

## Application of a Self-Assessment Methodology for Occupational Safety to Biogas Industry

Ada Saracino, Valeria Casson Moreno, Giacomo Antonioni\*, Gigliola Spadoni, Valerio Cozzani

Alma Mater Studiorum - Università di Bologna, Dipartimento di Ingegneria Chimica, Mineraria e delle Tecnologie Ambientali, via Terracini 28, 40131 Bologna, Italy  
[giacomo.antonioni3@unibo.it](mailto:giacomo.antonioni3@unibo.it)

In the present paper, a methodology for the self-assessment of health and safety management of a company was applied to biogas industry. The goal of this study was to depict a synthetic evaluation of the existing management system through the quantification of different key elements. Among them, the most interesting ones for the case under analysis were those related to (i) the attitude to risk reduction and people protection in compliance with the law, and (ii) the involvement, education and training of the personnel. The results obtained were compared with a previous application to a different sector with the aim of verifying the possible lack of safety management system, safety climate and risk perception in biogas industry.

### 1. Current importance and issues of biogas industry

Worldwide, biogas is becoming a crucial renewable source of energy and, in Europe above all, an emerging industrial sector (EIA, 2014; EBA, 2015). A rapid development, promoted by governmental funds (REN21, 2015), caused a proliferation of facilities for biogas production from different types of waste, e.g. livestock slurry, waste from food industry and wastewater among all (Scarponi et al., 2015).

Bioprocesses, such as the production of biogas, are often wrongly perceived as safer and having a lower impact than conventional chemical processes (Casson Moreno & Cozzani 2015). However, the results of a recent survey showed that there is an increasing number of accident in biogas supply chain, whose trend is growing faster than production itself (Casson Moreno et al. 2015). It worth noticing that the majority of biogas production facilities are medium to small scale, therefore falling below the thresholds for the application of Seveso III Directive (2012/18/EU). ATEX (2014/34/UE) and D.lgs 81/2008 are a requirement only.

Analysing the final consequences of the accidents (i.e. injuries and fatalities) with a matrix approach, the estimated risk was demonstrated to be not negligible for the sector.

Several lessons could be learnt from past accidents analysis in biogas industry (Casson Moreno et al. 2015). Among all, it was found that that several major events, such as fatalities happened during not regulated maintenance operations, could have been prevented by simply adapting process safety experience acquired in other industrial sectors.

Such results have to be considered as an early warning of the major accidents hazard in biogas industry and should rise the attention about the need for improving safety culture and risk awareness, also by developing and adopting appropriate and specific safety standards.

The present paper contributes to this aim by applying a general methodology for the self-assessment of the health and safety management of a company, including aspects related to safety climate and risk perception.

### 2. Occupational Health and Safety (OHS) Management System and the MIMOSA Methodology

In the current occupational safety practice, one of the key principles is that one of the aim of an Occupational Health and Safety Management System (OHSMS) is to improve working conditions and peoples' health in the work place (Battaglia et al., 2014). OHS management can reduce costs related to injury and illness among

employees, including medical care, sick leave and disability benefit (Tappura et al., 2015). OHS management can also increase (or decrease if not correctly implemented) a company's reputation and its image among stakeholders (EU-OHSA, 2010).

OHS management system facilitates the management of the OH&S risks associated with the activities of the company as defined by BSI OHSAS 18001-07. OH&S management includes: organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the organisations' OH&S policies (BSI OHSAS 18001-07). The positive impact of introducing OHSMS at the organizational level, is now recognized by governments, employers and workers (ILO-OSH, 2001) in terms of its ability in reducing hazards and risks thus increasing also productivity.

Italian companies are required by national health and safety legislation (D.lgs 81/2008) to define an organisational management and to identify and remove causes of risk, through technology integration and operational activities aimed at the reduction of health and safety risks in the workplace.

A Methodology for the Implementation and Monitoring of Occupational SAFety (MIMOSA) was developed, thanks to the contribution of both scientific and industrial partners, in order to evaluate the performance of a company concerning Health & Safety in the workplace through specific key-elements and themes (Saracino et al., 2012). Company employees that have responsibility in occupational safety and health management should use this tool, but it is not legally binding and is not intended to replace national laws, regulations or accepted standards and its application does not require any certification.

The methodology is semi-quantitative, since not all the themes can be strictly quantified, but it allows a first evaluation of the OH&S performance of a company, which can be useful especially for comparative purposes. MIMOSA is a practical tool for assisting companies as a means of achieving continuous improvement in OHS performance.

The structure of MIMOSA, which is described in details elsewhere (MIMOSA, 2012), has been determined through a complex analysis and it contains:

- 6 main "key-elements", which has been considered as necessary for a proper OHSMS (leadership of the management, attitude to risk reduction, personnel involvement, etc.);
- more than 20 "themes", which contribute to describe in more detail each key-element through the assessment of tailored checklists and Key Performance Indicators (KPIs).

The final assessment of the key-elements should allow for a correct OHSMS implementation, since it should point-out deficiencies and possible improvements in the organization and management of the company.

### **2.1 The concept of safety culture in MIMOSA and the simplified approach**

As previously mentioned, due to its developing trend, in biogas sector there is a lack of competence in safety policies (Casson Moreno & Cozzani, 2015; Casson Moreno et al. 2015) and no OHSMS is present at all. Thus, it is difficult or even impossible to apply the complete MIMOSA including all its key-elements and themes. In fact, the entire methodology consists of more than 50 checklists (each one with different number of questions) and more than 50 KPIs and it has been thought especially for large companies, in which the concept of safety culture is quite deep-rooted at least among the top management of the company.

Therefore, in order to analyse the issue of occupational safety in biogas sector, in which basic notions of safety culture are widespread in a limited way, only a sub-set of key-elements has been selected for its application. In particular, only two elements that allow to promptly assess the level of safety of operators and to instruct them on safe processes of a biogas plant have been selected.

The first key-element selected (KE-1) is called "Attitude to risk reduction and people protection, in compliance with the law" and 11 themes contribute to its definition. Though this key-element is mainly focused on the compliance with the laws, attention is put also on the compliance with requirements, which govern substantial features or priorities and which have a great influence on levels of health and safety at work (Saracino et al., 2012). The second selected key-element (KE-2) is composed by four themes and is named "Involvement, learning and development of personal education". Like for the first one, it also considers activities that have the greatest impact on the level of health and safety (even without the formalization of a real model). In particular, this element is devoted to show that all human resources operating in the enterprise are the fundamental essence of the organization. As a matter of fact, one of its four themes is explicitly called "Safety climate", which is to be intended as "the manifestation of safety culture in the behaviour and expressed attitude of employees". In MIMOSA methodology this theme related to Safety Climate refers more specifically to workers' perceptions of "how safety is managed in the workplace" and to the likelihood that those perceptions contribute to a safer workplace. The themes belonging to first and to the second key-element are shown in Figure 1 along with other themes of the overall methodology not considered in the present study.

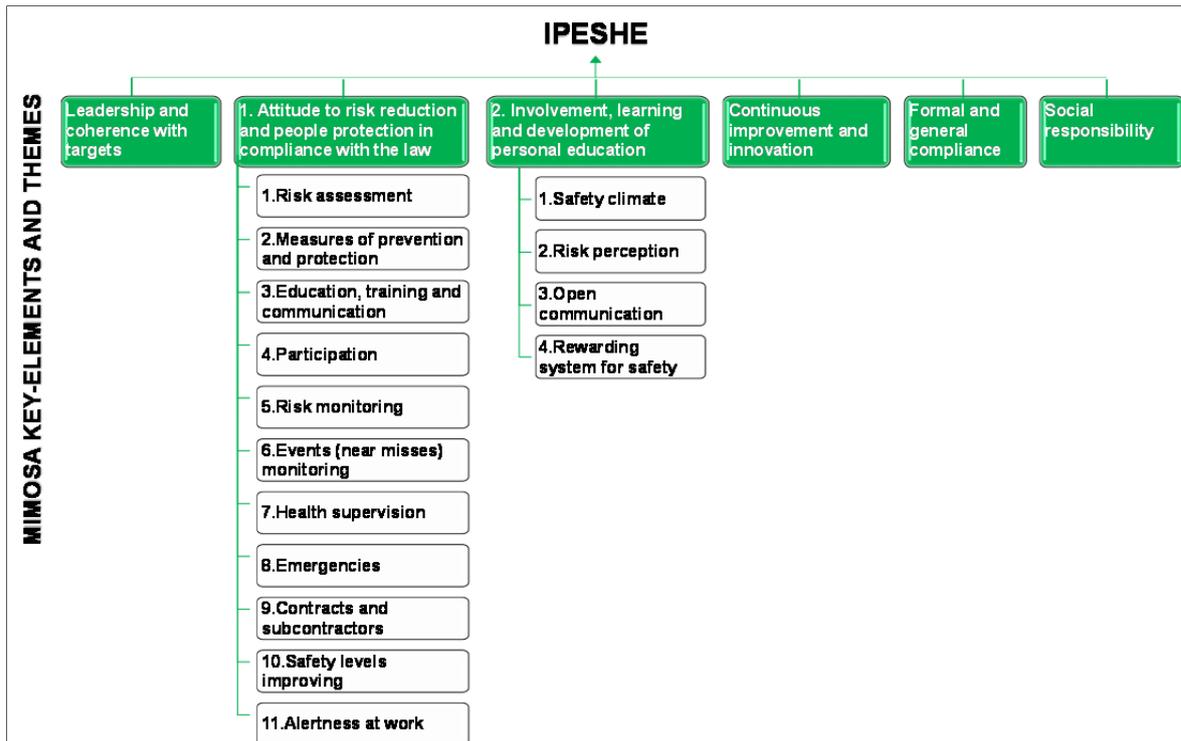


Figure 1: Schematic of MIMOSA methodology with focus on the set of key-elements and related themes applied in the present work.

In the framework of MIMOSA methodology also an overall Index of Performance for Safety and Health level (IPESHE) of the company/activity was defined according to eq. (1), in which also different criteria for the weights of KPIs/check-lists, themes and key-elements ( $p_k$ ,  $t_j$  and  $\omega_i$  respectively) can be used as discussed by Saracino et al. (2015a).

$$IPESHE = \sum_{i=1}^{N_{ke}} \omega_i \sum_{j=1}^{N_i(i)} t_j \sum_{k=1}^{nKPI/ckl(j)} p_k I_k \quad (1)$$

In the present work, due to the limited number of selected key elements, only a partial IPESHE index can be calculated, considering only the contribution of those key elements (i.e.  $N_{ke} = 2$ ).

### 3. Application to biogas industry

Once the MIMOSA key-elements of interest have been selected, the checklists related to each theme (15 in number and 110 questions) have been evaluated for the biogas field by means of expert elicitation.

The answers to the questions in the checklists have been obtained through direct interview to three anonymous interlocutors (Expert 1, 2 and 3 in the following), selected on the basis of their expertise about biogas production processes. The approach requires only a YES/NO answer, but some questions cannot be applicable to a typical biogas plant as reported in Table 1. Thus, a first screening on the whole MIMOSA model has been applied in order to meet specific requirements for this application. As it can be deduced from Table 1, the percentage of not applicable questions ranges around 10%, as an average value for the 3 experts. "Not applicable questions" (N/A) have been sometimes found to be due to a lack of safety concepts like safety management and culture; as an example, questions about the definition of figures/positions committed to safety such as the emergency personnel or about the company policy about safety audit and management of contracts and subcontractors have been excluded from the analysis since these issues are not managed in a systematic way as it occurs for larger companies. Within the second key-element, not applicable questions have been found in the theme "Open Communication", which should measure how the company tries to increase the attractiveness of safety issues towards workers and employees, improving for

instance hazard communication. For these questions all 3 experts have not been able to give an answer and thus this theme has been excluded from the analysis.

Table 1: Percentage of “Not Applicable questions”

Questions	Expert 1	Expert 2	Expert 3
KE-1	10%	0%	15%
KE-2	20%	17.3%	10.4%
Total	12.7%	4.5%	13.6%

#### 4. Results and discussion

At the end of the survey, an average index of 37% was obtained for the first key-element, while for the second key-element the average index was approximately 10%, though large differences between experts for the latter has been observed, thus meaning that a consensus about the 2<sup>nd</sup> key-element was not reached (Figure 2). However, figures are rather low for all the experts.

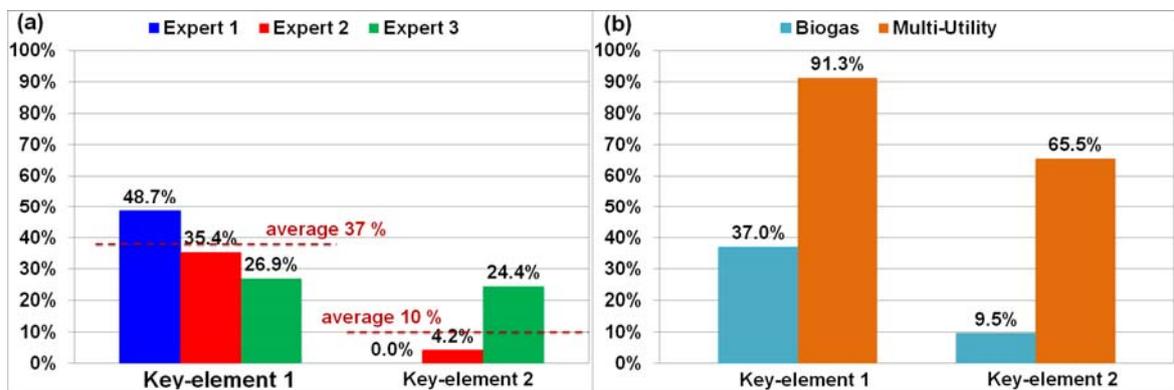


Figure 2: a) Assessment of key-element 1 and 2: “Attitude to risk reduction and people protection, in compliance with the law” and “Involvement, learning and development of personal education; b) Comparison between two examined companies.

These results come from the scores obtained for different themes within the 2 key-elements that are reported in Table 2, from which emerges that some themes are actually poorly managed in the biogas sector. In particular, as expected, scarce attention is paid to risk participation (15.7%, probably because few workers are usually employed in these plants) and consequently alertness at work has a modest importance (11.1%). As a result, though risk assessment is acceptably performed (54.5%), no measures are normally taken in order to improve safety level. Thus indicates that the common approach in this field is to simply comply with the law, without implementing any other additional safety measure.

This is also confirmed by extremely low values obtained for the 2<sup>nd</sup> key-element, in which all the 3 applicable themes obtained scores below 25%, showing that safety climate, risk perception and other proactive approaches to occupational safety (Saracino et al., 2015b) are not applied or even not known in the biogas field.

With the aim of verifying the lack in the aspects of safety management, safety climate and risk perception in the biogas field, the results of this application have been compared to those obtained from a previous application of MIMOSA methodology to the branch of a large multi-utility company operating in northern Italy, which manages the whole company’s fleet of road vehicles (Saracino, et al., 2015). Figure 2 shows the different results between two companies and confirms that the adoption of a structured OHSMS (also certified according to the BS OHSAS 18001:2007 starting from 2012) can lead to significant benefits in terms of improved safety level.

As a final resuming comparison, the partial (including only KE-1 and KE-2) IPESHE index has been calculated for both the biogas sector and for the company selected as a benchmark, having assumed for the weights of the two key elements 0.307 and 0.174 respectively for KE-1 and KE-2, after the application of a simplified Analytic Hierarchy Process (Saaty, 1990), in which key-elements were taken as criteria and the evaluation of IPESHE as the goal. The normalized performance obtained for the biogas sector is 27.0% and 82.0% for the

benchmark company, thus confirming the large distance in the management of occupational safety between well-established industrial activities and the developing biogas industry.

Table 2: Average scores of themes

	Experts average KE-1		Experts average KE-2
Risk assessment	54.5%	Safety climate	11.1%
Measures of prevention and protection	33.3%	Risk perception	22.2%
Education, training and communication	22.7%	Open communication	n.a.
Participation	15.7%	Rewarding system for safety	4.8%
Risk monitoring	50.0%		
Events monitoring (near misses)	16.7%		
Health supervision	59.3%		
Emergencies	85.2%		
Contracts and subcontractors	58.6%		
Safety levels improving	0%		
Alertness at work	11.1%		

## 5. Conclusions

In this paper, a first test of the MIMOSA methodology to biogas sector was presented. The aim of the work was to evaluate safety climate and risk perception in the biogas industry, where knowledge about occupational safety looked not sufficient if compared with other sectors. The whole MIMOSA methodology was simplified in order to select only its aspects that could be able of evaluate safety culture and risk perception.

Different considerations can be drawn from this application. The results confirmed the non-negligible risk profile in biogas supply chain, due to an inadequate management of risks. Moreover, only for the first expert risk assessment, measures of prevention and protection, education and other themes belonging to key-element 1 are assessed with a value close to 50%, which is anyway considered not sufficient for MIMOSA's standard of safety and health: in Saracino et al., 2015 the overall obtained result (about 80%) show that OHSMS implemented by the examined company resulted in a good performance. Whereas for other experts the stated situation of biogas workers safety is even worse and critical, since results are not sufficient for both key-elements (and most of the themes), thus meaning that levels of safety (and in particular its management and its culture) in work environment have to be increased, on the basis of the criticalities emerged from the checklists of MIMOSA themes.

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