown in the statistics.



**Figure 2. The number of bus or coach fires in Sweden, 1996-2004.**

### 4.2.1 The number of bus or coach fires in Norway and Sweden as a function of the number of vehicles, 2000 – 2004.

Table 3 and Table 4 present a summary of the number of bus or coach fires as a function of the number of vehicles. The figures include buses or coaches in regular timetabled traffic or tourist traffic carrying 22 persons or more (Classes I, II and III).

**Table 3. Fires in Norwegian buses/coaches**

Year	Number of buses/coaches	Number of reported fires	Number of reported fires, (%)	Total no. of fires, including uncertainties	Total number of fires, (%)
2000	8 608	34	0,40	57	0,66
2001	8 542	57	0,67	95	1,11
2002	8 518	57	0,70	95	1,12
2003	8 494	52	0,61	87	1,02
2004	8 520	45	0,53	75	0,88
<b>Mean value</b>	<b>8 519</b>	<b>49,0 (5 years)</b>	<b>0,58</b>	<b>81,8 (5 years)</b>	<b>0,96</b>

**Table 4. Fires in Swedish buses/coaches**

Year	Number of buses/coaches	Number of reported fires	Number of reported fires, (%)	Total no. of fires, including uncertainties	Total number of fires, (%)
1996	14 720	68	0,46	114	0,78
1997	14 783	65	0,44	109	0,74
1998	14 902	64	0,43	107	0,72
1999	15 106	83	0,55	139	0,92
2000	14 536	105	0,72	175	1,20
2001	14 465	121	1,45	202	1,40
2002	14 292	123	0,86	205	1,43
2003	14 120	139	0,98	232	1,64
2004	13 883	125	0,90	209	1,51
<b>Mean value</b>	<b>14 464</b>	<b>122,6 (5 years)</b>	<b>0,85</b>	<b>204,6 (5 years)</b>	<b>1,42</b>



### 4.3 Injuries to persons in bus or coach fires

Statistics concerning the number of persons killed or injured in bus or coach fires are available from both SCB and DSB. Other information providers do not have such information in their material. See Table 5 and Table 6 for a summary of this data. Fortunately, no deaths from fire were reported for the period under investigation.

The Norwegian statistics for the period 1997-2000 show a very low incidence of injuries, with only a few cases of drivers suffering from smoke inhalation<sup>1</sup>. This is similar to the data made available for the later period of 2001-2005, as shown in Table 5.

Apart from the more serious accident and fire in Fjärdhundra in 1998, injuries are few and of a less serious nature. In most cases of fires, the incidents have been of such a type, and have occurred in such places, as to allow the vehicles to be safely evacuated.

**Table 5. Number of persons injured in bus or coach fires in Norway over the period 2001-2005.**

Year	Injuries, drivers	Injuries, passengers
2001	0	0
2002	0	1
2003	0	0
2004	0	0
2005	0	0

**Table 6. Number of persons injured in bus or coach fires in Sweden over the period 2001-2005.**

Year	Injuries, drivers	Injuries, passengers
1996	3	"Few"
1997	0	0
1998	0	26
1999	0	2
2000	1	0
2001	2	1
2002	0	3
2003	1	2
2004	1	0
2005	0	0

## 4.4 Causes of reported fires

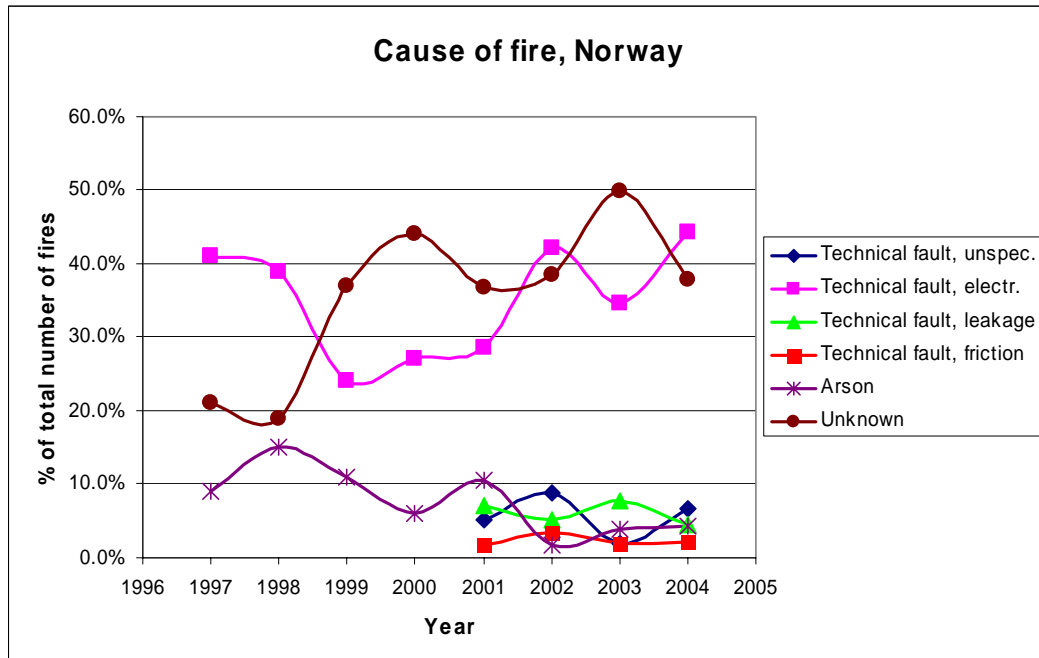
### 4.4.1 Causes of reported bus or coach fires in Norway

Figure 3 and Figure 4 show the reported causes of bus or coach fires in Norway, broken down into six different categories:

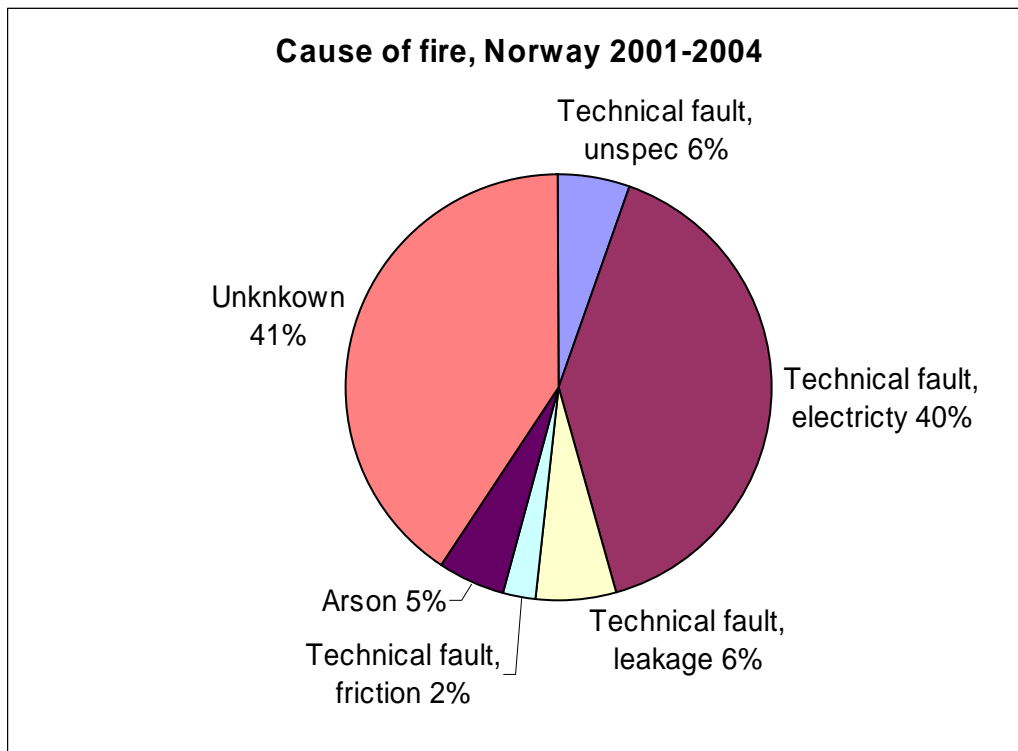
- Technical fault (unspecified, but not arson).
- Technical fault, electrical (the fire has started in the vehicle's electrical system).
- Technical fault, leakage (the fire has started as the result of leakage of a flammable liquid, ignited by [for example] coming into contact with the hot exhaust system).
- Technical fault, friction (the fire has started as a result of frictional heating, usually in the wheel bearings or braking systems).
- Arson.
- Unknown.

Figure 3 shows these causes plotted on a year-by-year basis, while Figure 4 shows the types of fires, expressed as a five-year average.

Data is available for the Electrical Faults, Arson and Unknown categories from the SINTEF Report<sup>1</sup> for 1997-2000, and has been included in Figure 3 in order to reveal any trends. The cause of some of these fires is uncertain, and has therefore not been included in the figure.



**Figure 3.** The causes of fires in Norwegian buses or coaches between 1997 and 2004, shown as a proportion of the total number of reported fires. Data from 1997-2000 has been taken from the SINTEF report<sup>1</sup>.



**Figure 4. Breakdown of causes of fires over the period 2001–2004: Mean values.**

#### **4.4.2 Causes of reported bus or coach fires in Sweden**

Figure 5 and Figure 6 show the reported cause of bus or coach fires in Sweden. The categories are the same as those for Norway (see above).

Information on the causes of fires differs very considerably between Norway and Sweden, particularly for the category of ‘Technical Fault’, which Norway indicates as being responsible for about 40 % of fires, while Sweden cites it for only about 10 %. This indicates some uncertainty, particularly in the writing of event reports.

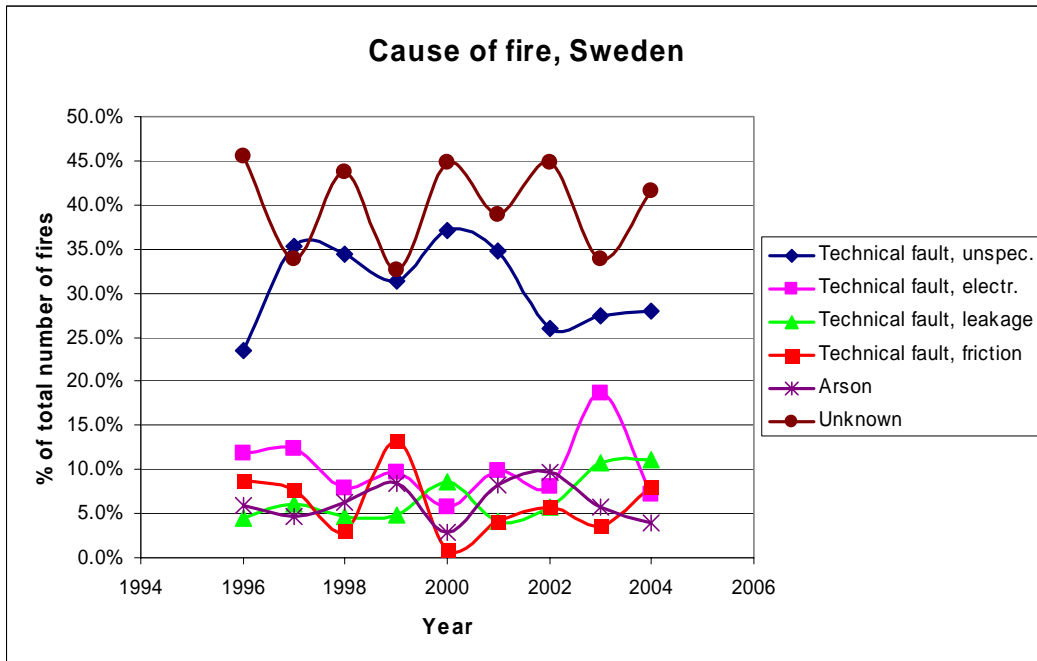


Figure 5. Causes of bus or coach fires in Sweden, 1996 - 2004.

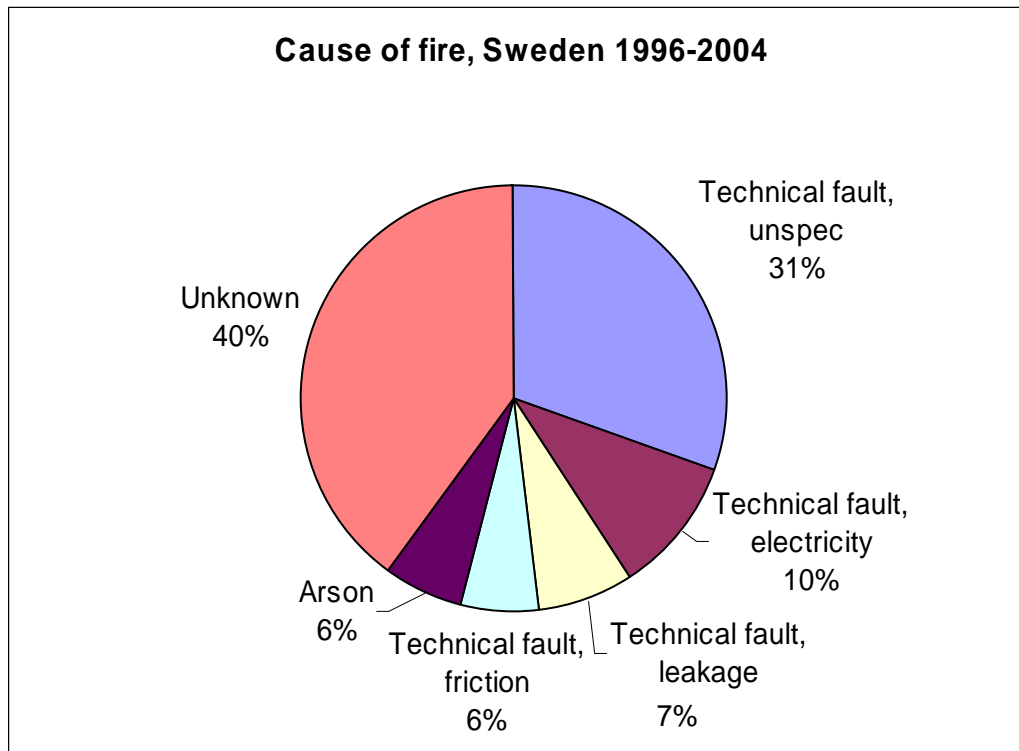


Figure 6. Breakdown of causes of fires in Sweden over the period 1996–2004: Mean values.

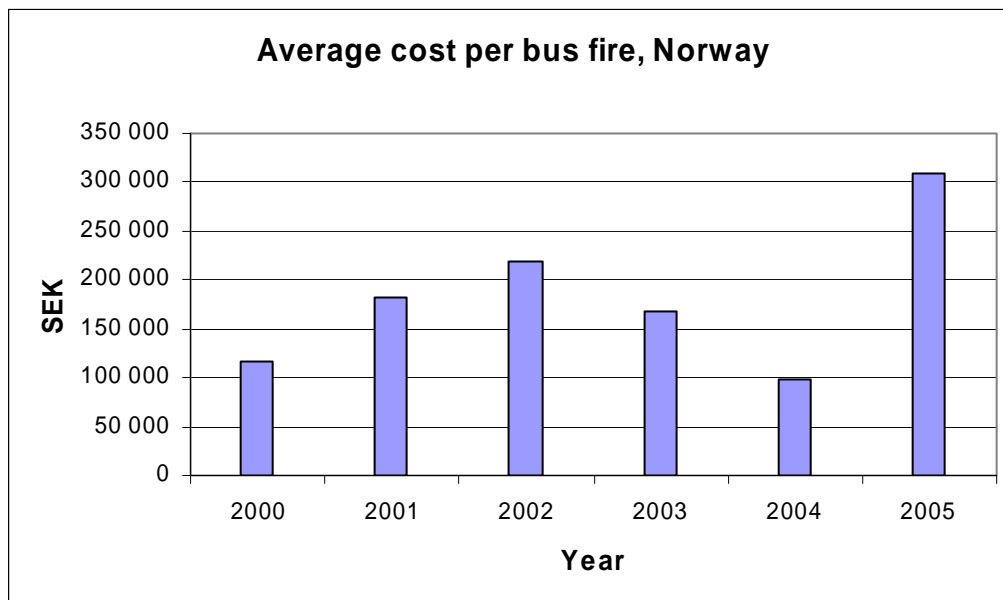
## 4.5 Consequential costs of bus or coach fires

Insurance companies have provided us with information on the size of settlements of claims for fires in buses or coaches. However, these costs are, of course, not the entire cost to all affected as a whole, as costs for loss of availability, loss of revenue etc., are not included. The true costs can therefore be considerably higher than the costs shown in this report.

### 4.5.1 Consequential costs of bus or coach fires in Norway

Figure 7 shows the average settlement payments in Norway over the period 2001–2004. In order to simplify comparison between Norwegian and Swedish conditions, all costs have been converted to Swedish crowns (SEK).

The average settlement payment is lower in Norway than in Sweden, and the apparent downward trend between 2002 and 2004 can be seen to be only temporary. If we ignore smaller settlements (below NOK 10 000), the average value of settlements increases by between 20 and 50 %. The information from 2005 covers only 10.5 months of the year, and represents a substantial increase in settlement payments.



**Figure 7. Average cost (SEK) per bus/coach fire in Norway, 2000 - 2005.**

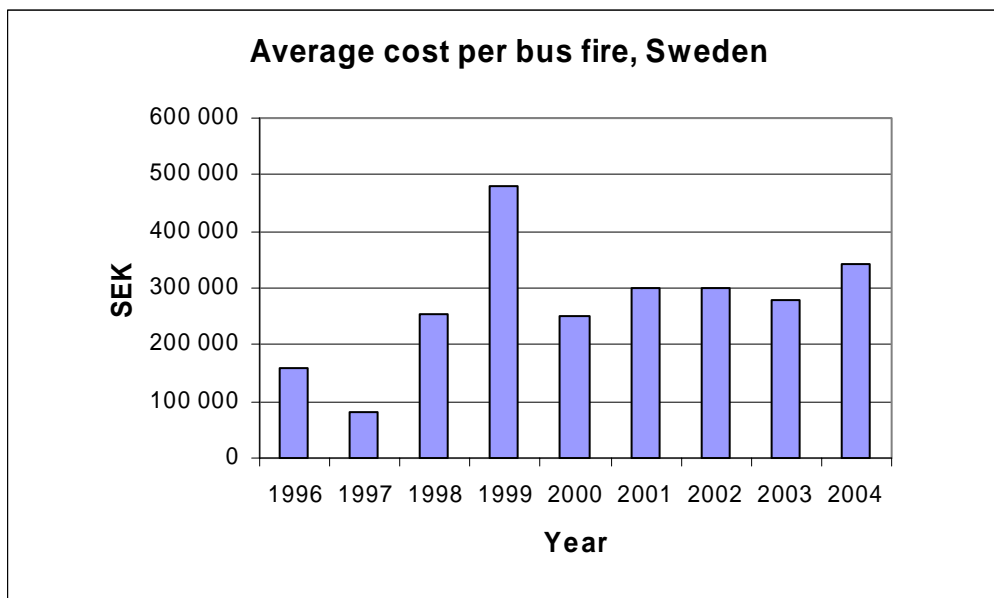
Table 7 is an overview of the size of settlement payments in connection with bus/coach fires, based on information from Gjensidige. It is only the insurance companies that have access to information on costs. Note, therefore, that the table does not include figures for all fires, and that the number of insured vehicles can vary from year to year.

**Table 7. Summary of claims and settlements in Norway (Gjensidige), during the period 2000 – 2005-11-15**

All claims (incl. lesser incidents)				Only claims over NOK 10 000			
Year	Total payouts (NOK)	No.	Average settlement (NOK / SEK)	Year	No.	Total payouts (NOK)	Average settlement (NOK / SEK)
2000	3 194 114	33	96 791 / 116 323	2000	27	3 163 202	117 156 / 140 798
2001	3 175 953	21	151 236 / 181 755	2001	17	3 145 310	185 018 / 222 354
2002	4 379 225	24	182 468 / 219 290	2002	19	4 338 363	228 335 / 274 413
2003	1 663 471	12	138 623 / 166 597	2003	8	1 638 941	204 868 / 246 210
2004	737 535	9	81 948 / 98 485	2004	6	735 899	122 650 / 147 400
2005	2 581 600	10	258 160 / 310 256	2005	9	2 556 045	284 005 / 341 317
Av.		15	144 329 / 173 454	Av.	14		181 137 / 217 690

## 4.5.2 Consequential costs of bus and coach fires in Sweden

Figure 8 and Table 8 provide corresponding overviews of the size of settlement claims for bus/coach fires in Sweden, as provided by two insurance companies. Over the whole period, it can be seen that the average cost per fire is tending to increase. The peak in 1999 seems to be of temporary character. The average cost of fires is somewhat higher in Sweden than in Norway.



**Figure 8. Average cost (SEK) per bus/coach fire in Sweden, 1996-2004.**

Note that the figures in Table 8 include only information from insurance companies, and do not include all fires.

**Table 8. Summary of claims and settlements in Sweden (Länsförsäkringar and Trygg Hansa), during the period 2000 – 2004.**

Year	All claims (including lesser incidents)		Claims in excess of SEK 10 000	
	No.	Average settlement	No.	Average settlement
2000	35	397 643	24	584 830
2001	47	537 448	37	683 135
2002	46	620 659	30	1 005 032
2003	58	506 761	44	667 769
2004	53	486 372	36	719 281
Average (5 years)	48	510 000	34	732 000

## 4.6 Summary of the results

Table 9 and Table 10 present a summary of all the data in terms of the number of fires and their causes, for all reported bus/coach fires over the period 1997-2004. Data for fires in Norway over the period 1997-2000 has been taken from SINTEF's report<sup>1</sup>, which is why there is no breakdown for the causes of the fires during these years.

**Table 9. Bus/coach fires in Norway, 1997 – 2004.**

Bus/coach fires in Norway							
Year	Total number of fires	Technical faults	Technical faults, electrical	Technical faults, leakage	Technical faults, friction	Arson	Unknown
1996	-	-	-	-	-	-	-
1997	36	10	15	-	-	3	8
1998	26	7	10	-	-	4	5
1999	39	12	9	-	-	4	14
2000	34	8	9	-	-	2	15
2001	57	3	22	4	1	6	21
2002	57	5	24	3	2	1	22
2003	52	1	18	4	1	2	26
2004	45	3	20	2	1	2	17
<b>Total</b>	<b>346</b>	<b>49</b>	<b>127</b>	<b>13</b>	<b>5</b>	<b>24</b>	<b>128</b>

**Table 10. Bus/coach fires in Sweden, 1996 – 2004.**

Bus/coach fires in Sweden							
Year	Total number of fires	Technical faults	Technical faults, electrical	Technical faults, leakage	Technical faults, friction	Arson	Unknown
1996	68	16	8	3	6	4	31
1997	65	23	8	4	5	3	22
1998	64	22	5	3	2	4	28
1999	83	26	8	4	11	7	27
2000	105	39	6	9	1	3	47
2001	121	42	12	5	5	10	47
2002	123	32	10	7	7	12	55
2003	139	38	26	15	5	8	47
2004	125	35	9	14	10	5	52
<b>Total</b>	<b>893</b>	<b>273</b>	<b>92</b>	<b>64</b>	<b>52</b>	<b>56</b>	<b>356</b>

## 5 Analysis and discussion

The number of fires in buses or coaches is high in comparison with the number of fires in other vehicle categories; up to 5-10 times higher than the number of fires in private cars or goods vehicles. Fortunately, the number of injuries is very few. There are, however, a number of examples from other countries showing how such fires can have serious consequences, such as a bus/coach fire in Poland in 2005, in which 13 persons died.

### 5.1 Reported and estimated numbers of fires

As described in Chapter 3, the information in this report covers about 90 % of the reported bus or coach fires in Norway and Sweden. This means that the figures that we give are somewhat on the low side, and that the estimated unreported fires (two-thirds of the reported numbers) are also probably relatively conservative values.

Some care should be taken when making comparisons with existing data from Norway for the period 1997-2000. The material for the SINTEF investigation is probably very similar to that used for this investigation for the period 2001 and on, but there may be some differences in the extent and definition of fires, as described in Chapter 2.

### 5.2 Trends and causes

#### **The increase in the number of bus/coach fires since 1998**

This investigation has shown a very clear increase in the number of bus or coach fires between 1998 and 2001. In Sweden, the number of reported cases doubled, from 60 to 120 per year, and there was a similar development in Norway. A possible reason for this increase could be the introduction, from 1<sup>st</sup> October 1996, of two new requirements for buses and coaches in Europe:

1. The permissible noise level was reduced from 83 to 80 dB(A), which represents a halving of the noise level. This also meant that it was necessary to totally enclose engine compartments in order to comply with the requirement.
2. New emission requirements. Euro 2 engines have to operate at somewhat higher engine temperatures.

It was the noise requirements in particular, necessitating new engine compartment enclosures, which resulted in considerably higher temperature levels and reduced ventilation in the engine compartments. Although there was no immediate effect in terms of the number of bus/coach fires, the number did increase noticeably after a few years when the number of new buses had grown and the vehicles were beginning to show their age. We can see a clear increase over the period 1998-2001 in both Norway and Sweden.

Present-day buses and coaches are worked very hard. In order to pay their way, they have to be on the road for as long as possible, which in turn requires careful maintenance. Maintenance should be structured so that the vehicles continue to maintain a high standard, or have a high second-hand value. Unfortunately, the general pressure on costs also affects maintenance, and thus increases the risk of fires. Ideally, vehicles should be serviced regularly and at short intervals, with parts or materials in poor condition being replaced at an early stage. Unfortunately, when there is not enough money, operators tend to test the limits of their equipment in the hope that equipment can last a little longer.



### 5.3 The causes of reported fires

When comparing the causes of fires between Norway and Sweden, we notice a substantial difference between ‘Technical Faults’ and ‘Technical Faults, Electrical’, with Norway having a substantial number of fires defined as having been caused by electrical faults, while Sweden has a large number of unspecified technical faults. ‘Technical Faults, Leakage’ are surprisingly low in both countries. Previous experience from investigations of fires in vehicles says that ‘Technical Faults, Electrical’ and ‘Technical Faults, Leakage’ should both be at about the same level.

If we compare the material from DSB/SCB with that from detailed fire investigations, it becomes quite clear that many of the fires defined as ‘Technical Faults’ should be ‘Technical Faults, Leakage’. ‘Technical Faults, Friction’ and ‘Arson’ are regarded as being of reasonable values. Finally, the proportion of ‘Unknown’ is high, and should probably be proportionately allocated between the other causes. See Table 11.

The reason for the levels varying, and for the high proportion of unknown causes of fires, can be traced to the lack of detailed investigations. Time available at the site of an accident seldom allows the fire and rescue personnel to investigate the cause of a fire, while at the same time the necessary skills to investigate fires in vehicles by the fire and rescue services is also relatively limited.

**Table 11. Breakdown of causes of fires between Norway and Sweden.**

Cause	Norway (%)	Sweden (%)	Differences between the two countries	Comments on the levels
Technical faults	5,7	30,6	Considerable	See text above.
Technical faults, Electrical	39,8	10,3	Considerable	See text above.
Technical faults, Leakage	6,2	7,2	Within the margin of error	Too low level.
Technical faults, Friction	2,4	5,8	Within the margin of error	OK
Arson	5,2	6,3	Within the margin of error	OK
Unknown	40,8	39,9	Within the margin of error	Assign it proportionately between the other causes

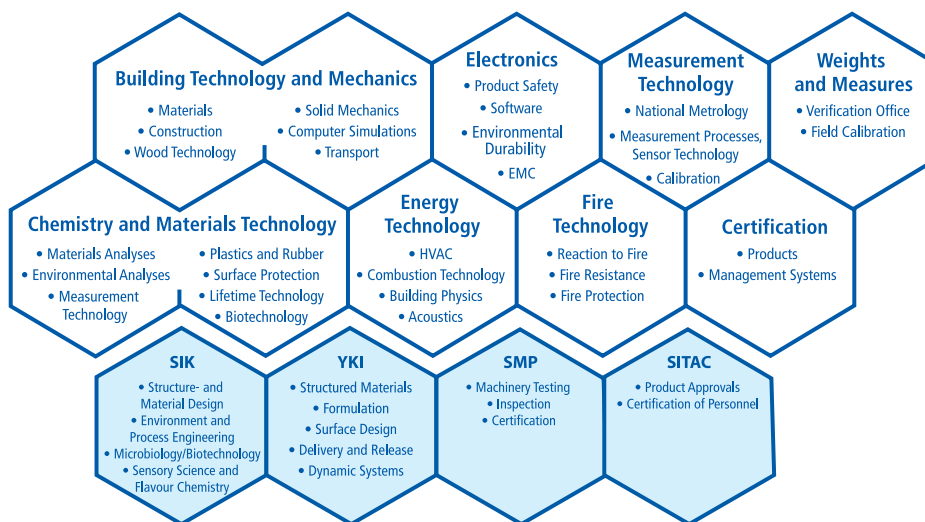
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- 6 Vesta Forsikring, Rune Klubnes
- 7 IF Norway, Tor Andresen
- 8 DSB, Direktoratet for for samfunnssikkerhet og beredskap, brann- og eksplosjonsvern, Anne Myrestøl
- 9 SCB, Statistiska Centralbyrån, Lena Bernhardt
- 10 Scania Buss AB, Kaj Kanesund
- 11 Volvo Buss AB, Jan Andersson

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