MANAGEMENT AND REUSE OF INDUSTRIAL WASTE: INERT ASBESTOS AS A RAW MATERIAL IN THE CONSTRUCTION SECTOR IN A CIRCULAR ECONOMY PERSPECTIVE*

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Abstract

Waste disposal, over the years, has become increasingly a major problem; in particular with regard to industrial waste, which often require long processes to be eliminated and very often are very difficult to recover. The major problem is represented by the so-called “large-scale waste”; a practical example is given by asbestos, which is harmful for health. Asbestos is an industrial material that was widely used until the end of the eighties, until several cases related to the dust released by the material, which mainly caused tumors, were detected. The objective of this case study is to find valid alternatives to the reuse of asbestos-derived waste so that it can be made inert to be re-introduced into new production cycles. This is possible thanks to a collaboration with the F.E.R. S.R.L.; in fact the emerging Sicilian company deals with activities aimed at energy saving and energy production from renewable sources and provides the resources needed to develop skills and competences that can be applied by construction companies in future project in a circular economy perspective.

Keywords: asbestos, construction, raw material, reuse, circular economy, special waste

*Selection and peer-review under responsibility of the ECOMONDO
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1. Introduction

A novel field of research in materials science is the recycling of secondary raw materials for construction and building materials such as concrete (Gualtieri and Boccaletti, 2011; Donaldson and Tran, 2004). Asbestos and asbestos-containing materials have been widely used in many applications, such as insulators, asbestos cement and fireproof construction materials, because of their low thermal conductivity and high mechanical strength. However, asbestos is known to be extremely carcinogenic, especially in causing a severe asbestosis, lung cancer and pleural mesothelioma when the respiratory system is exposed to it (Boccaccini et al., 2007; Fubini and Mollo, 1995; Gulumian, 2005; Iwaszko et al., 2018a).

The hazardous nature of asbestos material lies in the release of respirable asbestos fibers from waste materials into the environment. The inhalation of these carcinogenic substances and their deep penetration into the lungs represents a serious risk of disease. This risk increases with the concentration of fibers in space and time of its impingement on the human body (Gomez et al., 2009; Làzár et al., 2016). As a result, nowadays, in most countries the mining, refinement and use of asbestos have been banned, apart from some exceptional applications (Arean et al., 2001). Recovering industrial waste heat (IWH) provides an attractive opportunity for a low-emission and low-cost energy source (Mirò et al., 2016, a, b). This heat can be recovered and reused in other processes onsite (to preheat incoming water or combustion air, preheating furnace loads, etc.), or transformed into electricity, cold or other type of heat.

While some of the approaches and models behind the CE discourse have made important contributions to sustainability science in the past, the theoretical connection is not that clear. The research using solid theoretical foundations is rather scanty. In a recently published paper (Korhonen et al., 2018a, b) showed that there are severe limitations and challenges in the practical application of the concept, in the application of material cycles, renewable and cascading type energy flows in production-consumption systems. Asbestos-cement was extensively produced in Italy between 1904 and 1985, with the result that a huge quantity of such materials have been used all over the country and, according to the latest estimates, very large quantities of these are still on site (Bianchi and Bianchi, 2002; Chapman, 2000). Recent Italian directives (and Environment Management Act, 2005; Ministry of Cultural Heritage, 2015) classify all asbestos-containing waste (ACW) as hazardous in line with the European Waste Catalogue code 170605* and requires its treatment prior to disposal in controlled landfills (EU Council Decision, 1994). The Italian Environment Ministry Decree n. 248/2004 lays down guidelines for the treatment, disposal and recycling of ACW and recommends that preference be given to those stabilization and inertization processes that favour recycling in order to reduce ACW-related hazards (Chan et al., 2000; Gualtieri and Tartaglia, 2000; Gualtieri et al., 2008; Leonelli et al., 2006). In particular, high energy milling (HEM) is mentioned as being able to ensure waste amorphisation through the mineralogical and morphological transformation of asbestos phases (Plescia et al., 2003).

The aim of this paper is to develop an economic comparison between technology options. Moreover, an economic analysis taking into account the maximum acceptable investment cost for each technology is estimated and compared with the current investment cost depending on the operating hours of the systems proposed (Brueckner et al., 2015).
2. Materials and methods

In our society buildings are omnipresent, but inevitably they entail negative consequences from an environmental point of view. During their lifespan, they consume plenty of resources and energy, occupy land and eventually they are demolished. As the interest in environmental issues is rapidly growing, also within the construction industry, more attention is being paid to sustainable housing technologies and construction methods. This general increasing awareness led to the Kyoto-protocol, an international agreement on reducing the emission of greenhouse gasses and global warming (Buyle et al., 2013; Ewing et al., 2010). Asbestos has a fibrous structure with high mechanical resistance and flexibility, Asbestos-cement industry – generally speaking, in all the products not containing asbestos, contaminated during the asbestos cement production process. Asbestos comes from the Greek ἀέρβεσο (ásbestos), which means “unquenchable, inextinguishable”. The definition of asbestos, found in the Italian Dictionary of traded goods and commodities (1972), is: “a mineral that, when adequately prepared, provides fire-resistant and flexible fibers that can be spun and woven and which feature a high dielectric stiffness and chemical resistance” (Nuovo dizionario, 1972). Asbestos has been long marketed and used for its insulating, fire resistance, chemical resistance, soundproofing qualities and tensile strength. Asbestos is classified as a Carcinogen in Category 1A (it may cause cancer). The disposal in a landfill of suitable category, avoiding disposal in structurally unsuitable sites that could lead to undue exposure of workers (prepared for a lower-risk type of waste and not equipped with appropriate PPE) and contamination of the air, water and soil.

The asbestos removal process is a difficult and costly project and can be implemented either by disposal or by depositing in hazardous waste landfills. This second solution is far simpler and cheaper to implement because it only comes down to storage of asbestos-containing materials in special landfills or in inactive mines without interfering with asbestos properties and structure. A solution that is more expensive and more technologically complex, but which makes it possible to completely neutralize asbestos and convert it into a reusable material, is disposal (Iwaszko et al., 2018b).

The construction sector is still the world's largest consumer of raw materials, and accounts for 25e40% of global carbon dioxide emissions (WEF, 2016). ‘Green buildings’ were believed to be a panacea, but it was later found that the sole focus on the operational stage of a building would not suffice to reduce its environmental impact. Whole life approaches were then put forward as the right pathway to sustainability, but despite the admirable intention to look at ecological threats and environmental impacts (ISO, 2006), the focus in the day-to-day practice within the construction sector has been rather circumscribed and most often limited to energy consumption and carbon emissions (Pomponi and Moncaster, 2016) without considering the risk of just shifting environmental impacts from one category to another (Pomponi et al., 2016). In spite of these efforts building related CO₂ emissions are continuing to rise, with the International Energy Agency (IEA) suggesting that emissions are on track to double by 2050 (IEA, 2014). A new paradigm, circular economy (CE), is now gaining momentum, and it promises to overcome the contradiction between economic and environmental prosperity. There are many different schools of thought on the CE (Blomsma and Brennan, 2017; Ellen MacArthur Foundation, 2016; Winans et al., 2017) however, the shared founding principles lie in the better management of resources. The role of the built environment is therefore crucial, due to its high environmental impacts, which also conversely offer significant opportunities for reductions in energy use, greenhouse gas emissions and waste production.

Compared to other products, buildings are more difficult to evaluate for the following reasons: they are large in scale, complex in materials and function and temporally dynamic due to limited service life of building components and changing user requirements.
Moreover, their production processes are much less standardized than most manufactured goods because of the unique character of each building. There is limited quantitative information about the environmental impacts of the production and manufacturing of construction materials, or the actual process of construction and demolition, making environmental assessments of the building industry challenging (Tukker, 2015; Welford, 1998) carried out a survey on acoustical properties of sustainable materials, both natural and recycled. Considered natural materials are hemp, kenaf, coco fiber, sheep wool, wood wool, cork, cellulose, and flax; traditional materials are glass wool, rock wool, and expanded polystyrene. Considered recycled materials are rubber, plastic, textile fibers, and solid wastes (Scheuer et al., 2003).

In the light of the discussed series of challenges and the underlying limitations of a linear economy, i.e. take-make-use dispose, the concept of a circular economy (CE) is considered as a solution for harmonizing ambitions for economic growth and environmental protection. There are various possibilities for defining CE. In line with eco-industrial development CE is understood as “realization of closed loop material flow in the whole economic system”. In association with the so called 3R principles (reduction, reuse and recycling) “the core of CE is the circular (closed) flow of materials and the use of raw materials and energy through multiple phases” (Yuan et al., 2006). Taking into account economic aspects CE can also be defined as “an economy based on a “spiral-loop system” that minimizes matter, energy-flow and environmental deterioration without restricting economic growth or social and technical progress”. For this paper, the relevant CE definition is the one of “an industrial economy that is restorative or regenerative by intention and design” (Ellen MacArthur Foundation, 2016). This definition is more comprehensive as it considers both the environmental and economic advantages simultaneously under the notion of regenerative performance requiring high quality circulation of technical nutrients while ensuring safe entry of bio nutrients in the biological sphere.

3. Case study: F.E.R.srl

F.E.R. S.r.l., located in Caltagirone (CT) Sicily, comes from the synergy of managers, engineers and designers and fans of the World of renewable energy, which after years of experience at the best companies involved into activities aimed at energy saving and energy production renewable, and that thanks to their know-how and experience, design, develop and implement photovoltaic and energy saving solutions. F.E.R. consists of a highly qualified and experienced in different situations working in the field of photovoltaics that from 2007 to date have contributed to many photovoltaic and feasibility studies. It is able to offer advice and assistance to the design and construction, centrically the needs of each individual project. One of the purposes of the technical assistance is to provide the resources necessary for the development of new skills and competencies that designers and contractors will apply to future projects. The company is deepening energy issues in relation to their Importance in today’s economy. In particular, the company aims to promote alternative energy sources and the diffusion of advanced technologies in the industry, helping to encourage the development sustainable and complete supply chains in the energy sector, encouraging growth technological 3 innovation and competitiveness of Sicilian firms operating in the energy sector (F.E.R. Srl, 2014). In particular, the FER dealt with asbestos with photo voltaic of our own, with the help of the production of a company, Mirabella Imbaccari, staff with asbestos trainers. Each company was incentivized thanks to 5 cents more for those who used asbestos. The company dealt with 6 asbestos also province of Catania, even from private individuals, the costs for us are more come, asbestos as previously has a strong impacted.
4. Results and discussion

In recent years the company has dedicated itself to the replacement of asbestos panels to cover the sheds to replace them with photovoltaic panels; photovoltaic systems whose photovoltaic modules are installed in place of roofs of rural buildings and buildings on which the complete removal of the eternit or asbestos is carried out. The surface of the modules cannot be greater than that of the removed cover; In addition to electricity incentives, photovoltaic systems are entitled to a premium of 12 euros/MWh, which is paid on all the energy produced (Forman et al., 2016). The Gse discloses the documentation to be provided to certify the correct removal and disposal of the eternit and asbestos, in order to access the prize.

The Decree of the Ministry of Health of 06/09/94 defines the techniques that can be used for the carrying out of the clean-up operations; they are reflected in the actions of: removal-encapsulation - confinement of asbestos-containing material, and finally a certificate is issued by the ASP agency that investigates the correct removal of asbestos.

For the purpose of carrying out the disposal operations, the FER company needs the assistance of specialized and trained personnel in the field of asbestos removal; Costs vary depending on the area that will have to be removed with an average of 10 to 20 euros per square meter. In choosing the technical intervention system, several removal methodologies are possible that take into account multiple assessments on different factors, considering, moreover, that the rules require the removal of the materials must proceed with the subsequent demolition or refurbishment of the structures that contain them.

Inertization treatments differ in seven categories: chemical modification, mechanochemical modification, lithification, vitrification, glassmaking, pyrolytic mytization, clinker production, ceramization, depending on the type of process, which can be of a predominantly mechanical, thermal or chemical nature and the products that can be obtained.

The FER company, to improve the application of the circular economy concept, intends to implement the process through the development of different asbestos recycling techniques; this in order to instead bring asbestos, once confined directly to landfill, to be able to take advantage of a definitive inertization process and then make asbestos a raw material that can be reused in construction or something similar. Among the various inertization treatments, the company aims to carry out the process of thermochemical conversion of asbestos, which involves the combined use of chemical treatments and heat, in order to carry out the re-mineralization of asbestos and other silicate materials. This process allows you to pursue several objectives: to achieve the conversion of asbestos into other mineral forms, without going through fusion; the transformation of the organic components present in the waste to be treated, through the reaction of pyrolysis and/or oxidation; immobilization of metals possibly present in the waste (APAT, 2004). This technology provides for four main systems that provide: 1) power preparation; 2) rotating form conversion; 3) treatment of output gases; 4) Removing the outgoing product. The costs of such thermochemical conversion, excluding the transport costs of the waste, vary within a range of 175 euros to 225 euros per tonne treated, considering a plant that processes 37tonn /per day. The type of plant is very flexible, as it can be built in a place where it is planned to build a permanent plant of felling of the environment but is also offered the alternative of implementing a mobile plant, mounted on trailer, which works in depression, if this choice is more advantageous.

The material obtained through this technology is extremely versatile as it has extensive and varied industrial applications, construction and consumer products. A classification of asbestos-present materials, conducted based on their use, leads to the identification of the following groups: Cement-asbestos, material obtained from Portland cement mixtures, chrysoty asbestos, crocidolite, amphibole asbestos and/or Maoist and
water; Friction materials mainly for the transport sector; Strings and fabrics mostly from thermal and electrical systems, very homogeneous spray materials for composition and chemical and mineralogical characteristics; Vinyl materials such as tiles and vinyl flooring products with asbestos paper gaps; Cards and cartons: materials formed from asbestos and cellulose paste or inert inorganic, used as electric and thermal or acoustic insulators.

5. Concluding remarks

The presented approach is a novel estimate for the waste heat potential on a global scale. It reveals the vast amount of waste heat from common sectors of end use energy as well as from electricity generation.

Eternit for example is a composite with a ceramic matrix strengthened with asbestos fibers which found a huge application in the building materials industry. Its application potential resulted from both its very good insulating properties, ease of assembly, but above all from its very competitive price: eternit was thus an economical alternative to other building materials of a similar purpose. It is worth noting that as a result of the thermal decomposition of asbestos, products harmless to humans are created, which can be used, for example, in the building materials industry, or in road construction.

References

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