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Occupational Health and Safety Issues in the Photovoltaics Industry

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To promote the shift toward a low-carbon economy, the European Union adopted in 2008 the so-called 20-20-20 package. According to the related system of common but differentiated responsibilities, Italy was assigned the ambitious target of 17% share of energy production from renewable sources by 2020 (directive n. 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing directives n. 2001/77/EC and n. 2003/30/EC). In fact among all the renewables, photovoltaics represents the market with the highest occupational and economic potential in Italy.

A report issued by the Consiglio Nazionale dell'Economia e del Lavoro (CNEL, *Indagine sull'Impatto delle Politiche di mitigazione dei Cambiamenti Climatici sul Sistema Produttivo e sull'Occupazione in Italia*, 2009) states that the PV market will experience a two, three-fold growth compared to the wind energy industry, which already reached its peak of production in 2008. Thanks to a favorable combination of demand-centred policies, good levels of solar irradiance and growing installed capacity trends, in Italy the PV industry is expected to employ 52,600 temporary workers and more than 5,000 permanent workers on average each year between 2009 and 2020. However, there is a huge question mark which accompanies job creation in renewable energy industries: are green jobs sustainable, healthy and safe jobs? and which are the open challenges for the health and safety of workers in the photovoltaics industry?

Although there are no doubts that green employment is associated with the issue of environmental sustainability and helps to lower production carbon footprints, some concerns arise when the debate comes to investigate the quality and social sustainability dimensions of green occupations. In fact, being a green worker means much more than working in a low-carbon industry: For example, the definition of 'green-collar worker' already entails a positive correlation between blue-collar jobs in green industries and higher labor standards (Apollo Alliance, Green for All, Center for American Progress, Center on Wisconsin Strategy, *Green-Collar Jobs in America's Cities*, 2008), while the Just Transition approach links claims of low emissions and decent work (ILO, UNEP, IOE, ITUC, *Green Jobs, Toward Decent Work in a Sustainable, Low Carbon World*, 2008).

OHS challenges vary across different stages of the supply chain. The lion's share of Italian enterprises attains the very last stages of the PV supply chain, namely solar panels installation and distribution, while there are fewer economic players in the area of PV row materials manufacturing. However, PV cells manufacturing industry is forecasted to grow due to consistent public and private investments: in Italy, 86% of the forecasted investment projections for 2009 concerned just solar manufacturing (ENEA, *Rapporto Energia e Ambiente 2007 – Analisi e scenari*, 2008). The international literature extensively focuses on the potential health and safety risks associated to PV cells manufacturing. Further research is needed for the area of installation and distribution.

On the side of PV cells production, the main factors to be addressed are widespread schemes of work organization, chemical and physical hazards.

In regard to the latter, extensive researches have been carried on by the National PV EHS Assistance Center Department of Environmental Sciences Brookhaven National Laboratory, located in the US.

OHS hazards should be distinguished on the ground of types of different PV technologies. The main concerns are related to the shift from semi-conductor materials to thin-films and

nanotechnologies. The most relevant hazards arise from crystalline silicon cells manufacturing process involving the deployment of explosive gases, like silane gas, and toxic substances. The risk of explosion instead concerns mostly the amorphous silicon cells manufacturing production facilities. However, explosion events are very rare than compared to the fossil energy industry. The PV industry has an excellent record in complying with existing safety codes and regulations (V. Fthenakis, C. Carlisle,W. Chan, *Silane Safety in Amorphous Silicon and Nitride Operations*, 21st European Photovoltaic Solar Energy Conference, 4-8 September 2006, Dresden, Germany).
Cadmium Tellurium solar cells manufacturing concerns are associated with the use of toxic and potential carcionogenics like cadmium and selenium compounds. However, in CdTE technologies the amount of cadmium which shows acute health effects if ingested or inhalated- is lower than in much wide-spread applications, like batteries. While there are zero emissions under standard manufacturing conditions, there are minor concerns related to the release of toxics during massive industrial fires (V.M. Fthenakis, M. Fuhrmann, J. Heiser, A. Lanzirotti, J. Fitts, W. Wang, *Emissions and encapsulation of cadmium in CdTe PV modules during fires*, in *Progress in Photovoltaics*, 2005, vol. 13, n. 8, 713).
Workers protection from chemical and potential carcinogenic hazards is however ensured, provided that regular OHS standards are implemented.
Then, new generation PV cells mainly rely on nanotechnologies processing: the health and safety implications of occupational exposure to nanoparticles is an issue at stake in the international debate (European Agency for Safety and Health at Work, *Workplace Exposure to Nanoparticles*, 3 June 2009). The major hazards related to nano-scale materials concern inhalation, which may cause respiratory toxicity, increased chemical reactivity, which may be associated with the production of free radicals, and potential bioavailability, involving nanoparticles crossing cellular barriers (Silicon Valley Toxics Coalition, *Regulating Emerging Technologies in Silicon Valley and Beyond*, 2008). However, there is no clear evidence of the above-mentioned correlations and further research is needed.
The European regulatory framework provides for high standards to protect workers from exposure to dangerous chemical substances in electrical and electronic equipment. Since the Rohs Regulation came into force in 2006, by implementing directive 2002/95/EC (also known as *RoHS Directive*, or *Directive on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment*), all electronics sold on the EU market must contain only minimal amounts of lead, mercury, cadmium, chromium, polybrominated biphenyls (PBBs), or brominated diphenylethers (PBDEs).
The legal framework for chemicals was also improved with the adoption of the REACH directive (n. 2006/121/EC) and regulation (n. 1907/2006/EC), concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency located in Helsinki. This directive improves the information system about the safety of an huge range of chemicals, implementing more comprehensive and systemic communication requirements throughout all the supply chain.
Among voluntary standards in PV manufacturing, a multi-layer strategy for workers protection is usually implemented to counter relevant chemical and physical hazards. Such systemic approach provides for several layers of protection, concerning technology, processes and materials, safety system to prevent accidental chemicals releases, measures to prevent and minimize human exposure, etc.
Additionally, in Italy, biological monitoring is included in medical surveillance of workers occupationally exposed to carcinogens and chemical agents, according to the SIMLII guidelines. Such approach should be complemented by the analysis of intervening factors related to work culture and organizational structure.
Also workers' well-being could be negatively affected by work-organisation in PV manufacturing, since alternative schemes of work organization and shift-work are very common for PV cells manufacturing, like for most of the micro-electronics facilities.

Solar panels installation and distribution represent the very last stages of the PV supply chain. The main job profiles employed in this business area are solar PV installers and repairers.
ENEA estimates that the Italian PV market will need 3,240 PV installers by 2010 (ENEA, MESOS, *The certification of skills in the field of renewable energy sources (RES): the case of photovoltaics*, 2008).
Such occupations are often related to outdoor hazardous outdoor conditions. Panel installation requires working on the roof and doing high-voltage electrical wiring, thus exposing workers to the risks of fall from rooftops and ladders, electrical shock and electrocution (death due to electrical shock).
An already at-risk situation is exacerbated by the combination of specific worksite hazards with the most widespread schemes of work organization in PV installation and distribution.
In Italy, most of the installations performed are outsourced work, due to the highly fragmented structure of the PV supply chain and the size of most of the PV enterprises, which mainly serve the residential sector. In fact, installers are usually small enterprises or self-employed workers, out of which only a modest 15% is specialized in photovoltaics installation, while the vast majority serves multiple markets, like constructions and other renewables industry (Energy & Strategy Group, *Solar Energy Report*, 2008). Both this cross-industry business attitude and potential risks which accompany with outsourcing, such as lower investments in adequate OHS training and weak integration in the organization of work, may hamper the development of an adequate PV OHS know-how. The European Regulatory Framework ensures high protection standards for workers at heights. Annex to the directive n. 2001/45/EC establishes a set of provisions concerning the use of work equipment provided for temporary work at a height, giving priority to collective protection measures rather than personal protection ones, defining specific standards for the use of ladders and scaffolding.
Recently a new law has been passed in the construction sector (d.P.R. n. 59/2009, *Regolamento di attuazione dell'articolo 4, comma 1, lettere a) e b), del decreto legislativo 19 agosto 2005, n. 192, concernente attuazione della direttiva 2002/91/CE sul rendimento energetico in edilizia*). It is part of a process of transposal of the EU directive n. 2002/91/EC on the energy performance of buildings and requires the installation of PV panels on new buildings and renewed ones whose area is at least 1000M2.
PV OHS issues and new sources of risks should be incorporated into decision making about OHS in the construction industry. It means that d.lgs. n. 81/2008, Title IV, establishing a special OSH regulation for the construction industry (based on a special penalty point system, particular risk assessment process and distribution of responsibilities) will have to be implemented to face new risks or an unexpected mixture of risks (chemical, electrical, biological) deriving from the use of new materials and peculiar production processes and requiring an innovative systemic approach. At the same time good practices should be developed.
A comparative analysis points out good practices. For the aim of improving environmental health and safety compliance, moral-suasion is often regarded as a more effective mean than command-and-control systems, namely laws and regulations (B. Fisse, J. Braithwaite, *Corporations, Crime and Accountability*, Cambridge University Press, Cambridge, 1993). An example of a voluntary health and safety system for the PV industry is the Green Jobs Platform for Solar Principles promoted by the Silicon Valley Toxics Coalition, which companies in the industrial Silicon Valley district are called to endorse. The project is especially valuable because its authors have a special expertise in the field of environmental and health and safety hazards in the High Tech and PV industry: the coalition, made up by of high-tech workers, community members, law enforcement actors, emergency workers and environmentalists, was created after that a groundwater contamination was discovered nearby the area and the rate of workers affected by cancer dramatically raised.

Because of the highly fragmented, cross-national structure of the PV supply chain, a systemic OHS approach requires that the same set of standards should be adopted by different players, regardless of their geographical location.
The combination of both the EU regulatory framework provisions applied throughout the whole supply chain and voluntary OHS standards adopted throughout the global life-cycle of the product generate a systemic OHS approach in the PV industry. Compliance should be ensured even for smaller economic players belonging to the very last stage of the PV supply chain.

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