Trends in Risks Associated with Gas

by H. Pequignot and M. Bertin

"Gas" is regarded at present as one of the forms of energy which presents the least health problems. All studies comparing the hazards of the various forms of energy have come to the same conclusion.

For reasons of method this article views the situation from the viewpoint of the responsibilities and liabilities of the gas undertakings. When the gas supplied to customers was produced from coal, the risks inherent in mining the coal were not added to those of the production and distribution of the gas. Likewise, the problems raised by the production and transport of petroleum products which may be used by the gas industry, apart from natural gas of course, will not be considered here.

At the outset, three particular points deserve to be stressed:

- Hazards exist at the stage of use and not at that of production; in this respect, gas differs from nuclear power and coal and the problems of prevention are therefore quite different;
- The hazards have declined sharply in the course of the past 25 years, and even at the distribution stage they have become fewer than in the case of most other forms of energy;
- The collection of epidemiological data was, and still is, better than in other power industries.

PRODUCTION AND TRANSPORT

Natural gas

The principal problems relate to alteration of the environment and accident risks:

- French natural gas production originates almost entirely from the Lacq deposit, the working of which raises an environmental problem owing to possible accidents involving atmospheric pollution by sulphur derivatives;
- In any case, however, the larger part of the gas which we consume is imported.

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The undersea gas pipelines, the methane tankers and the "methane terminals" (where these ships unload and where the natural gas can in part be stored in tanks) obviously involve safety problems similar to those of the transport and storage of oil. So far no accident of this type has occurred in France, but the risk does exist.

Transport by gas pipelines and underground storage, on the other hand, are especially safe in spite of recent criticisms, which appear to be entirely unfounded.

In short, risks to human beings are minimal because:

- the gas industry operates with no or with very few plants;
- the "raw materials" are not modified but are simply purified and treated;
- the labour component is very small at the production and transport stages — a few thousand persons for more than 12 per cent (to rise soon to 16 per cent) of the total energy distributed in France;
- the gas industry is fully automated.

Liquefied petroleum gases

This industry has certain features which distinguish it from the natural gas industry:

- Production is a part of the oil industry because the products are largely obtained in refineries;
- Transport entails more hazards than in the case of natural gas, since railway wagons, barges and road vehicles are used and not gas pipelines. The accident involving a propylene transporter at Los Alfaques in Spain showed up the potential hazard;
- Storage on the users' premises also calls for precautions.

DISTRIBUTION AND USE

Health hazards exist at the distribution stage and in particular during use. They are related to the physical characteristics (inflammability and danger of explosion) and the chemical nature of hydrocarbons.

They have practically no toxicity:

Methane

This is the main constituent of natural gas. It has no true toxicity and is an inert gas, leading to asphyxia only by reducing the oxygen content of the air; it thus causes anoxia.

Experimental studies on man and animals have shown that they can live without discernible consequences in an atmosphere containing methane, which is of course the well-known fire-damp of coal-mines, and that any troubles are due to the lowering of the oxygen content of the air breathed in.

Other hydrocarbons

They undoubtedly have a slight true toxicity but act essentially by causing acute anoxia.

The real toxicological problem lies elsewhere — in the form of asphyxia caused by the gases formed during incomplete combustion, very often due to insufficient ventilation, i.e. insufficiency of air to support combustion. These combustion gases not only contain large amounts of carbon dioxide but also have high contents especially of carbon monoxide.

The asphyxia caused by them is therefore acute carbon monoxide poisoning, aggravated by a high content of carbon dioxide and occurring in an atmosphere saturated with water and very often depleted in oxygen, the second aggravating factor. It is not always easy in practice to distinguish between the pure, relatively benign anoxia due to hydrocarbon inhalation and the much more serious carbon monoxide poisoning by combustion gases; this gives rise to a number of errors with grave consequences.

A last comment on toxicity: although the specific toxicity of these hydrocarbons is certainly minimal, some recent publications have drawn attention to certain effects (cardiac, haematological and so on) varying as a function of the length of the hydrocarbon chain and its degree of saturation. Further research should be carried out in these areas.

THE REDUCTION OF RISKS

The changes which have taken place in the gas industry have had important consequences.

At the production stage

The disappearance of conventional gas works has certainly represented a gain from the health standpoint.

Apart from local atmospheric pollution, these plants exposed the operating personnel to various risks, which were sometimes minimized since no epidemiological study was made; it is now certain, as statistics in various countries (including France) show, that the frequency of some cancers, especially lung cancers, was clearly higher in certain jobs than among the rest of the personnel. These particularly dangerous jobs have disappeared completely; however, such cancers have a very long latent period (more than 20 years) and can therefore appear very late.

At the distribution stage

The gas produced from the distillation of coal or the cracking of petroleum products had a variable content of carbon monoxide, regardless of the process used. This carbon monoxide represented the major risk; acute poisoning by unburnt gas, i.e. the classic cases of gas leaks resulting from unlighted burners, extinguishing due to overflowing of liquids, and cracked or broken connections, accounted for nearly 90 per cent of the deaths attributable to this form of energy.

Asphyxia by combustion gases and explosions resulted in a much smaller number of victims.

RESPECTIVE RISKS OF DIFFERENT ENERGY SOURCES

Replacement of gases containing carbon monoxide by natural gas has radically altered the situation. Actual carbon monoxide poisoning due to gas leaks has of course disappeared, since natural gas contains no carbon monoxide. On the other hand, asphyxia due to combustion gases and explosions are, relatively speaking, by far the most frequent accidents, even though in absolute terms such accidents are fairly few in number — some 15 to 20 cases of death result annually from explosions.

It is very difficult to prevent these accidents, for the responsibility for the occurrence itself lies not with the producer but with the user. In France there are more than eight million units in operation, which cannot in practice be inspected efficiently. Another equally generalized risk is the problem of education of the consumer and the quality and reliability of the appliances and units at his disposal.

The difficulties of prevention and the nature of the technical problems which it raises are thus quite different, depending on whether we are speaking about production or utilization of energy.

It must be borne in mind that, because of rises in the price of hydrocarbons, the trend in the future may well be towards further distillation of coal and that certain risks may reappear. However, the gas to be produced for domestic, tertiary and commercial use will no longer be town gas as we have known it, but one which will be a substitute for natural gas, if only to avoid a fresh conversion of appliances and units, and will offer the same advantages from the health point of view.

Results

During the 26 years from 1950 to 1975:

- The amount of gas distributed by Gaz de France increased by a factor of 12.8;
- According to INSERM[1] statistics, the number of suicides by asphyxia declined by a factor of 7.5;
- The number of accidental deaths by asphyxia declined by a factor of 14.5.

If the rate of deaths by accidental asphyxia related to consumption had remained the same as in 1950, there would not have been 44 recorded deaths in 1975 but more than 8000. This shows how much progress has been achieved. Likewise, in 25 years, the annual number of suicides by gas dropped by about 400. This naturally does not necessarily mean that the number of suicide attempts decreased, but demonstrates, almost experimentally, that inhalation of natural gas involves very low risks of asphyxia (Table 1).

The same trend is likewise observed in other countries. In Great Britain, where suicides by gas accounted for 50 per cent of the total (as compared to 6 per cent in France), the rapid disappearance of coal gas even had the effect of reducing the total number of recorded suicides for some years, because would-be suicides, unaware of the different nature of the gas, continued to resort to this method (Table 2).

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[1] INSERM Institut National de la Santé et de la Recherche Médicale (National Institute of Health and Medical Research)

Table 1. Number of deaths due to gas between 1950 and 1975 (Sources: Gaz de France, INSEE[1] and INSERM[2])

Year	Gas sales, millions of therms (Gaz de France)	Suicides by asphyxia due to gas	Total number of suicides	Deaths by accidental asphyxia among gas users		Accidental deaths from other combustion gases
1950	10 096	430*	6402	640		239
1951	10 489	444*	6567	588		238
1952	10 956	429*	6547	593		208
1953	11 155	455*	6571	703		268
1954	11 738	503*	6974	751		245
1955	12 397	420*	6903	761		319
1956	13 624	546*	7577	805		356
1957	14 300	537*	7268	671		322
1958	15 406	554*	7390	746		272
1959	15 706	603*	7569	735		253
1960	17 114	500*	7222	661		271
1961	17 983	427*	7305	532		251
1962	20 634	396*	7112	567		274
1963	22 831	447*	7433	741		319
1964	24 591	412*	7206	589		309
1965	27 249	423*	7352	667		326
1966	28 703	329*	7668	572		332
1967	31 293	355*	7716	493		301
1968	35 531	216*	7629	126		294**
1969	41 656	145*	7934	173		380**
1970	50 042	109*	7834	158		373**
1971	63 659	122*	7890	111		368**
1972	83 438	126*	8339	84**	26**	304**
1973	107 751	86*	8079	77**	20**	287**
1974	115 599	58*	8192	40**	20**	215**
1975	128 532	57*	8323	30**	14**	262**

Table 2. Number of suicides by lighting gas in France (Sources: INSEE and INSERM)

		Recorded suicides	Recorded suicides by lighting gas	Percentage of total
Annual average	1950–54	6610	452	6.84
Annual average	1955–59	7341	532	7.25
Annual average	1960–64	7256	436	6.01
Annual number	1965	7352	423	5.75
	1966	7668	329	4.29
	1967	7716	355	4.60
	1968	7629	216	2.83
	1969	7934	145	1.83
	1970	7838	109	1.39
	1971	7890	122	1.55
	1972	8339	126	1.51
	1973	8079	86	1.06
	1974	8192	58	0.71
	1975	8323	57	0.68

Table 1 (continued)

** Gas distributed through pipes (including combustion gases).
** Liquefied petroleum gases distributed in mobile containers (including combustion gases).
•• Carbon monoxide.

Suicides by asphyxia due to:
* lighting gas;
• domestic gas.

[1] INSEE Institut National de la Statistique et des Etudes Economiques (National Institute for Statistic and Economic Studies).
[2] INSERM Institut National de la Santé et de la Recherche Médicale (National Institute of Health and Medical Research)

OBSERVATIONS EMERGING FROM THE FOREGOING

This trend shows how particular technical changes can have important health consequences. Let us imagine a trend in the opposite direction; it would have been essential to foresee the additional risk in order to take the necessary preventive measures. This observation therefore justifies the studies which are carried out to evaluate the potential health risks of the various forms of energy or of new technologies of production and utilization.

Contrary to what is often said and written, the development of energy consumption is not necessarily accompanied by a parallel increase in health risks.

- In the case of gas, the number of deaths in France decreased in spite of the rise in gas consumption and the increase in the share of gas in total energy consumption. The reason lies in the profound changes which occurred in this industry;
- However, the same trend is found in the case of electricity where, at the distribution stage, there was no modification of the product supplied;
- For 26 years the number of electrocutions recorded in France, taking one year with another, has remained stable; yet during the period in question (1950–1975) electricity consumption rose by a factor of 6.3 and the number of users by a factor of 1.7, while the share of electricity in total energy consumption increased from 12.1 to 25%. Therefore, certain risks can be, and are being, controlled (Table 3).

In order to follow such trends, medical data are required; it is thus essential to carry out epidemiological surveys on a permanent basis Such surveys were made in Paris long before the war and have been carried out in France for over 25 years in the case of deaths due to gas distributed through pipes. They are based on two different sources of data, thus allowing cross-checking:

1. The mortality statistics prepared by INSEE[1] and then by INSERM on the basis of death certificates;
2. The statistics of the Prevention and Safety Service of Gaz de France prepared from accident reports.

Only the former statistics have been utilized in this article. It is possible that they may lead to some underestimation of the risk (deaths of aged persons attributed to cardiac or cerebro-vascular accidents, for example). However, the extent of underestimation is undoubtedly small and could be checked against the second source of statistics.

Statistics of this kind are not available for any other form of energy supply; furthermore, it was at the request of the International Gas Union that the World Health Organization Code was modified so as to permit recording of cases of asphyxia in accordance with their causes, i.e. by distinguishing gases supplied through pipes and those supplied in "mobile

[1] INSEE: Institut National de la Statistique et des Etudes Economiques (National Institute for Statistics and Economic Studies)

Table 3. Trends in electricity generation and in the number of electrocutions (Sources: Electricité de France, INSEE and INSERM)

Year	Electricity consumption (MTOE)[1]	Share of electricity in total supplied energy (%))	Number of users (millions)	Number of deaths by electrocution observed	calculated*
1950	5.7	12.1	–	181	–
1951	6.6	12.8	12.4	216	210
1952	7.1	13.4	12.7	208	225
1953	7.3	13.9	12.9	149	232
1954	8.1	14.8	13.2	177	257
1955	8.9	15.3	13.5	193	283
1956	9.8	15.8	13.9	153	311
1957	10.5	15.9	14.3	158	333
1958	11.4	17.4	14.6	178	362
1959	11.8	17.8	14.9	174	375
1960	13.3	18.9	15.2	184	422
1961	14.4	19.1	15.6	188	457
1962	15.6	19.8	15.9	185	495
1963	16.9	19.8	16.2	236	537
1964	18.4	20.2	16.5	239	584
1965	19.6	20.8	16.9	203	622
1966	20.9	21.2	17.3	196	664
1967	22.0	21.2	17.7	210	698
1968	23.1	21.0	18.1	153	734
1969	25.4	21.5	18.4	197	806
1970	27.3	21.5	18.9	202	867
1971	28.8	21.9	19.3	189	914
1972	31.0	22.1	19.8	171	984
1973	33.9	22.4	20.4	206	1076
1974	35.7	23.3	21.0	171	1133
1975	35.9	25.0	21.5	173	1140

* Assuming a constant ratio between electricity consumption and the number of electrocutions
[1] MTOE Million ton of oil equivalent.

containers" (liquefied petroleum gases). On the other hand, the medical consequences and after-effects of non-fatal asphyxia are not recorded.

It would be useful to consider how such surveys could be improved and the area of investigation extended.

OTHER PROBLEMS AT THE STAGE OF USE

In evaluating health risks, not only severe accidents should be taken into account.

Pollution of the premises where gases are used, which in most cases are residential, is also an important problem. Although the principal pollutants are nitrogen oxides, undoubtedly the most significant aspect is incomplete and repeated combustion and thus exposure to carbon monoxide. Obviously these risks exist only to the extent that the conditions of ventilation and use of appliances are not observed and the latter's state of repair is not properly checked.

The consequences of such pollution cannot be recorded from the epidemiological standpoint because we are here dealing with non-specific, long-term effects of very common pollutants.

CONCLUSION

The recent development of the gas industry in France has been accompanied by a spectacular decline in the risks associated with it. This proves that an increase in energy consumption can go hand in hand with a considerable diminution of risks.

It is evident, however, that a problem of this kind cannot be mastered except by applying all the necessary procedures, on the one hand in terms of production and distribution technologies and means of prevention, and on the other in terms of epidemiological data collection and medical and toxicological research.

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RESPECTIVE RISKS OF DIFFERENT ENERGY SOURCES

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