ELSEVIER

Journal of Hazardous Materials 130 (2006) 293–299

Journal of Hazardous Materials

www.elsevier.com/locate/jhazmat

# Implementation of new legislative measures on industrial risks prevention and control in urban areas

Bruno Cahen *

*Industrial Risks Prevention and Control Office, Department for Pollution and Risk Prevention, French Ministry for Ecology and Sustainable Development, MEDD, 20 Avenue de Segur, F-75302 Paris 07 SP, France*

Available online 1 September 2005

**Abstract**

Incompatible at first sight, but vital to each other, the industry and the city have been developing a complex relationship for decades. From 1810 on in France, risk prevention and control in and around major industrial sites evolves step-by-step, learning from accidents. Land-use planning in the vicinity of SEVESO[1] establishments becomes one of the key policies in the prevention of major industrial accident hazard on European level in 1996, focussing on historical situation of concern [M.D. Christou, S. Porter, Guidance on Land-use Planning as required by the Council Directive 96/82/EC. Joint Research Centre, European Commission, 1999]. The Toulouse (F) accidents, on 21 September 2001 evidenced the need for new tools to reinforce protective action and ease the situation of clusters of factories engulfed in the urban setting. In France, new legislative measures adopted on 30 July 2003 deeply modified the approach to land-use planning around the main dangerous facilities (622 establishments). The implementation of technological risk prevention plans [Fr. "PPRT"] will limit the exposition of the population to the consequences of accidents. These plans, derived from the risk assessment (safety reports) produced by the operators of the hazardous facilities, will delineate areas within which requirements can be imposed on existing and future buildings and within which future building rights may be restricted. On the grounds of extremely serious danger that threatens human life, pre-existing constructions may be progressively expropriated. The financing of the corresponding measures, estimated a rough € 2–4 billions, will be defined by agreements among the Central Government, the industrial company and the local and regional bodies.


*Keywords:* Industrial risk; Urban; France

## 1. Maintaining "appropriate distances" between dangerous activities and urban areas is a two centuries old concern in France

From 1760 to 1800, heavily polluting factories were transferred from Paris to the countryside, by royal, imperial or court decision. In 1794 the explosion of the Grenelle explosive manufacture in Paris, killing 1000 people and destroying hundred of buildings, triggered a major scientific and regulatory change. The Institute (Academy of Sciences nowadays), consulted by Napoleon, defined three categories of dangerous activities and substances. Their report [1] leads to the first general legislation on risk and pollution prevention and control of industrial activities in 1810. The question of the appropriate distance that had to be maintained between hazardous or polluting facility and their neighbours was already subject to scientific and social debate. The president of the Institute concluded that "[*the appropriate distance*] *should not be defined on purely scientific grounds. It was not possible to define the distance in the decree and, try as I might to avoid arbitrary decisions, we had to leave it to the local authority*."

More accidents in the textile, oil, processing and explosive industries during the 20th century lead the governments to complete the regulatory framework in 1917 and 1976. The 19/07/76 law [6] encompassed all activities potentially threatening their neighbourhood or the environment with accidents pollution or nuisances. In 2004 in France, 400 000 installations fell under the scope of this legislation, of which 65 000 need a permit, issued by the state, to operate.

* Tel.: +33 1 42 19 14 34; fax: +33 1 42 19 14 67.
*E-mail address:* Bruno.cahen@ecologie.gouv.fr.

[1] Referring to the "SEVESO 2" directive (96/82/EU, 9 December 1996) (JOCE no. L 10 du 14 Janvier 1997).

0304-3894/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.jhazmat.2005.07.029

The lack of legislative tools allowing compensation for land owners to maintain a safe distance and the pressure put on land-use around industrial parks during the second half of the 20th century explain part of the urban development around all major chemical and oil industrial settlements nowadays.

## 2. The legislative tools used in land-use planning before the 30/07/03 law

In 1980, a ministerial decree defined strict rules for construction around explosives manufactures and storages. It delineates 25 levels of risk and subsequent restrictions, resulting from the combination of five level of probability and five levels of severity of potential accidents. This precise regulation was made possible by the well-known characteristics of the products and documented analysis of centuries of learnt lessons in accidental explosions. The general land-use planning tools around dangerous sites were designed later, in two main phases, in 1987 and 2003.

After the Mexico and Bhopal accidents, a law (22/07/87) and decree (14/11/89) organised civil emergency planning and land-use planning for high-risk facilities. A guidance, published in 1990,[2] defined appropriate distances, based both on local provisions and on the consequences of the worst case scenario (bulk storage explosion or fire, reactor of pipe rupture) with a two level zoning—zone 1: first lethality, zone 2: irreversible damage on human beings. A three-step procedure was used:

1. The state (competent authority for risk prevention and control) notified the distances resulting from the safety report made by the operator of the site (zones 1 and 2) to the local community, responsible for land-use planning.
2. The local community and the state negotiate the "appropriate distance" using a multi-criteria approach based on the local situation (socio-economical provisions . . .) and on the consequence-based distances determined by the state.
3. The local community modifies the local land-use plan to restrict the construction rights in the aforementioned zones.

In case of disagreement, the state had the right to substitute to the local community and impose distances and restrictions for land-use planning.

For new sites, built after 1989: theses restrictions consisted in public utility easements compensated for by the operator generating the risk. For pre-existing sites, the restrictions imposed on land use in large zones (up to 1 km from the source) were not compensated for.

This system was applied from 1989 to 2003 to 30 new sites and 700 pre-existing "high-risk" establishments not without difficulties mainly due to the absence of compensation for the restrictions imposed on land use in large zones (up to 1 km from the source) around existing sites. Theses rules reasonably limited the extension or densification of urban areas in the vicinity of large chemical and oil facilities and storages, but were unable reduce the vulnerability of pre-existing situations were densely populated areas, commercial and public buildings surrounded a plant. Theses rules probably arrived a few decades too late to avoid the already dense urban setting around 60% of the 700 majors industrial sites in France.

The lessons learnt from the 1987 law and the shock of the Toulouse accident in 2001 triggered a deep change in policies tools and maintain, or where possible, reduce, the potential damage by working both on the source of risk and on vulnerability of the surrounding elements.

## 3. Lessons learnt from the Toulouse accident in risk-informed land-use planning

The explosion of 300 t of off-specs ammonium nitrate-based fertilizers in Toulouse on 21 September 2001, killed 30 people; left 3000 people injured and damaged the surrounding area up to 7 km away from the crater. This scenario was not taken into account in the land-use planning system (Fig. 1).

Two lessons were learnt as far as land-use planning is concerned:

- Defence in depth is more than never necessary. However, good the risk prevention measures are, maintaining appropriate distances and preparedness in case of accident are key elements. The consistency of the four principles of the SEVESO II directive are confirmed but the tools and practical implementation need a brush-up:
  1. Prevent and reduce risk by appropriate design, operation, maintenance and coordination on site. In addition to the technical improvements and the improvements in the reliability of equipment, prevention occurs by better understanding the risk factors in organisation and in people behaviour (human factor) [7].
  2. Emergency plans on and off-site: to be updated and tested on a regular basis.

Fig. 1. Crater left by the explosion in Toulouse and damage.

[2] This guidance was suppressed by a ministerial letter, on 30 September 2003 [12].

- 3, 4 on Richter's scale
- equivalent to 20 à 40 t TNT;
- a crater 40 m in diameter and 7 m deep.
- 30 people killed of which:
  - nine off-site (of which one child in a school);
  - 21 on-site workers.
- Injuries:
  2500 people being cared of in hospitals of which 30 still needing care 1 month later.
  Thousands of houses of buildings destroyed or heavily damaged in a 2-km radius.
  Broken glass up to 7 km from the explosion.

3. Information to the public: debate to promote a risk-based culture on local level.
4. Land-use planning: maintain or reduce risks over time and deal with historical situations of concern.

- The chief element of progress to be made is to improve practices on and around existing sites, leaning from experience. In particular, the actions of reducing risk at the source and continuous improvement of safety by including employees, and the expansion of coordination are fundamental and priorities to avoid accidents such as the Toulouse accident. The way to introduce these changes is to introduce factors of comparison, on the national level, or even on the European or international level (by industry, for feedback). In addition to the technical improvements and improvements in the reliability of equipment, prevention occurs by better taking into account the risk factors that are associated with the organisation and with persons.

## 4. From 2001 on, towards a comprehensive, risk-based approach to risk prevention and control

In the aftermath of the Toulouse accident, the law of 30 July 2003 [2] and the national measures [5,8] that go along with it were adopted to strengthen the prevention and repair of damage. Theses measures, largely derived from the recommendation made by a specific parliament enquiry commission in 2002 [13] target the industrial plants that come under the EU directive concerning the prevention of major accidents in which dangerous substances are involved, known as SEVESO.[3] From 2006 on, transports hubs of dangerous goods such as marshalling yards, ports, multi-modal facilities or truck parking areas will also be required to submit a safety report to the authorities. The chief goal is to control and, where possible, to reduce over time, risks and check their acceptability on a case-by-case basis, using a national guidance and, where possible, European common principles and criteria.

[3] 96/82/CE of 9 December 1996.

Control over urbanization [12] around hazardous sites will be facilitated in future by two tools ensuring that future industrial and urban development are compatible and having the situations of clusters of factories in the urban setting progressively repaired.

1. Public utility easements compensated by the operator at the source of the risk, created for any new risk caused by the extension or creation of a high-risk industrial facility that would require an additional restriction of land use.
2. The implementation of technological risk prevention plans [Fr. "PPRT"]. The effect of these plans is to limit the exposition of the population to the consequences of accidents, the impact of which is in particular understood via the danger studies that the industrial company produces.

## 5. Technological risks prevention plans (TRPP): land-use planning in the long term

As defined by the 2003-699 law [2] adopted on 30 July 2003, technological risk prevention plans (Fr: PPRT) will be defined for each plant or industrial park falling under the scope of the SEVESO II regulation as "top tier" establishment [11]. These plans can delineate areas within which requirements can be imposed on existing and future buildings and within which future buildings may be regulated. They also can define sectors within which expropriation is possible on the grounds of extremely serious danger that threatens human life, those within which the "communes" [municipalities] may pre-empt the assets when properties are sold or transferred. The financing of the corresponding measures will be defined by agreements among the Central Government, the industrial company and the local and regional bodies. These agreements will also specify the procedures for developing these spaces, whereas the renovation work that is made mandatory by the technological risk prevention plans and carried out on principal residences that existed on the date of approval of the plan will receive a tax accredit. As in the case of plans for the prevention of natural risks, the préfet is the one who order, develop and approve the plan after coordination, consultation of the local bodies and a public enquiry.

Four hundred and thirty plans concerning 622 SEVESO establishments and more than 1000 local communities (Fr. Communes) must be prepared and published before 31 July 2008. Theses plans have to be:

- Consistent on national level (national guidance published from 2003 to 2005).
- Locally defined, using cost-benefit analysis.
- Risk-informed and proportionate to risk.
- Progressively implemented, over a 20–30 years period, on the grounds of urgency and cost-effectiveness.
- Financed by the industries generating the risks, the local communities receiving taxes from the industrial activity and the state.

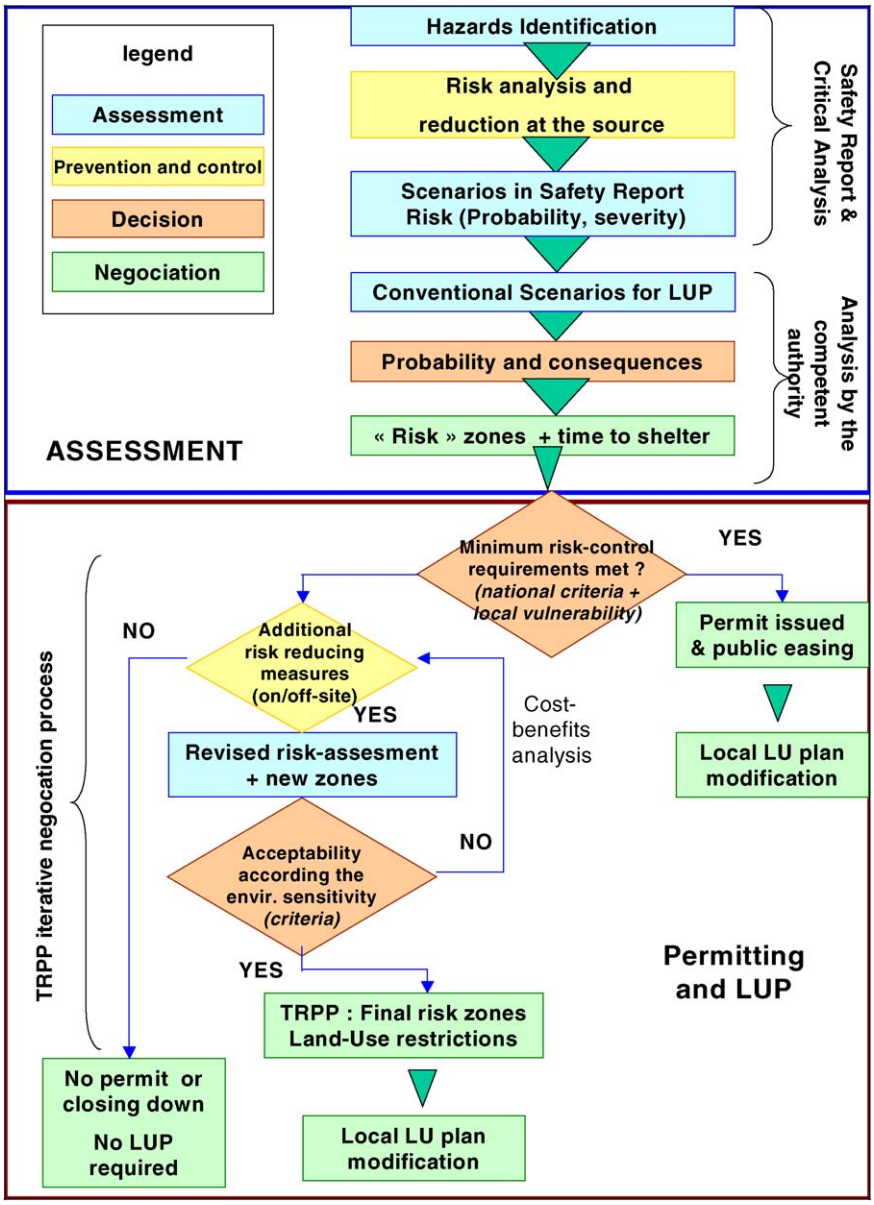


Fig. 2. Permitting and LUP process.

### *5.1. Harmonizing criteria and distances use in the land-use planning process: assumptions related to probability, safety barriers and consequence assessment*

Regarding risk assessment methods, rather than contrasting determinism and probabilism, combining the two approaches can contribute to improve the understanding of risk, and, to start with, the safety of the facilities. The experience of foreign country (e.g., USA, The Netherlands, UK) or of aeronautics or of the nuclear industry provides an initial feedback.

The safety barriers, defined and maintained by the safety management system of the establishment, prevent the occurrence of some events or reduce their consequences. The performance of the facilities in terms of safety is assessed before the operator is issued a permit. Land-use planning zoning should take into account the robust and most reliable safety barriers, for example, those defined and maintained according to international standards. The operating conditions and domino effects should be taken into account, if not directly, at least through uncertainty factors or separate criteria to be weighted before the final decision is made.

Since there are still great uncertainties on the performance of safety barriers and few reliability data, the safety barriers should be identified, reviewed and accepted with a consensus by the authorities and the other stakeholders of the LUP process. The land-use planning distances should derive from a conventional set of scenarios and/or criteria. Using the results from the ASSURANCE, the ARAMIS and the ACUTEX European projects, the European working group on land-use

planning steered by the commission and the national expert groups (on chlorine storage, LPG storage, fine chemicals, etc.) play a fundamental role in building reliable databases and largely agreed criteria for decision making.

For similar motives, the vulnerability of the surroundings of the hazardous installations has to be conventionally described and quantified. A national guidance is currently developed [14], using the ARAMIS project provisional results and national data gathered from 15 years of experience in land-use planning.

Decrees and guidance [14] defining the criteria, thresholds and methods to be used in TRPP are being published by the Ministry of Ecology and sustainable development. The general principles for restrictions is described in the following table:

| Restriction | Risk criteria to define the zone where restrictions apply | | |
|---|---|---|---|
| | Time before exposure | Severity | Probability |
| *Expropriation* of existing housing and no future construction allowed | No time to get to shelter (or no shelter possible) | Significant lethality: >CL 5% tox; >200 mbar; >8 kW/m$^2$ or 1800 (kW/m$^2$)$^{4/3}$ | Not extremely improbable |
| *Renunciation* (housing) (owner obliges community to buy its property at market price) | No time to get to shelter (or no sufficient shelter possible) | Lethality: CL 1% tox to CL 5%; 140–200 mbars; 5–8 kW/m$^2$ or 1000–1800 (kW/m$^2$)$^{4/3}$ | Not extremely improbable |
| *New construction*: possible under with requirements regarding vulnerability (no. of persons, type of activity, blast-proof windows, etc.) | Requirements depending on whether or not there is time enough to alert people and have them get to the nearest shelter before they actually suffer damage to their lives (taking into account distances, reaction times, the type of shelter) | Progressive requirement depending on risk: zones combining probability, severity and time requirements for evacuation of buildings—very high risk: no construction, but those necessary to the hazardous facility or contributing to reduce the risk; high risk: construction limited to low vulnerability structures, not exposing the public and modification of existing vulnerable buildings where necessary; medium risk: limitation for high buildings, commercial and public buildings, major transport routes. Modification of existing vulnerable buildings where necessary; low risk: specific public buildings forbidden (hospitals, jails, etc.), shatterproof coating of windows | |
| *Existing buildings, infrastructures and constructions*: reinforce protection to reduce vulnerability | Requirements depending on kinetics: time enough to alert people? To get to the nearest shelter? (type and size of shelter) | Progressive requirement depending on risk: zones combining probability, severity and time requirements—very high risk: shelter/protection gear mandatory and limitation of the number of persons in the zone; high risk: modification of existing vulnerable buildings (blast-proof of shatter-proof windows, roofs, air-tight rooms, etc.); medium risk: limitation for high buildings, commercial and public buildings, major transport routes. Modification of existing vulnerable buildings where necessary; low risk: specific public buildings forbidden (hospitals, jails, etc.), shatterproof coating of windows | |
| *Transport and outdoor activities* | Time enough to alert people? To get to the nearest shelter? | Emergency measures and preventive information first: recommendations or limitation for specific events with a large number of people. Specifically designed equipments (emergency lane, protection equipment required where operable) | |

Figure: restrictions in land-use: general principles and criteria.

### 5.2. A public decision making process: from consequence distances and probability to LUP zones and cost-effective appropriate measures

Defining certain assumptions for risk assessment could reduce the discrepancy in the decision process, and should make it more transparent. The distances used should be traceable from the risk assessment made by the industrialist. They are defined by the competent authority and are discussed with all stakeholders: facilities operators, competent authorities (state), mayors, communities and local committees for information on industrial risks[4] before being settled.

Geographical information systems are used to combine and/or superimpose vulnerability and consequence data layers in order to:

- evaluate the impact of additional measures to facilitate comparison and cost-benefit analysis on potential additional risk-reduction measures;
- identify zones where description and evaluation of vulnerability must be examined in closer detail.

The competent authorities, in close cooperation with the other parties involved must then define the best set of measures, balancing additional risk reduction at the source, LUP measures, emergency planning measures and other means used to reduce risk and potential damage (insurance-based incentives, tax modulation). The strategy must take into account not only general requirement and cost-effectiveness, but also local constraints, existing programs reducing

[4] Defined by the article 2 of the 30/07/03 law.

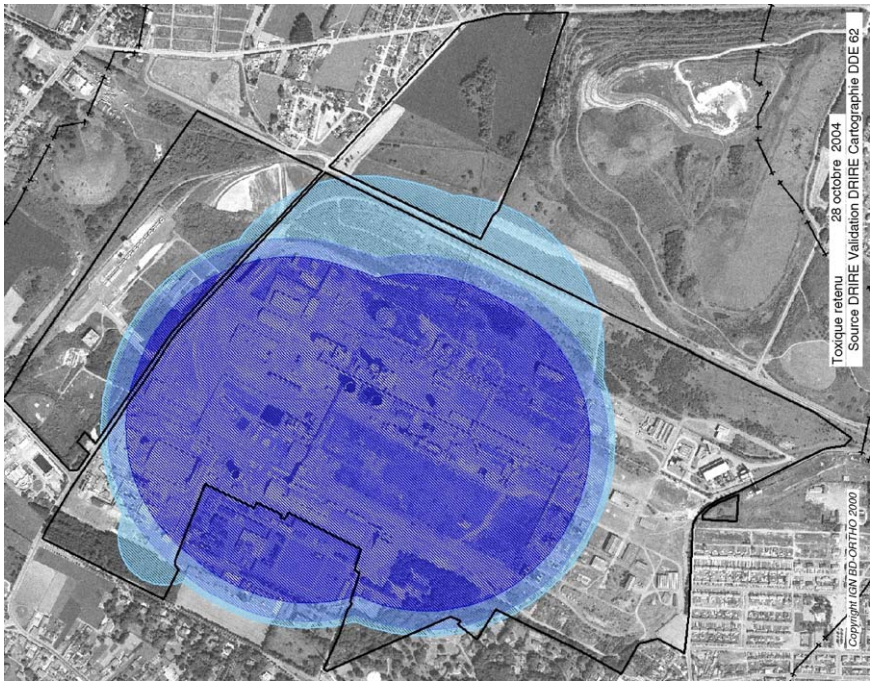


Fig. 3. Illustrative risk-zoning for the experimental TRPP in Mazingarbe.

vulnerability, development on a larger scale than that of the TRPP. In a pragmatic way, the best mix is the one accepted which minimizes the costs and the number of people having to be expropriated (exposed to the highest risk). This is a crucial step in the decision making-process. Risk, social and economic data is the key to a balanced and cost-effective mix of LUP, risk-reduction at the source and emergency planning.

The process is described in the following scheme (Fig. 2).

## 6. Transparency in public decisions regarding risk prevention and land-use planning

In July 2002, a ministerial letter to local authorities [10], allowed the creation of local risk information and coordination committees around top-tier SEVESO establishments. The 30/07/03 law gave theses committees a legislative status. These committees discuss the preventative measures and the risks that the facilities generate. It may call upon the expertise

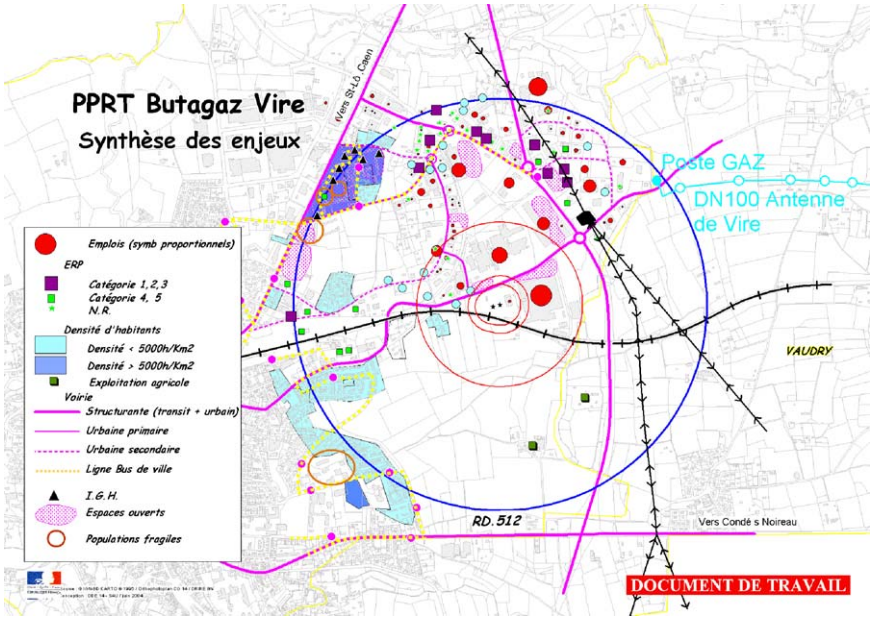


Fig. 4. Illustrative identification of the main vulnerable items and localisation of persons (experimental TRPP of Vire).

Eight experimental TRPP [3] have been launched in 2004. The sites have been selected among the main industrial sectors representing the 622 top tier SEVESO establishments in France, in different situation (suburban or not, large cities or one or more communities involved): two LPG storages, two fuel and refined oil storages, one refinery, two chemical site (one fine chemicals and one petrochemical).
The first results confirm the need to communicate on precise data and options for further risk-reduction, either at the source or reducing vulnerability. The data on land use and vulnerability is difficult to collect and analyse. The costs of the various options (constructive measures, restrictions on future construction, reduction at the source, etc.) are not known precisely yet. A detailed study in under way.

of expert outside bodies. It is consulted on the draft TRPP (plan to prevent technological risks). By the end of 2003, 130 committees existed, covering 70% of the top-tier SEVESO establishments, i.e., about 400 plants (Figs. 3 and 4).

In more general terms, in the case of real estate and land transactions, the sellers or landlords must inform the potential buyers or renters of the risks to which the asset is exposed.

## 7. Conclusion

The approach described in this paper results from the experience 15 years of risk-informed LUP in France. It is based a transparent and traceable negotiation of a set of risk reducing measures which best fits the local situation, combining restriction of land use, constructive measures, reduction at the source and emergency planning. The suggested approach is consistent with the approach developed on European level in the LUP working group launched in September 2002, which is currently working on a database and a guidance of good practices. With the recent developments allowed by the 30/07/03 law, a strategic approach to technological risks prevention and control, managing the social, economic and environmental challenges for a risk-informed urban and economic development."

"Having the risk under control" still is utopia. Hence, the need for all stakeholders to share information and assess in a best way, as a function of the resources of each, and of the benefits associated to the industrial activity. Whatever the risk zones used for LUP purposes may be, catastrophic or unpredicted accidents could happen and have significant impact beyond the limits of theses zones. Understanding and reducing uncertainty factors could help, but LUP choices remain a risk management decision.

## References

[1] Rapport du 9 Octobre 1810 de l'Institut à l'empereur Napoléon.
[2] Loi no. 2003-699 du 30 juillet 2003 relative à la prévention des risques technologiques et naturels et à la réparation des dommages, JO 31/07/03. http://www.legifrance.fr.
[3] Expérimentation relative à l'élaboration des PPRT en 2004. http://www.ecologie.gouv.fr/article.php3?id_article=2758.
[4] M.D. Christou, S. Porter, Guidance on Land-use Planning as required by the Council Directive 96/82/EC. Joint Research Centre, European Commission, 1999.
[5] Politique et programme d'action du MEDD en matière de prévention des risques industriels. http://www.ecologie.gouv.fr/article.php3?id_article=2762.
[6] Code de l'environnement livre V, Titre 1er (Loi no. 1976- du 19 juillet 1976 modifiée). http://www.legifrance.fr.
[7] Principes généraux d'élaboration et de lecture des études de danger (guidelines for risk assessment and safety reports), June 25, 2003.
[8] Dossier d'information: AZF, trois ans après l'explosion. Le point sur les actions suivies par le ministère de l'écologie et du développement durable, http://www.ecologie.gouv.fr/article.php3?id_article=2856.
[10] Circulaire du 12 juillet 2002 du ministre de l'Ecologie et du développement durable relative à la création de commission locale d'information sur les risques technologiques.
[11] Directive no. 96/82 du Conseil du 9 Décembre 1996 concernant la maîtrise des dangers liés aux accidents majeurs impliquant des substances dangereuses (JOCE no. L 10 du 14 Janvier 1997).
[12] Circulaire du 30 Septembre 2003 relative au rapport de l'inspection des installations classées concernant les risques industriels réalisé dans le cadre de l'élaboration des porters à connaissance ou des plans d'urgence externes (BOMEDD no. 03/22).
[13] F. Loos, J.-Y. LeDéhaut, et al., Rapport no. 3559 fait au nom de la commission d'enquête sur la sûreté des installations industrielles et centres de recherche et sur la protection des personnes et de l'environneùment en cas d'accident industriel majeur, enregistré le 29 janvier 2002 à l'Assemblée Nationale, Constitution du 4 octobre 1958, onzième legislature.
[14] Arrete du ministre de l'Ecologie et du developpement durable relatif aux valeurs de reference de seuils d'effets des phenomenes accidentels des installations classes—22/10/04 published in the 19/12/04 official journal [ministerial decree defining criteria and thresholds to determine consequence-zones of accidents occurring in industrial installations. Three levels of damage on man and three levels of damage on structures are defined for each relevant effect (thermal flow, thermal dosis, explosion, toxic releases). Another ministerial decree (defining probability requirement, and acceptable risk) and a guidance on TRPP (Fr. PPRT) procedure are expected by september 2005.