SANITSER LIFE12 ENV/IT/001095

Deliverable Action C3

Report on socio-economic impacts of the project

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Introduction

A social Life Cycle Assessment (S-LCA) aims at assessing the social aspects of products and their potential impacts along their life cycle encompassing extraction and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling; and final disposal. The approach used all over the S-LCA is like the environmental LCA approach.

The Life Cycle Costing (LCC) is a methodology for systematic economic evaluation of life-cycle costs over a period of analysis. It is defined as the sum of all recurring and one-time (non-recurring) costs over the full life span or a specified period of a good, service, structure, or system. Life-cycle costing can address a period of analysis that covers the entire life cycle, or selected stages or periods of interest thereof.

The aim of the application of S-LCA and LCC within SANITSER project is to provide a sustainability overview of the project, by carrying out a reliable benchmark between the innovative technology and the traditional one for sanitary ware production, also from the social and economic points of view.

The present document has the goal of reporting the results of the Social LCA and of the LCC analysis, giving also an overview of all collected data. The first part, regarding the Social Life Cycle Assessment, consists of results of the application of the Evaluation Matrix elaborated in the past months; for this reason, the methodological assumptions are not reported here, since already presented in the deliverable “S-LCA Evaluation matrix”.

Part I

Social

Life Cycle Assessment

1. Goal and Scope Definition

1.1. Goal of the study

The aim of this first part of the study is to compare the traditional system for producing sanitary ware with the innovative SANITSER process, to identify pros and cons of the two systems from a social perspective.

1.2. Reference standards

The methodology used in this study is based on the Guidelines for Social Life Cycle Assessment of Products (UNEP/SETAC 2009), here referred to as the "Guidelines", and the Handbook for Product Social Impact Assessment, version 3.0 (Roundtable for Product Social Metrics 2016), referred to as the "Handbook". Moreover, S-LCA follows the ISO 14040:2006 LCA framework. To give homogeneity with the LCA results, the Product Category Rules (PCR) 2012:01 for Construction products was kept into account for the development of some aspects (i.e. system boundaries). In fact, this document contains all rules for the development of an Environmental Product Declaration (EPD) within the International EPD System, thus it represents a good framework for the development of all LCA-related studies.

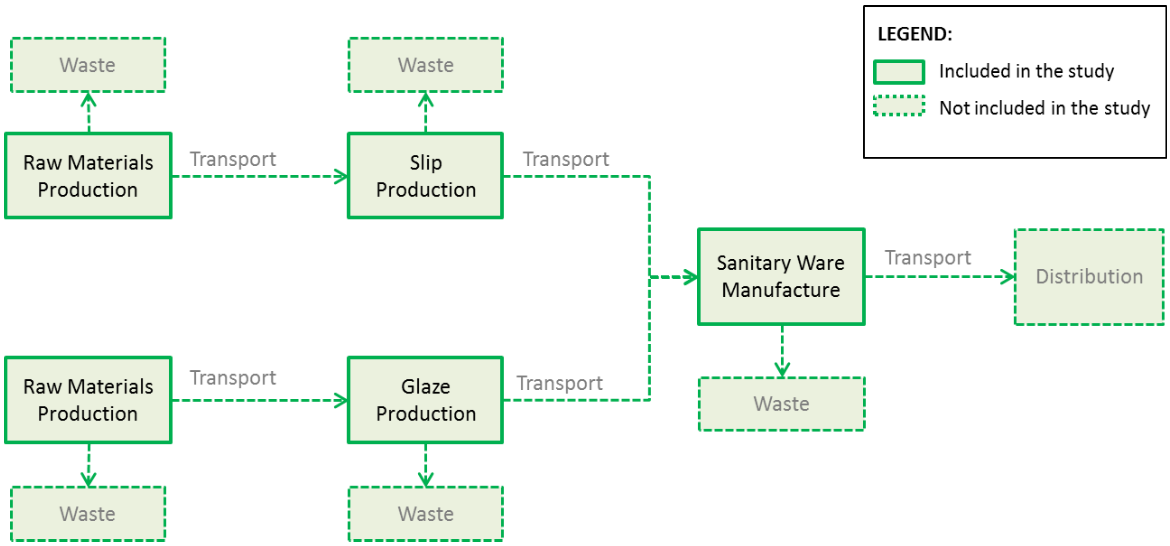
1.3. Scope and system boundaries

The most relevant challenge of the SANITSER project is probably the use of recycled raw materials in the ceramic sanitary ware production, matching process data between innovative and traditional technologies.

Boundaries cover the "cradle to gate" system (from raw materials production to finished product at the production plant gate). Subsequent phases (e.g. transport to installation place, installation and use phase) are not considered in the analysis because they are assumed to be equivalent for both systems.

The system boundaries considered for the SLCA are represented in FIGURE 1 and are formally the same used for the elaboration of Evaluation Matrix (deliverable "S-LCA Evaluation matrix").

Figure 1 System boundaries



The reference period for traditional process is 2015 while for the innovative one is 2016. In particular, for the innovative process, the production stage B8 (industrial) was taken into consideration.

All investigated production stages are localized in Europe, most of the processes take place in Italy.

Companies involved in the study have different sizes. Raw materials are supplied by a various range of companies, which might be small and medium as well as big enterprises (i.e. MI). Glaze is produced by GEMICA and slip is produced by SETEC, both SMEs. For the sanitary ware production, the involved companies cover all the three dimension classes:

- **Amerina Ceramics** and **Alice Ceramics** are two small size companies;
- **Scarabeo Ltd** is a medium size company;
- **Kerasan srl** is a medium-large company.

1.3.1. Upstream processes

The upstream processes are those related to raw materials production. Some materials are common for both traditional and innovative processes, while others are specific for one of the two processes. All considered raw material production processes are reported in Table 1.

Table 1 Raw material production processes considered within upstream stage

	BOTH PROCESSES	ONLY TRADITIONAL	ONLY INNOVATIVE
SLIP	Clay (Hycast)	Quartz	Glass Filler GS-VF
	Clay (Samblend)	Feldspar	Pitcher BVC-VF
	Kaolin		Feldspar F60-PB VF
			Talk
GLAZE	Zircosil (Zircobit)	Magnesite	Glass VB-FF
	Zinc oxide		Glass VBI-FF
	Kaolin		
	Calcium carbonate		
	Quartz		

1.3.2. Core processes

Processes included in this stage are:

- Slip production process
- Glaze production process
- Sanitary ware production process

Slip and glaze production processes are included in the core stage since they are "pre-product", following the stages subdivision foreseen by the PCR 2012:01 for Construction products.

1.3.3. Cut-off rules

Some stages of the life cycle have been excluded from this analysis, since they have relatively low impacts from a social perspective compared to other life cycle stages; moreover, these activities are not modified by the innovative SANITSER production process.

The processes excluded from the analysis are:

- Auxiliary materials production;
- Fuels and electricity production;
- Raw and auxiliary materials transportation;
- Waste final treatment;
- Final product distribution.

2. Methodology

A complete description of the methodology can be found in the deliverable "S-LCA Evaluation matrix".

3. Social Life Cycle Inventory

3.1. Data collection

Information related to stakeholder workers for the innovative and traditional production processes were gathered through a data collection made with questionnaires. The same collection method was applied to stakeholder local communities; however, collection efficiency and results were much lower.

A complete description of involved stakeholders and method of choice is present in the deliverable "S-LCA Evaluation matrix".

3.1.1. Workers

Partners of the project collected all the necessary information related to glaze, slip and sanitary ware processes for both the traditional and the innovative systems. The survey for traditional processes was supported by internal data analysis and elaborations, as well as by direct experts' experience. To avoid contamination of results due to the contemporary presence within the plants of both the innovative and the traditional process, the hypothesis of having only the innovative processes within the plant was applied.

Survey for raw materials production was easily completed for the materials created specifically for SANITSER project. Since it was not possible to contact some suppliers, experts' experience on materials and production processes, as well as literature data, were used to fill the questionnaires.

3.1.2. Local communities and public agencies

As described in deliverable "S-LCA Evaluation matrix", actors individuated as relevant for this category were:

- local health authority (ASL),
- workers living in the neighbourhood of plants,
- local community associations.

After some contacts, it was clear that the asked information was not available for these actors, being very specific and, in the case of innovative process, related to a hypothetical scenario. For this reason, the survey was mainly based on experts' judgement results of some surveys conducted by ASLs and other literature data (which are mainly specific for Civita Castellana district, so can be considered a specific information).

3.1. Inventory elaboration and analysis

Before the application of the evaluation matrix, an analysis of data received was carried out and general socio-profiles, representing the Social life cycle inventory, were created. As described in deliverable "S-LCA Evaluation matrix", all data received for every production stage were averaged together, without applying weighting factors. The following tables represent the obtained socio-profiles, divided into production steps, of the innovative and traditional production processes for the two stakeholders (Table 3, Table 4, Table 5 and Table 6). The socio-profiles indicate both data collected for every performance indicators and the calculated data for every social topic (bold italic). To understand the reported performance indicators, the scale of values legend is also reported (Table 2).

Table 2 Scale values used for the performance indicators

PERFORMANCE INDICATORS	CODE
Very good	**1**
Good	**2**
Satisfactory	**3**
Inadequate	**4**
Poor	**5**
Very poor	**6**

Table 3 Socio-profile for the stakeholder Workers, related to the traditional production process

SOCIOPROFILE	SLIP RAW MATERIALS	GLAZE RAW MATERIALS	SLIP PRODUCTION	GLAZE PRODUCTION	SANITARYWARE PRODUCTION
Health and Safety	***3,3***	***3,3***	***4,8***	***4,8***	***4,8***
Hours of health and safety training per worker	1,0	1,0	1,0	1,0	1,0
Rate of incidents	5,3	5,3	6,0	6,0	6,0
Rate of incidents due to Sliding	5,3	5,3	6,0	6,0	6,0
Cases of Silicosis occurred	1,7	1,7	6,0	6,0	6,0
Fair salary	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
Wages meeting minimum legal/industrial standards	1,0	1,0	1,0	1,0	1,0
Social benefits and social security	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
Social benefits meeting legal/industry minimum standards and provision fully complying with all applicable laws	1,0	1,0	1,0	1,0	1,0
Working hours	***3,9***	***3,9***	***6,0***	***6,0***	***6,0***
Hours per week worked with exposition to silica	2,4	2,4	6,0	6,0	6,0
Preparation steps higher than 30 minutes	5,3	5,3	6,0	6,0	6,0
Equal opportunities and discrimination	***6,0***	***6,0***	***6,0***	***6,0***	***6,0***
Actions to increase staff diversity and/or promote equal opportunities	6,0	6,0	6,0	6,0	6,0
Freedom of association and collective bargaining	***1,0***	***1,0***	***1,0***	***6,0***	***1,0***
Workers members of associations able to organise themselves and/or bargain collectively	1,0	1,0	1,0	6,0	1,0
Employment relationship	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
Workers with documented employment conditions	1,0	1,0	1,0	1,0	1,0
Training and formation	***1,0***	***1,0***	***1,0***	***6,0***	***1,0***
Numbers of hours of training per employee during the reporting period	1,0	1,0	1,0	6,0	1,0
Job satisfaction and engagement	***6,0***	***6,0***	***1,0***	***6,0***	***6,0***
Workers participating in a job satisfaction and engagement survey	6,0	6,0	1,0	6,0	6,0

Table 4 Socio-profile for the stakeholder workers, related to the innovative production process

SOCIOPROFILE	SLIP RAW MATERIALS	GLAZE RAW MATERIALS	SLIP PRODUCTION	GLAZE PRODUCTION	SANITARYWARE PRODUCTION
Health and Safety	***2,9***	***2,3***	***1,0***	***1,0***	***1,0***
Hours of health and safety training per worker	1,0	1,0	1,0	1,0	1,0
Rate of incidents	4,3	3,5	1,0	1,0	1,0
Rate of incidents due to Sliding	4,3	3,5	1,0	1,0	1,0
Cases of Silicosis occurred	2,1	1,0	1,0	1,0	1,0
Fair salary	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
Wages meeting minimum legal/industrial standards	1,0	1,0	1,0	1,0	1,0
Social benefits and social security	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
Social benefits meeting legal/industry minimum standards and provision fully complying with all applicable laws	1,0	1,0	1,0	1,0	1,0
Working hours	***4,1***	***3,5***	***1,0***	***1,0***	***1,0***
Hours per week worked with exposition to silica	3,8	3,5	1,0	1,0	1,0
Preparation steps higher than 30 minutes	4,3	3,5	1,0	1,0	1,0
Equal opportunities and discrimination	***6,0***	***6,0***	***3,5***	***6,0***	***6,0***
Actions to increase staff diversity and/or promote equal opportunities	6,0	6,0	3,5	6,0	6,0
Freedom of association and collective bargaining	***1,0***	***1,6***	***6,0***	***6,0***	***1,0***
Workers members of associations able to organise themselves and/or bargain collectively	1,0	1,6	6,0	6,0	1,0
Employment relationship	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
Workers with documented employment conditions	1,0	1,0	1,0	1,0	1,0
Training and formation	***1,0***	***1,6***	***1,0***	***6,0***	***3,5***
Numbers of hours of training per employee during the reporting period	1,0	1,6	1,0	6,0	3,5
Job satisfaction and engagement	***6,0***	***6,0***	***1,0***	***6,0***	***6,0***
Workers participating in a job satisfaction and engagement survey	6,0	6,0	1,0	6,0	6,0

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Table 5 Socio-profile for the stakeholder Local Communities, related to the traditional production process

SOCIOPROFILE	SLIP RAW MATERIALS	GLAZE RAW MATERIALS	SLIP PRODUCTION	GLAZE PRODUCTION	SANITARYWARE PRODUCTION
Safe and healthy living conditions	***2,3***	***2,9***	***3,0***	***3,0***	***3,0***
Adverse impacts on community health or safety	6,0	6,0	6,0	6,0	6,0
Assessment and monitoring of risks and impacts on community health and safety	1,0	1,7	1,0	1,0	1,0
Measures for adverse impacts on community health and safety	1,0	1,7	1,0	1,0	1,0
Programmes for community health or safety	1,0	1,7	1,0	1,0	1,0
Silicosis cases within local community	2,4	3,1	6,0	6,0	6,0
Access to tangible resources	***2,7***	***3,1***	***2,7***	***2,7***	***2,7***
Assessment and monitoring of risks and impacts on community access to tangible resources	1,0	1,7	1,0	1,0	1,0
Measures for adverse impacts or to restore community access to tangible resources	6,0	6,0	6,0	6,0	6,0
Proactive action for community access to tangible resources	1,0	1,7	1,0	1,0	1,0
Local capacity building	***3,5***	***3,9***	***3,5***	***3,5***	***3,5***
Programmes targeting capacity building in the community	6,0	6,0	6,0	6,0	6,0
People in the community benefitting from capacity building programmes	1,0	1,7	1,0	1,0	1,0
Community engagement	***3,5***	***3,9***	***1,0***	***1,0***	***1,0***
Programmes or events targeting community engagement	1,0	1,7	1,0	1,0	1,0
Opportunities and programmes for community support	6,0	6,0	1,0	1,0	1,0
Local employment	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
New jobs created	1,0	1,0	1,0	1,0	1,0

Table 6 Socio-profile for the stakeholder Local Communities, related to the innovative production process

SOCIOPROFILE	SLIP RAW MATERIALS	GLAZE RAW MATERIALS	SLIP PRODUCTION	GLAZE PRODUCTION	SANITARYWARE PRODUCTION
Safe and healthy living conditions	***2,1***	***2,0***	***2,0***	***2,0***	***2,0***
Adverse impacts on community health or safety	6,0	6,0	6,0	6,0	6,0
Assessment and monitoring of risks and impacts on community health and safety	1,0	1,0	1,0	1,0	1,0
Measures for adverse impacts on community health and safety	1,0	1,0	1,0	1,0	1,0
Programmes for community health or safety	1,0	1,0	1,0	1,0	1,0
Silicosis cases within local community	1,6	1,0	1,0	1,0	1,0
Access to tangible resources	***2,3***	***2,3***	***1,0***	***1,0***	***1,0***
Assessment and monitoring of risks and impacts on community access to tangible resources	1,0	1,0	1,0	1,0	1,0
Measures for adverse impacts or to restore community access to tangible resources	4,9	4,8	1,0	1,0	1,0
Proactive action for community access to tangible resources	1,0	1,0	1,0	1,0	1,0
Local capacity building	***3,5***	***3,5***	***1,0***	***1,0***	***1,0***
Programmes targeting capacity building in the community	6,0	6,0	1,0	1,0	1,0
People in the community benefitting from capacity building programmes	1,0	1,0	1,0	1,0	1,0
Community engagement	***2,9***	***2,9***	***1,0***	***1,0***	***1,0***
Programmes or events targeting community engagement	1,0	1,0	1,0	1,0	1,0
Opportunities and programmes for community support	4,9	4,8	1,0	1,0	1,0
Local employment	***1,0***	***1,0***	***1,0***	***1,0***	***1,0***
New jobs created	1,0	1,0	1,0	1,0	1,0

SANITSER innovative process has globally a lower social impact, especially for the *Workers* category. In particular, the topics *Health and Safety* and *Working hours* for Workers are those benefiting most from the switch to the new process.

To have a clearer comparison of inventories, in the following table results for the two processes are directly compared only for social topics (Table 7 and Table 8).

Table 7 Comparison of socio-profiles (traditional vs innovative) for stakeholder Workers. a negative delta value indicates better performances of SANITSER process.

SOCIOPROFILE - WORKERS	SLIP RAW MATERIALS	GLAZE RAW MATERIASL	SLIP PRODUCTION	GLAZE PRODUCTION	SANITARYWARE PRODUCTION
Health and Safety	**-11%**	**-32%**	**-79%**	**-79%**	**-79%**
Traditional	3,3	3,3	4,8	4,8	4,8
Innovative	2,9	2,3	1,0	1,0	1,0
Fair salary	**0%**	**0%**	**0%**	**0%**	**0%**
Traditional	1,0	1,0	1,0	1,0	1,0
Innovative	1,0	1,0	1,0	1,0	1,0
Social benefits and social security	**0%**	**0%**	**0%**	**0%**	**0%**
Traditional	1,0	1,0	1,0	1,0	1,0
Innovative	1,0	1,0	1,0	1,0	1,0
Working hours	**5%**	**-9%**	**-83%**	**-83%**	**-83%**
Traditional	3,9	3,9	6,0	6,0	6,0
Innovative	4,1	3,5	1,0	1,0	1,0
Equal opportunities and discrimination	**0%**	**0%**	**-42%**	**0%**	**0%**
Traditional	6,0	6,0	6,0	6,0	6,0
Innovative	6,0	6,0	3,5	6,0	6,0
Freedom of association and collective bargaining	**0%**	**63%**	**500%**	**0%**	**0%**
Traditional	1,0	1,0	1,0	6,0	1,0
Innovative	1,0	1,6	6,0	6,0	1,0
Employment relationship	**0%**	**0%**	**0%**	**0%**	**0%**
Traditional	1,0	1,0	1,0	1,0	1,0
Innovative	1,0	1,0	1,0	1,0	1,0
Training and formation	**0%**	**63%**	**0%**	**0%**	**250%**
Traditional	1,0	1,0	1,0	6,0	1,0
Innovative	1,0	1,6	1,0	6,0	3,5
Job satisfaction and engagement	**0%**	**0%**	**0%**	**0%**	**0%**
Traditional	6,0	6,0	1,0	6,0	6,0
Innovative	6,0	6,0	1,0	6,0	6,0

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Table 8 Comparison of socio-profiles (traditional vs innovative) for stakeholder Local Communities. a negative delta value indicates better performances of SANITSER process.

SOCIOPROFILE – LOCAL COMMUNITIES	SLIP RAW MATERIALS	GLAZE RAW MATERIASL	SLIP PRODUCTION	GLAZE PRODUCTION	SANITARYWARE PRODUCTION
Safe and healthy living conditions	**-8%**	**-30%**	**-33%**	**-33%**	**-33%**
Traditional	2,3	2,9	3,0	3,0	3,0
Innovative	2,1	2,0	2,0	2,0	2,0
Access to tangible resources	**-14%**	**-28%**	**-63%**	**-63%**	**-63%**
Traditional	2,7	3,1	2,7	2,7	2,7
Innovative	2,3	2,3	1,0	1,0	1,0
Local capacity building	**0%**	**-9%**	**-71%**	**-71%**	**-71%**
Traditional	3,5	3,9	3,5	3,5	3,5
Innovative	3,5	3,5	1,0	1,0	1,0
Community engagement	**-16%**	**-25%**	**0%**	**0%**	**0%**
Traditional	3,5	3,9	1,0	1,0	1,0
Innovative	2,9	2,9	1,0	1,0	1,0
Local employment	**0%**	**0%**	**0%**	**0%**	**0%**
Traditional	1,0	1,0	1,0	1,0	1,0
Innovative	1,0	1,0	1,0	1,0	1,0

The direct comparison highlights potential benefits of the SANITSER scenario, in particular for Workers. Performance indicators show high decreases, mostly in the final stages (glaze, slip and sanitary ware productions). Raw materials are less affected by SANITSER process, since SANITSER compositions for glaze and slip differ from traditional ones only for some components.

4. S-LCA results

4.1. Results per life cycle stage

The application of the evaluation matrix to all obtained socio-profiles generated the maps of social impact. Two maps were created per each stakeholder, one for traditional process and one for SANITSER one (Figure 2, Figure 3, Figure 4 and Figure 5). To understand the reported performance indicators, the scale values legend is also reported (Table 9).

Table 9 Scale values used for the performance indicators

IMPACT ASSESSMENT	CODE
Positive effect	1
Lightly positive effect	2
Indifferent effect	3
Lightly negative effect	4
Negative effect	5
Very negative effect	6

Figure 2 Social impact map for Workers, for the traditional production process

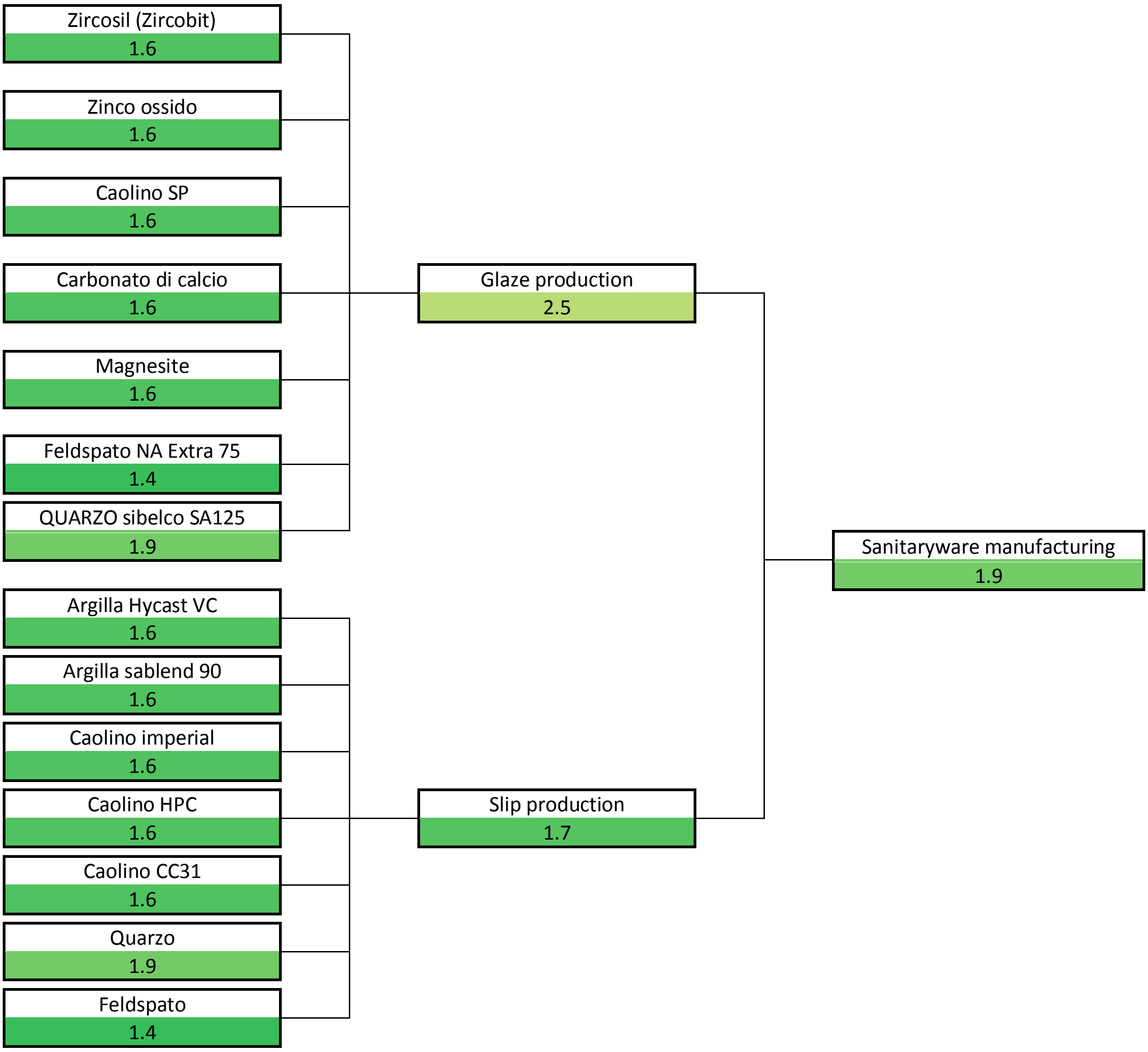


Figure 3 Social impact map for Workers, for the innovative production process

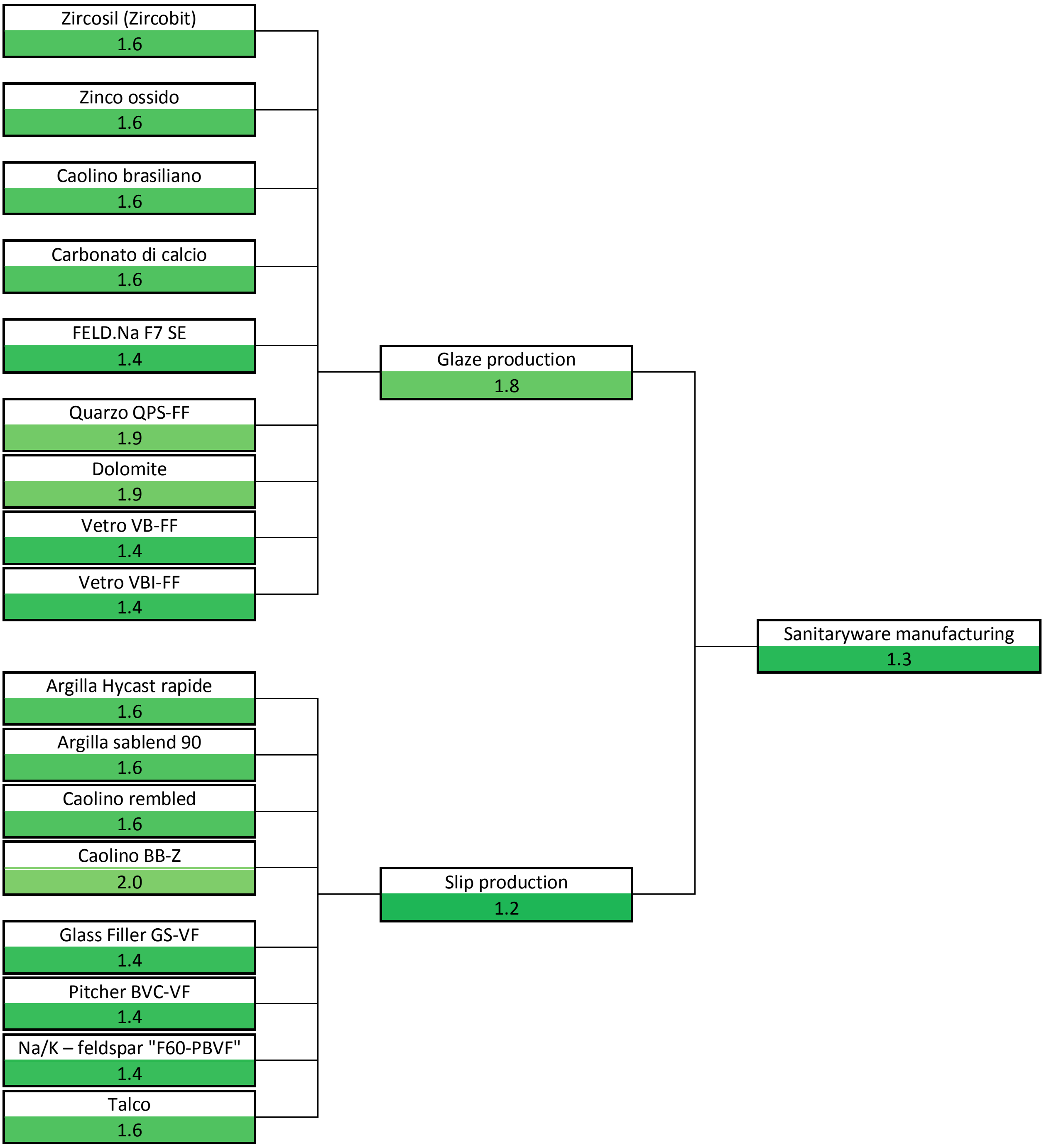


Figure 4 Social impact map for Local communities, for the traditional production process

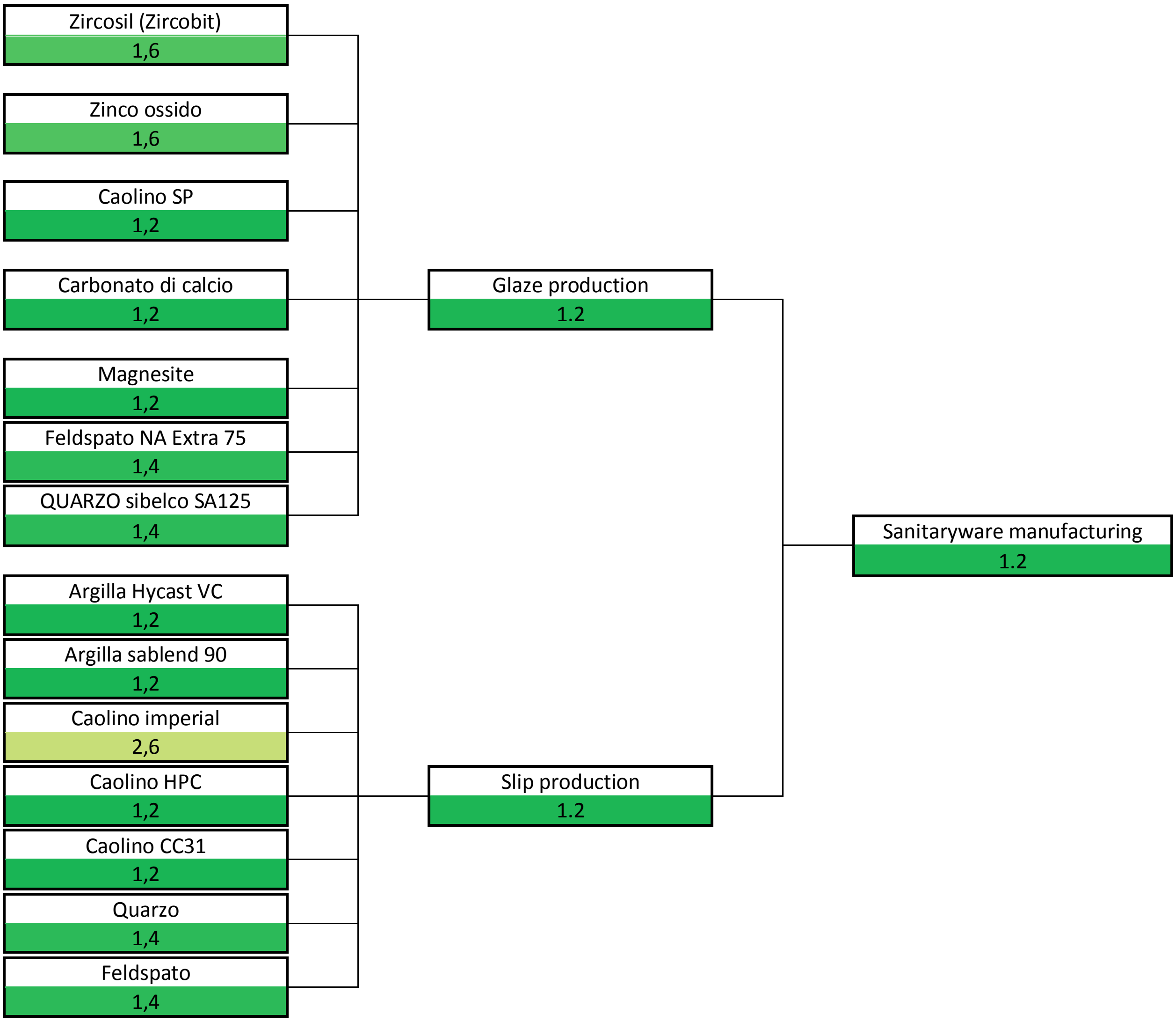


Figure 5 Social impact map for Local communities, for the innovative production process

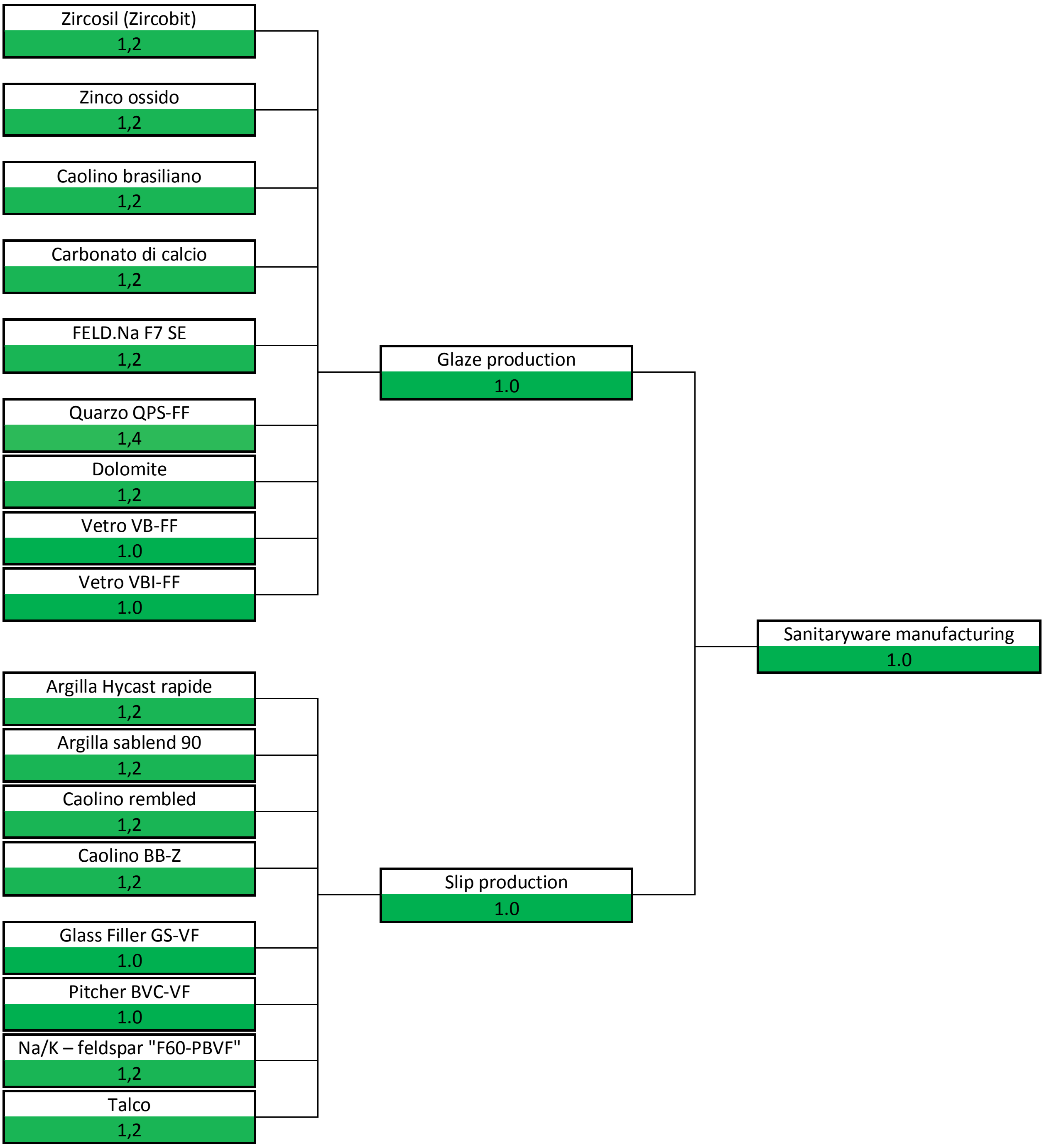


Figure 6 Comparison of social impact maps (traditional vs innovative) for stakeholder workers. A negative delta value indicates better performances of SANITSER process.

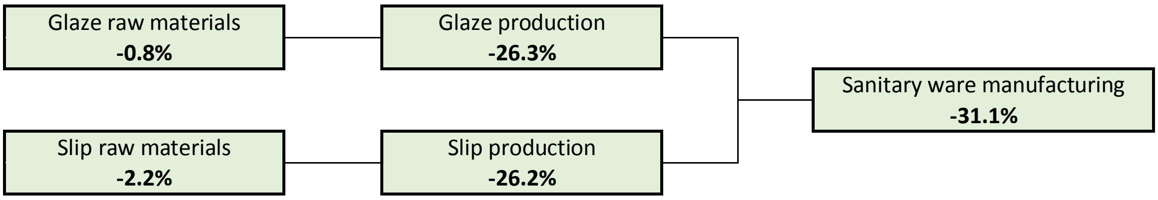
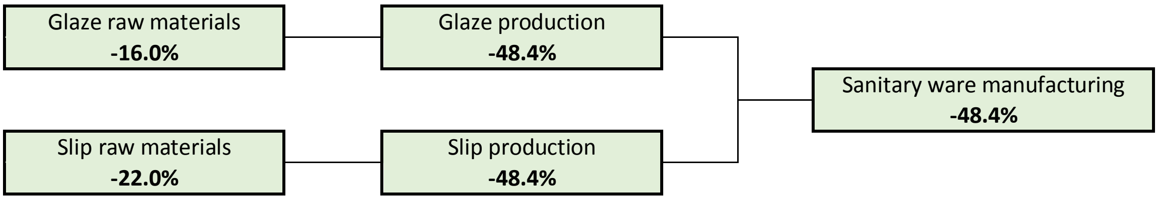


Figure 7 Comparison of social impact maps (traditional vs innovative) for stakeholder Local Communities. A negative delta value indicates better performances of SANITSER process.



The first consideration is that the average result, in both production processes, indicates that the social impact on both workers and local communities does not cause concern: all values are close to 1, thus indicating positive effects. However, some improvements are generated by the application of SANITSER process. To better understand the relevance of the improvements, in Figure 6 and

Figure 7 the delta between the two processes are reported. In these schemes, the results for raw materials are aggregated in two groups: glaze raw materials and slip raw materials. This is due to the difference of some of the involved raw materials, which prevents from direct comparison of every single raw material.

It is clear that SANITSER process provides a general improvement for both stakeholders, in particulars for the core processes (glaze, slip and sanitary ware production processes).

4.2. Results from cradle to gate

As described in the deliverable "S-LCA Evaluation matrix", no weighting factors has been used, so that all life cycle stages seem to have the same importance on the final product. For this reason, the final social impact results provided in this paragraph can only give a very easy overview of the results obtained, with the aim of comparison. In Table 10, social impact results from cradle to gate, per stakeholder, are reported for traditional and innovative processes. As in the previous social impact maps, results are provided in absolute numbers within a scale 1 to 6, where 1 indicates strong positive impacts and 6 strong negative impacts.

Table 10 Final cradle-to-gate social impact results for Workers and Local Communities.

PROCESS	WORKERS	LOCAL COMMUNITIES
Traditional	1.86	1.31
SANITSER	1.54	1.00
	- 20 %	**- 39 %**

It is clear that the score is very positive both for traditional process and for innovative SANITSER process. This happens because almost all the companies involved in the supply chain are in Europe where minimum standards for social aspects exist, guaranteeing an average good social situation. The application of weighting factors, however, might lead to a higher relevance for raw material production processes, so that the final cradle-to-gate values might differ.

5. Considerations and further developments

This S-LCA study was mostly approached by means of the reliable experience and expertise of partners. A focus on all aspects that are of real significance to provide a comparison of social impacts of the two production processes was therefore possible.

Probably, the most important aspect of the analysis, as foreseen in the deliverable "S-LCA Evaluation matrix", was related to the Silicosis issue. Silicosis is a form of occupational lung disease occurring after inhalation of crystalline silica dust, potentially present in all production processes involving materials containing silica. All over the traditional sanitary ware production process, risk of Silicosis can be find in stages involving quartz or semi-finished products containing it (e.g. slip), since quartz is mainly composed by Silica in its crystalline form. In particular, the quartz extraction stage and the slip production phases of finishing and cooking are the ones with the higher level of risk, releasing silica dust.

SANITSER process demonstrated to completely cut down the social impact related to this disease. However, this affected only social topics related to health and safety, so that the final results were not very touched by it. At the contrary, the main part of indicators was not affected by the process changes: this is since the traditional production can be easily substituted by the SANITSER one, so companies are not required to apply special procedures to improve their average social impacts. At the same time, the awareness of both workers and local communities related to the use of recycled materials, which might generate benefits like a higher level of involvement, was not registered by this study: this is due to the shortness of the innovative technology period of application. The same concept applies to the possible reduction of incidents linked to the lower waste production: this decrease might be registered only after a long period of application of SANITSER process.

In any case, this analysis was useful to confirm a first impression of the working team, so that further studies could focus even more on the social topics which demonstrates to be very affected by the innovative process application.

The survey conducted in this study was able to collect a good number of filled questionnaires, even if some difficulties were present for the raw materials suppliers. It is clear that the possibility of obtaining questionnaires from all suppliers would have led to more reliable results. This is particularly true for Local Communities, for which nowadays data availability is still not very high, but will be improved in next years with the spreading of this kind of analysis.

For the same reason, future analysis will probably be able to make a reliable and useful weighting of Social topics and of life cycle stage: the first would be useful to give more value to process specificities (i.e. Silicosis disease for Sanitary ware manufacturing), while the second would balance the influence of the different life cycle stages, individuating the stages having only a marginal influence on product social impact.

Part II

Life Cycle Costing

1. Goal and scope definition

1.1. Goal of the study

The aim of this second part of the study is to benchmark the life cycle costing performance of the innovative technology for producing sanitary ware (SANITSER process) versus the traditional one.

1.2. Reference standards

The methodology used in this study is based on the international standard ISO 15686:2008 "Buildings and constructed assets —Service-life planning", which gives guidance on performing life cycle cost analyses of buildings and constructed assets and their parts.

Other documents publicly available were consulted too, such as "Life Cycle Costing (LCC) as a contribution to sustainable construction: a common methodology", produced by Langdon consulting (2007) under request of the European Commission.

The calculation model has been developed as Excel spreadsheet, taking as a reference the Swedish National Agency for Public Procurement's LCC tool available on their website: http://www.upphandlingsmyndigheten.se/en/subject-areas/lcc-tools/.

1.3. The production process: general description

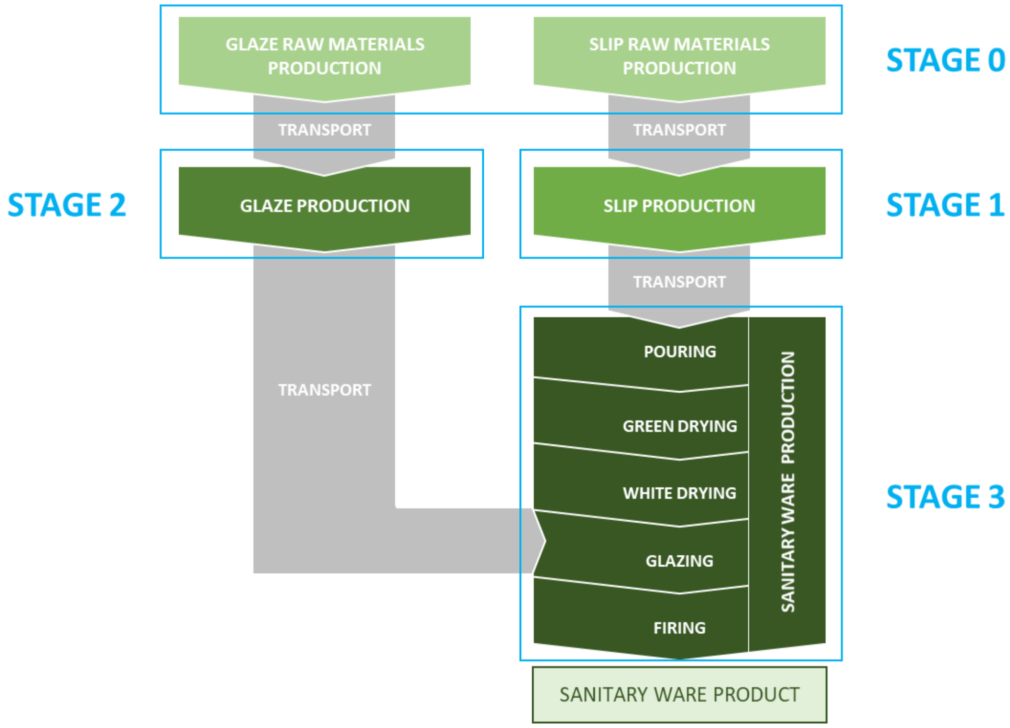
The sanitary ware manufacturing is composed by four main stages:

- **STAGE 0**: Raw materials extraction and/or production;
- **STAGE 1**: Slip production, starting from dry raw materials and water which are mixed to obtain a liquid intermediate product;
- **STAGE 2**: Glaze production, which is obtained by mixture of dry raw materials and water with a process very similar to the slip production;
- **STAGE 3**: Final sanitary ware production. The slip is initially poured within a mould, then the main water content is removed by two drying stages (green drying and white drying). The moulded and dried slip is then glazed and, in the end, fired at around 1250°C (for traditional process) or 1170°C (for SANITSER process).

The main production stages are reported in FIGURE 8.

SANITSER

Figure 8 Unit processes describing the main stages of sanitary ware manufacturing.



1.4. Scope of the analysis

This study compares the economic performances of traditional vs innovative (SANITSER) sanitary ware production systems.

The analysis focuses on direct costs occurring during the operating and maintenance activities of a sanitary ware production system, which includes the following stage:

- Ceramic slip production (**STAGE 1**);
- Glaze production (**STAGE 2**);
- Sanitary ware production (**STAGE 3**).

Raw material procurement costs have been considered in the analysis of STAGE 1 and 2.

The choice of focusing the analysis only on operating and maintenance costs relies in the fact that these are the only ones for which a variation between the traditional and SANITSER process is foreseen.

Indeed, the introduction of recycled material in ceramic slip and glaze for sanitary ware production, achieved with SANITSER project, is expected to influence these cost categories, since it allows a reduction both in costs for raw materials procurement and in natural resources consumption (gas and electricity).

On the contrary, fixed costs such as capital equipment and decommissioning costs can be assumed equal for both traditional and innovative processes, as SANITSER technology can be adopted even by plants already operating with traditional system, with no need for additional investments.

The study has been carried out considering the case of a plant with three integrated product lines for the three production stages (slip, glaze, sanitary ware), with size reflecting the pilot plant designed and described in the project deliverable B9 (1 design for industrial VSW plant).

The declared unit chosen for this analysis is **1 ton of sanitary ware**, produced either with the traditional or SANITSER process.

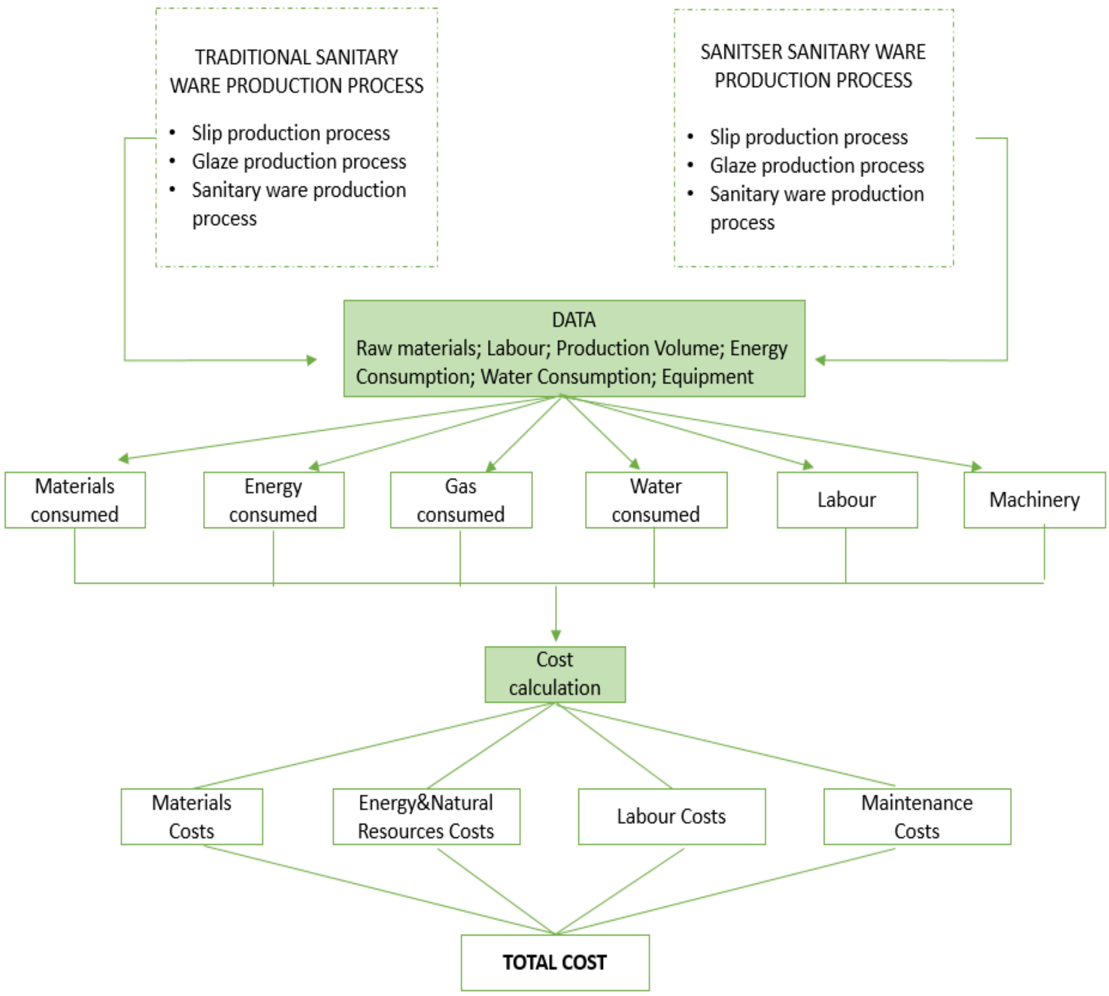
2. Methodology

2.1. The process

LCC analysis (Figure 9) begins with the characterization of the object of the study, to set the boundaries of the analysis by means of the identification of the core processes of both traditional and SANITSER production systems (from an economic point of view).

After the identification of the core processes and the definition of declared unit and system boundaries, it is possible to develop the LCC model, starting from data collection.

Figure 9 Methodology for LCC studies elaboration

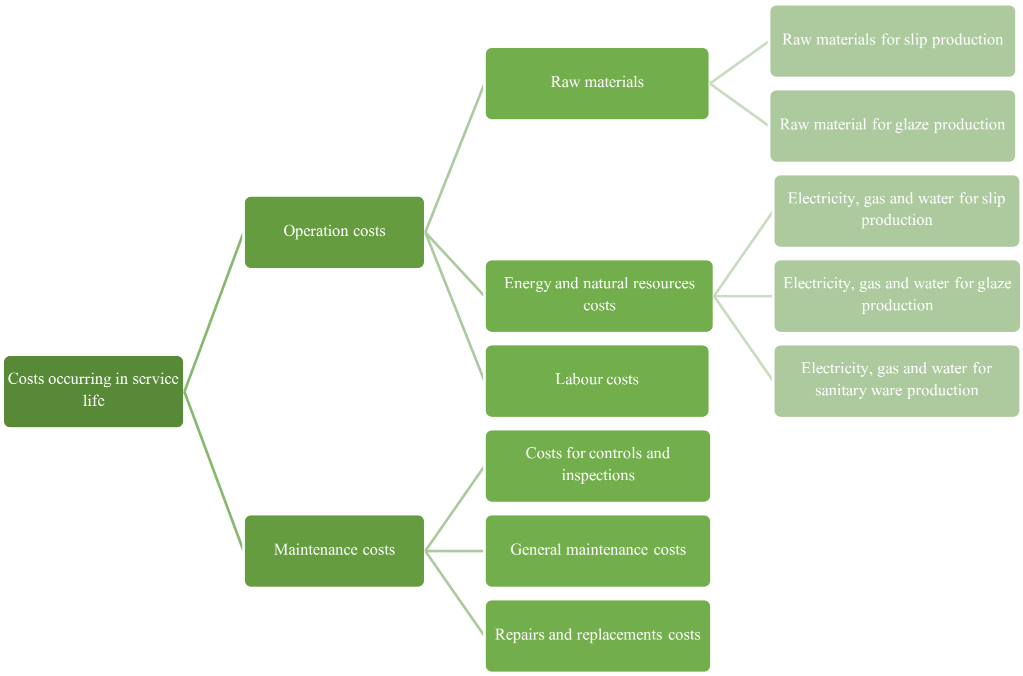


2.2. Cost categories

The determination of costs incurred throughout the sanitary ware manufacturing is achieved by summing all several expenses inherent to successive production stages, whose amount depends on type and quantity of used resources, materials and energy and obviously on their specific costs.

In this specific case, total cost is obtained by summing up all cost categories showed in FIGURE 10.

Figure 10 Cost categories and subcategories considered in present study



Operating costs include:

- raw material acquisition for slip and glaze preparation;
- energy and water consumption to carry out the three production stages;
- plant employees' salaries (labour cost).

Maintenance costs include:

- annual controls and inspections:
- general maintenance activities;
- costs replacement or repair costs.

In the final model, all costs were aggregated in four categories:

- **RAW MATERIALS COSTS**, associated with the procurement of disposable raw materials used for slip and glaze production (STAGE 1 and 2);
- **ENERGY AND NATURAL RESOURCES COSTS**, related with the amount of electric energy, water and gas consumed by the equipment during slip, glaze and sanitary ware processes respectively (STAGE 1, 2 and 3);
- **LABOUR COSTS** (STAGE 1, 2 and 3);
- **MAINTENANCE COSTS** (STAGE 1, 2 and 3).

2.3. Normalization

When input data are obtained from different sources and refer to different periods, a normalization process must be implemented to make them consistent and comparable.

To the purpose of this analysis, all data collected and presented in PARAGRAPH 3 LIFE CYCLE COSTING INVENTORY were reported to the declared unit. To do so, it was necessary to consider the different material conversion efficiencies occurring over slip, glaze and sanitary ware production stages (STAGE 1, 2 and 3).

These efficiencies are reported in TABLE 11 as ratio between input material and product of the stage.

Table 11 Conversion efficiencies for slip and glaze production stages

SLIP	Units	TRADITIONAL	SANITSER
Raw materials/slip	kg/kg	0.8	0.8
Slip /Sanitary ware	kg/kg	1.4	1.4
Raw materials/sanitary ware	kg/kg	1.1	1.1
GLAZE	**Units**	**TRADITIONAL**	**SANITSER**
Raw materials/glaze	kg/kg	0.7	0.7
Glaze/sanitary ware	kg/kg	0.2	0.2
Raw materials/ sanitary ware	kg/kg	0.1	0.1

2.4. Discounting

Discounting is a technique used to compare costs or incomes occurring in different time periods. Project costs happening at different points in the life cycle of a system cannot be compared or summed directly, due to the varying time value of money.

The time value of money is one of the basic theories of financial management. This theory, which underpins the concept of interest, states that there is a difference between the future value of a sum of money to be payed or earned, and the present value of the same amount. More in detail, people tend to prefer consuming immediate benefits to those occurring in the future.

When comparing two or more project options, a common basis is necessary to ensure fair evaluation. Present is considered to be the most suitable time reference and, for this reason, all future costs must be adjusted to their present value by means of a parameter called **discount rate**, which reflects the opportunity-cost of capital to an investor over time. Therefore, the present value of a future cost can be thought as the amount of money that would need to be invested today, at an interest rate equal to discount rate, to have the money available to meet the future cost at the time when it is predicted to occur.

To the purpose of this analysis, all future costs occurring during the two production systems service life were discounted to the present value.

Two types of discount rates can be used in computing the present value: a “real” rate or a “nominal” rate. The real discount rate reflects the time value of money without accounting for the effects of inflation and deflation. That is, it reflects the real earning power of money over time. On the contrary, nominal discount rates take into account general inflation, plus the real earning power of money (Langdon 2007).

In this analysis, a real discount rate of **4%**, as suggested by the Swedish National Agency for Public Procurement’s LCC tool, was applied. It has been assumed that energy costs remain unchanged throughout the reference period.

2.5. Economic evaluation

By calculating the life cycle cost of different projects or asset alternatives, it is possible to have an immediate picture of the economic efforts needed for their realization. Nevertheless, the project’s cost alone is not sufficient to evaluate different investment options, since there are other variables – e.g. present and future revenues – which must be considered.

Several financial analysis techniques are available for the assessment of alternative investment options. In this case, the **Net Present Value (NPV)** approach was used to determine and compare the cost effectiveness of proposed options.

NPV may be described as the difference between the sum of the discounted benefit (e.g. revenues from sales) of an option and the sum of the discounted costs.

A stream of future costs and benefits can be converted to a net present value using the following equation:

$$NPV = \sum_{n=1}^{p} \frac{C_n}{(1+i)^n}$$

where:

C is the net cash flow (benefit – cost) at year n;

i is the expected real discount rate per year;

n is the number of years between the base date and the occurrence of the cost;

p is the period of analysis.

NPV can be positive, zero or negative:

- **Positive NPV**: the present value of benefits (i.e., revenues from sanitary ware sales) is greater than the present value of expenditures. In this case, the investment should be accepted. In case of comparison among different investments, the option with the greatest NPV should be chosen, since it is supposed to be the most profitable.
- **Zero NPV**: the present value of benefits is equal to the present value of expenditures. The investment adds no monetary value, so the decision should be based on different criteria than economic profitability.
- **Negative NPV**: means that the present value of benefits is less than the present value of cost flows. In this case, the investment proposal should be rejected.

3. Life Cycle Costing Inventory

3.1. Data collection

Data referred to production stages (slip, glaze and sanitary ware) costs were collected by means of a specific questionnaire, prepared by LCE and submitted to all project partners directly involved in the production.

The questionnaire, including guidance and instruction for compilation, focused on cost categories described in PARAGRAPH 2.2 and had different field for collecting both traditional and SANITSER manufacturing data. Data requested by the questionnaire were mostly expressed on annual basis (€/year) and only during the following elaboration were normalized to be consistent with the declared unit.

An example of questionnaire (in Italian language) is provided hereafter (TABLE 12).

Table 12 Questionnaire used for LCC data collection

CATEGORIA	DESCRIZIONE	UdM	TRADIZIONALE	SANITSER	NOTE ED IPOTESI FATTE PER LA COMPILAZIONE
Info generali	Volume di produzione annuo	ton/anno			
	Volume di vendita annua	ton/anno			
	Tasso di interesse	%			
	Vita media dell'impianto produttivo	anni			
	Prezzo di vendita sanitario	€/ton			
Investimenti per R&D e beni capitali	DESIGN – R&D				
	Parcelle di professionisti	€/anno			
	Tasse e autorizzazioni				
	Test di laboratorio				
	Altri costi di R&D				
	SVILUPPO - ACQUISIZIONE				
	Acquisto o altri costi per infrastrutture	€/anno			
	Acquisto/ riconversione macchinari				
	Sviluppo prototipo				
	Personale per installazione				
Costi operativi	MATERIE PRIME				
	Materia prima 1	SLIP €/anno			
	Materia prima 2				
	Materia prima 3				
	,,,,,				
	CONSUMI				
	Elettricità	€/anno			
	Acqua				
	Gas				
	....				
	COSTI DEL PERSONALE				
	Profilo 1	€/anno			
	Profilo 2				
	....				
	ALTRE SPESE				
	Tasse per smaltimento rifiuti	€/anno			
	Altro (specificare)				
Mantenimento impianto	MANTENIMENTO				
	Controlli, ispezioni	€/anno			
	Manutenzioni				
	Sostituzione macchinari				
	Affitto, altri costi fissi				

3.2. General hypothesis and assumptions

This analysis relies on the assumptions presented hereafter.

- **SANITARY WARE AVERAGE WEIGHT**: an average weight of 22 kg per piece has been assumed.
- **DAILY TONS OF PRODUCED SANITARY WARE**: the daily production of a plant with comparable size of the one described in deliverable B9 (1 design for industrial VSW plant) ranges between 800 and 1 000 pieces. An average production of 900 pieces has been considered.
- **ANNUAL WORKING DAYS**: in Italy, there are almost 220 working days per year, while usually this amount increases up to 330 days per year in other countries. An average scenario with 275 working days has been considered.

- **ANNUAL PERCENTAGE OF SALES**: a percentage of sales equal to 95% of the total annual production has been considered.
- **AVERAGE SANITARY SELLING PRICE**: Italian sanitary ware price ranges from 80€ (for a basic, economic piece) to 500€ (for a design piece). An average price of 300€ was taken in consideration for this analysis.
- **LABOUR PROFILE**: the study focused on a medium/big size plant with 110 employers and two different salary level: manager (60 000€/y) and workmen (33 000€/y). It has been estimated that personnel in a company of 110 people is divided as follows: 15% managers and administrative roles, 85% general workers.
- **PACKAGING**: packaging needed for raw materials procurement are big bags (slip raw materials) and paper bags (glaze raw materials), whose average costs were assumed to be of 8€/piece for big bags and 0.50€/piece for paper bags.
- **ENERGY COSTS**: energy costs were calculated on the basis of the annual energy consumption estimated by Deliverable Action C2 Life Cycle Assessment Report, applying the following specific energy costs: 0.24 €/m3 methane; 0.12 €/kWh electricity. For slip production in SETEC premises, a specific cost of 0.22€/kWh was considered for electricity.
- **WATER COST FOR SANITARY WARE STAGE**: costs related to water consumption have been estimated to be around 5 000 €/y, being sanitary ware water consumption similar to slip and glaze production stages
- **MAINTENANCE COSTS FOR SANITARY WARE STAGE**: overall maintenance costs have been estimated equal to those occurring in the glaze process.
- **WASTE DISPOSAL OPERATIVE COST**: The ceramic process produces a high amount of waste, whom disposal has annual costs. SANITSER process is estimated to generate a 2% waste reduction, thus decreasing this operative cost. However, it was not possible to verify this estimation due to difficulties in data collection, due to short project period in comparison with waste management registrations.
- **ROUNDING**: data presented in the tables hereafter has been rounded to facilitate the understanding.

3.3. Inventory elaboration and analysis

This paragraph provides all details about input costs used in the LCC analysis. The two analysed options are called “Traditional” and “SANITSER” all over this paragraph.

3.3.1. General information

The sanitary ware selling price per ton has been obtained considering an average price of 300€ per sanitary ware piece and an average weight of 22 kg per sanitary piece.

All input data are reported in TABLE 13.

Table 13 Total production and selling prices for innovative and traditional sanitary ware production processes

DESCRIPTION	Units	TRADITIONAL	SANITSER
Annual production of sanitary ware pieces	tons/y	5 445	5 445
Annual amount of sold product	ton/y	5 173	5 173
Sanitary ware selling price	€/ton	13 636	13 636

3.3.1. Raw materials

The introduction of recycled materials in slip and glaze recipes allows the partial or total substitution of some raw materials, such as quartz and kaolin. TABLE 14 presents the comparison of procurement costs for traditional and SANITSER systems, referred to the declared unit. Please note, raw materials costs are subjected to complex dynamics which often causes fluctuations, thus results might be different changing the considered timeframe.

Table 14 Total cost for raw materials used in slip and glaze production, for traditional and innovative compositions

RAW MATERIALS	Unit	TRADITIONAL	SANITSER
CERAMIC SLIP PRODUCTION			
Clay Hycast VC	€/ton sanitary ware	24.9	-
Clay sablend 90		29.8	36.7
Kaolin imperial		37.8	-
Kaolin HPC		8.3	-
Kaolin CC31		65	-
Quarts		30.1	-
Feldspar		21.8	-
Clay Hycast rapide		-	17.1
Kaolin rembled		-	57.7
Kaolin BB-Z		-	5.9
Glass Filler GS-VF		-	6.8
Pitcher BVC-VF		-	7
Na/K – feldspar "F60-PBVF"		-	25.7
Talc		-	10.7
Packaging – big bag		8.7	8.7
GLAZE PRODUCTION			
Zircosil (Zircobit)	€/ton sanitary ware	19.6	19.8
Zinc oxide		7.9	16.1
Kaolin SP		5.6	6.8
Calcium carbonate		1.3	1.4
Magnesite		0.2	-
Feldspar NA Extra 75		4.9	2.7
Quarts sibelco SA125		6.5	-
Quarts QPS-FF		-	3.2
Glass VB-FF		-	2.2
Glass VBI-FF		-	3.6
Packaging – paper bag		2.7	2.7

3.3.2. Energy and natural resources costs

All Sanitary ware manufacturing stages imply the consumption of electricity, water and natural gas. TABLE 15 resumes the input data used to assess their total cost over the three stages. The assessment was based on the assumptions previously described in PARAGRAPH 3.2.

Table 15 Input data considered for the calculation of energy and natural resources related costs

RESOURCES COSTS	UNITS	TRADITIONAL	SANITSER
CERAMIC SLIP PRODUCTION			
Electricity	€/ton sanitary ware	36	36
Water		0.9	0.9
GLAZE PRODUCTION			
Electricity	€/ton sanitary ware	1	1
Water		1.5	1.5
SANITARY WARE PRODUCTION			
Electricity	€/ton sanitary ware	80	69
Water		1	1
Gas		160	143

3.3.1. Labour costs

TABLE 16 describes the annual estimated labour costs. Assumption regarding employees' salaries are reported in PARAGRAPH 3.2.

Table 16 Input data considered for the calculation of labour related costs

PERSONNEL ANNUAL SALARY	UNITS	TRADITIONAL	SANITSER
Profile 1 - Manager	€/ton sanitary ware	176	176
Profile 2 – General employee		570	570

3.3.2. Maintenance costs

Maintenance costs have been estimated separately for the three production stages, assuming that every stage requires different machineries, inspections and controls (TABLE 17).

SANITSER innovative slip and glaze are foreseen by experts to reduce the level of stress on machineries, thus decreasing all costs for maintenance and substitution. However, an estimation of this benefits can occur only after a period of application equal to one year or more, while project production period took only some months. For this reason, this benefit is not quantifiable within this study, and the maintenance cost structure for a plant adopting SANITSER process has been assumed equal to that of a traditional plan.

Moreover, due to difficulties occurred during data collection, maintenance costs for sanitary ware manufacturing stage have been assimilated to those occurring in glaze production process.

Table 17 Input data considered for the calculation of maintenance related costs

MAINTENANCE COSTS	Units	TRADITIONAL	SANITSER
CERAMIC SLIP PRODUCTION			
Controls and inspections	€/ton sanitary ware	2	2
General maintenance		19	19
Spare parts		28	28
GLAZE PRODUCTION			
Controls and inspections	€/ton sanitary ware	1.5	1.5
General maintenance		15	15
Spare parts		28	28
SANITARY WARE PRODUCTION			
Controls and inspections	€/ton sanitary ware	1.5	1.5
General maintenance		15	15
Spare parts		28	28

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4. LCC results

The analysis presented in the following pages is structured in two different parts:

- In the **first part**, the economic comparison focuses on the declared unit. The analysis is conducted "ex tempore", without considering the timeframe. To this aim, costs occurring on a yearly basis were reported to the declared unit by considering the yearly sanitary ware production.
- The **second part** analyses the investment appraisal on its entirety, thus considering all operating and maintenance costs occurring over the entire service life of a plant producing sanitary ware. To this aim, a reference period of 40 years has been considered, representing the average use-life of a sanitary ware production process. Costs were reported to the present value through the discounting techniques, as suggested by ISO 15686. More details on the methodological approach to economic evaluation are provided in PARAGRAPH 2.3 AND 2.4.

The two analysed options are called "Traditional" and "SANITSER" all over this paragraph.

4.1. Part 1: Cost comparison per declared unit

4.1.1. General considerations

The comparison between the total operation and maintenance costs (reported per declared unit) in the traditional and SANITSER processes is presented in TABLE 18. Overall operating costs are estimated to decrease by almost 5% with the adoption of SANITSER. This estimate, however, is voluntary precautious and may vary significantly according to the assumptions made on costs of energy and natural resources. Moreover, as explained in PARAGRAPH 3.3.2, maintenance costs are foreseen to be reduced with SANITSER process, although at the moment it is not possible to quantify this benefit in monetary terms. For this reason, it is reasonable to estimate that according to the conditions set for the variables described, the ultimate cost reduction may vary from 5% to 10%.

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Table 18 Total costs for operation and maintenance (€/ton sanitary ware), comparison between traditional and SANITSER processes (rounded data)

COSTS	Units	TRADITIONAL	SANITSER	NET SAVINGS SANITSER VS TRADITIONAL €/ton SW	NET SAVINGS SANITSER VS TRADITIONAL %
RAW MATERIALS COSTS	€/ton sanitary ware	275	235	- 40	-15%
Materials for Slip production	€/ton sanitary ware	227	176	-50	-22%
Materials for Glaze production		48	58	10	21%
ENERGY & NATURAL RESOURCES COSTS	€/ton sanitary ware	280	253	- 27	-10%
Electricity	€/ton sanitary ware	117	106	-11	-9%
Natural gas		160	143	-17	-10%
Water		3	3	-	unchanged
LABOUR COSTS	€/ton sanitary ware	746	746	unchanged	unchanged
Profile 1 – manager	€/ton sanitary ware	176	176	unchanged	unchanged
Profile 2 – general employees		570	570	unchanged	unchanged
MAINTENANCE COSTS	€/ton sanitary ware	135	135	unchanged	unchanged
Controls & inspections	€/ton sanitary ware	48	48	unchanged	unchanged
General maintenance		44	44	unchanged	unchanged
Spare parts		44	44	unchanged	unchanged
TOTAL COSTS	**€/ton sanitary ware**	**1 437**	**1 369**	**-70**	**-5%**

Below some considerations on results are provided.

- **RAW MATERIALS COST**. Overall, cost for raw materials decreases by up to 15% compared to the traditional process. This reduction is totally due to the innovative recipe for ceramic slip. More in detail, the introduction of recycled material in the ceramic slip brings a sensible reduction in raw materials cost (-22%). This reduction is partially compensated by the increase in the cost for glaze raw materials, mainly caused by the different composition of raw materials in the glaze recipes: glaze innovative recipe requires higher amounts of some expensive materials, so that even small increment of their percentage in the recipe generate relevant changes in the final cost (see TABLE 14 for further details). Anyway, the amount of glaze used for producing a ton of sanitary ware is limited, so total cost for raw materials still decreases.

- **ENERGY AND NATURAL RESOURCES COST**. The costs for utilities such as electricity and gas used in SANITSER process is 10% lower than within traditional system. While energy consumption remains unchanged during the slip and glaze preparation, during SANITSER sanitary ware production stage a decrease in the use of electricity and gas is reported. This is mainly due to the variations occurring during the firing process: SANITSER allows to significantly decrease the firing temperature and, consequently, the consumption of gas for the furnace. On the contrary, water consumption remains unchanged consistently with the assumptions described in PARAGRAPH 3.2.

- **LABOUR AND MAINTENANCE COSTS**. These two cost categories remain unchanged between the traditional sanitary ware production and SANITSER (Consistently with the assumptions set at PARAGRAPH 3.2 AND 3.3.2). Whether this result was expected for what concern the labour costs, since the number of employees is not effected by the change in ceramic production technology, a variation in maintenance costs could have been expected, as described in PARAGRAPH 3.3.2. Nevertheless, as previously said, this estimate couldn't be confirmed since the project duration was too short to evaluate significant differences in machinery useful life.

4.1.2. Contribution margins and break-even point

The contribution margin represents the difference between a company's sales revenue and variable costs. In other words, it measures how efficiently a company produce its products while maintaining low variable costs.

The contribution margin is calculated as difference between the sale price per unit and the total variable costs per unit, were "unit" is one sanitary ware piece. TABLE 19 shows the different contribution margins for the traditional and SANITSER process, respectively. Variable costs per unit were calculated starting from the total operative and maintenance costs per tonne of sanitary ware.

Table 19 Contribution margins

	UNIT	TRADITIONAL PROCESS	SANITSER PROCESS
SALE PRICE PER UNIT	€	300	300
VARIABLE COSTS PER UNIT	€	32	30
CONTRIBUTION MARGIN	€	268	270

As it can be seen, SANITSER has a higher contribution margin, since variable costs are lower than the traditional process.

Starting from the contribution margin, it is possible to calculate the break-even point, which expresses the amount of sales (or sold units) to be achieved in order to cover the entirety of the company expenses (variable and fixed costs).

Break-even point is calculated as follows:

$$\text{Break} - \text{Even Point (in units)} = \frac{Total\ Fixed\ Costs}{Contribution\ Margin\ per\ Unit}$$

Since capital equipment and other fixed costs are not included in the present LCC analysis, it is not possible to determine the break-even point for the two options.

Nevertheless, it is reasonable to foreseen that a company operating with SANITSER process will achieve the break-even point before the competitor operating with the traditional one. This is because the contribution margin of a plant operating with SANITSER is higher than traditional one, while fixed costs can be considered equal for the two productions. The adoption of SANITSER, indeed, does not affect company fixed costs (e.g. costs for rent and equipment), since the only things to be modified are glaze and slip recipes.

4.2. Part 2: Total costs over plant service life

4.2.1. Annual costs

TABLE 20 describes the operative expenses foreseen for the annual production of sanitary ware **with** traditional and SANITSER production options.

Table 20 Total annual variable costs comparison (rounded data)

	UNITS	TRADITIONAL	SANITSER	NET SAVINGS SANITSER VS TRADITIONAL
RAW MATERIALS COSTS	€	497 800	1 277 900	-15%
ENERGY & NATURAL RESOURCES COSTS	€	1 526 400	1 377 150	-10%
MAINTENANCE COSTS	€	736 000	736 000	unchanged
LABOUR COSTS	€	4 062 000	4 062 000	unchanged
TOTAL	€	7 822 300	7 453 070	-5%

4.2.2. Total life cycle costs at present values

Once the total annual costs have been identified, it is possible to assess the total life cycle cost of the asset (in this case of the two options, SANITSER and traditional). To do so, a discount factor is applied to the future expenditures, to actualize them to the base date.

The Total Actualized Cost of a project, or Net Present Cost, is obtained as a sum of the discounted future cost flows. A detailed scheme of cost flows throughout the reference period is described in ANNEX I - DISCOUNTED CASHFLOWS.

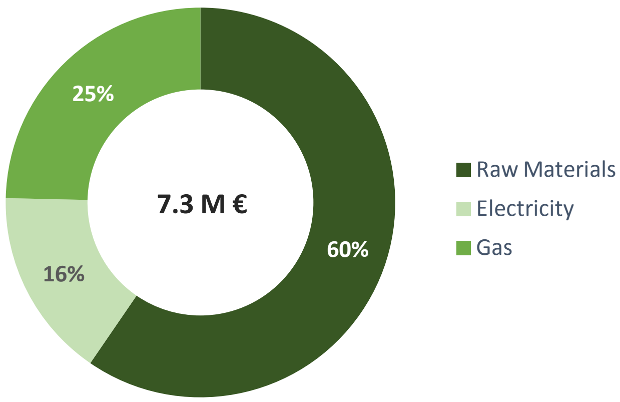
Annual cost flows were actualized using the discounting method described in PARAGRAPHS 2.4 AND 2.5, assuming a real discount rate of 4%.

The total costs of the two production systems, actualized at present value are presented in TABLE 21. Overall, switching from traditional production to SANITSER one could allow to save up to 7 million euros, with savings being distributed as in FIGURE 11.

Table 21 Total actualized costs and Net Present Value for the traditional and SANITSER processes

	UNITS	TRADITIONAL	SANITSER	NET SAVINGS (%)
TOTAL ANNUAL COSTS	M €	7. 8	7.5	-5%
TOTAL LCC COSTS (PRESENT VALUES)	M €	154.8	147.5	-5%
NET PRESENT VALUE (NPV)	M €	1 241	1 249	+1%

Figure 11 Breakdown of overall savings generated by SANITSER process



As described in PARAGRAPH 2.5, the Net Present Value Technique was used to compare the traditional and SANITSER production process profitability.

In this case, benefits (positive cash flows) were assimilated to the revenues from sale of sanitary ware pieces. Revenues were assessed multiplying the average unit price (€ 300) for the total amount of sold product, which consist in 95% of the total production (5 173 pieces, see PARAGRAPH 3.2). Revenues were considered equal in the two alternatives.

As shown in TABLE 11, NPV is clearly positive for both alternatives, but consistently with results of the cost comparison, SANITSER's NPV is slightly higher (+1%), thus confirming a higher profitability potential.

5. Final considerations

This LCC study was aimed at evaluating and comparing the economic profitability of traditional sanitary ware production with innovative SANITSER system. The analysis focused exclusively on direct variable costs occurring during the operating and maintenance activities of a sanitary ware production system.

Results shows that SANITSER process is characterized by lower operating cost; more in detail, the introduction of recycled raw materials within slip and glaze recipes allows raw materials costs reduction up to 15%. Energy costs are reduced as well, thanks to the lower firing temperature required by the innovative SANITSER recipe, which allows to decrease energy consumption.

This study focused exclusively on direct variable costs, since fixed costs such as capital equipment and decommissioning costs were not supposed to be affected by the substitution of the traditional production with SANITSER one.

Further developments could lead to broaden the system boundaries of the analysis, in order to include other cost categories (such as waste management and decommissioning costs), as well as the inclusion of environmental and social externalities, which at the moment have not been considered for lack of reliable data.

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SANITSER

ANNEX I - Discounted cashflows

GENERAL DATA		TRADITIONAL			SANITSER		
Year	Discount factor	Total costs	Revenues	Cash flow	Total costs	Revenues	Cash flow
0	1,00						
1	0,96	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
2	0,92	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
3	0,89	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
4	0,85	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
5	0,82	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
6	0,79	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
7	0,76	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
8	0,73	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
9	0,70	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
10	0,68	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
11	0,65	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
12	0,62	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
13	0,60	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
14	0,58	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
15	0,56	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
16	0,53	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
17	0,51	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
18	0,49	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
19	0,47	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
20	0,46	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
21	0,44	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
22	0,42	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
23	0,41	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
24	0,39	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
25	0,38	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
26	0,36	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
27	0,35	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
28	0,33	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
29	0,32	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
30	0,31	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
31	0,30	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
32	0,29	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
33	0,27	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
34	0,26	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
35	0,25	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
36	0,24	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
37	0,23	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
38	0,23	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
39	0,22	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424
40	0,21	7.822.262	70.537.500	62.715.238	7.453.076	70.537.500	63.084.424

ANNEX II - Acronymes

S-LCA	Social Life Cycle Assessment
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
PCR	Product Category Rules
UNEP	United Nations Environment Programme
SETAC	Society of Environmental Toxicology and Chemistry
ISO	International Organization for Standardization
MI	Minerali Industriali
LCE	Life Cycle Engineering
ASL	Azienda Sanitaria Locale (local health authority)