Università Politecnica delle Marche

Dipartimento di Ingegneria Industriale e Scienze Matematiche

REPORT

"LCA - Life Cycle Analyis of AIRCORAL+, the new photocatalytic and antibacterial material for lamp production"

PROF. FRANCESCO CORVARO

PROF. BARBARA MARCHETTI

ING. MARIELLA LEPORINI

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1. SCOPE OF WORK

The Buzzi & Buzzi company (also known as BUZZI), specialized in lighting, based in Milan, intends to evaluate the "carbon footprint" of **the innovative photocatalytic and antibacterial material named AIRCORAL+**. To this end, Prof. Marchetti together with Dr. Leporini and Prof. Corvaro, conducted a life cycle analysis in order to study the environmental impact (specifically the "carbon footprint") of the industrial process, **comparing it with two different scenarios, the market standard (hereinafter named 'MARKET STANDARD') and a previous photocatalytic material made by BUZZI (hereinafter named 'TRADITIONAL BUZZI').**

As AIRCORAL+ is in the pre-industrial phase, the results of the LCA analysis can be used to evaluate effects in terms of carbon footprint before being placed on the market.

An input / output databases to be used for the LCA analysis of the 3 materials (market standard, traditional BUZZI and AIRCORAL+) has been used. It was decided to neglect the logistics (also internal) and to consider the exit gate of the BUZZI company as the border of the system.

The applied methods are internationally recognized and are:

- **IPCC 2007 100a** (V1.1 Characterization) – The Intergovernmental Panel on Climate Change www.ipcc.ch was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO)
- **IMPACT 2002+** (V2.05): The Life Cycle Impact Assessment methodology IMPACT 2002+ suggests a feasible implementation of a combined midpoint/damage approach. These combinations link all types of Life Cycle Inventory (LCI) results, the elementary flows and other interventions, throughout the 14 midpoint categories summed up to four damage categories.

  New concepts and methods have been developed within IMPACT 2002+ for the comparative assessment of human toxicity and eco-toxicity. Human Damage Factors are calculated for carcinogens and non-carcinogens, employing intake fractions, best estimates of dose-response slope factors, as well as severities. The transfer of contaminants into the human food is no more based on consumption surveys, but accounts for agricultural and livestock production levels. Indoor and outdoor air emissions are compared and the intermittent character of rainfall is considered. Both human toxicity and ecotoxicity effect factors are based on mean responses rather than on conservative assumptions.

Other midpoint categories are adapted from existing characterizing methods (Eco-Indicator 99 and CML 2001). All midpoint scores are expressed in units of a reference substance and related to the four damage categories human health, ecosystem quality, climate change, and resources.

Normalisation are carried out either at midpoint or at damage level and the IMPACT 2002+ method presently provides characterisation factors for different LCI-results.

2. INPUT DATA

Data related to the three different products to analyze are reported in the following tables.

2.1 MARKET STANDARD

Raw materials and electrical components Standard Market material		Functional UNIT:	1 YIN LAMP
	Material / Component	Quantity [kg]	Notes
LAMP BODY - RAW MATERIALS	Calcium hydroxide	0,1	*At room temperature it appears as a white and odorless solid. It is an irritant compound.*
	Sodium nitrate	0,08	*Sodium nitrate is the sodium salt of nitric acid, It is a harmful, irritating compound. Because of its high oxygen content it has oxidative properties.*
	Silicon oxide	0,4	*Because of its microparticles it has a risk of inhalation toxicity.*
	Zirconium oxide	0,03	*The main use of zirconia is in the manufacture of ceramics, but there are many other uses including the protective coating on titanium dioxide pigment particles. Irritating to inhalation and skin.*
	H20	0,3	
	Hydrogen peroxide	0,28	*Reactive oxygenated forms; may irritate the respiratory tract. Corrosive, it can cause skin burns.*
	Calcium sulphate beta	0,5	
	Ceramic powder	0,2	
	Led	1 led - 78 lm/W	*Strongly improved in BETTAIR-LAMP lamps in respect with standard lamps.*
	Cables	30 cm	
ELECTRICAL COMPONENTS	Metal parts - galvanized steel	160 g	
	Mechanical components	60 g	*The same used in BETTAIR-LAMP lamp.*
	Block of polystyrene to be digged to adapt to final product form	1000 g	*A packing method using digged polystyrene was used.*

Process steps Standard Market material	Input materials	Output materials	By-product / waste	Energy sources (fuel, electric energy, biomass..)	kWh / STANDARD
	Calcium sulphate beta + marble powder	Dry mix	-	Electricity	0,075
Stage	Silicon oxide	Dry mix	-	Electricity	0,025
Dry mixing 1	Sodium nitrate	Dry mix	-	Electricity	0,008333333
Dry mixing 2	Calcium oxide	Dry mix	-	Electricity	0,016666667
Dry mixing 3	Zirconium oxide	Dry mix	-	Electricity	0,008333333
Dry mixing 4	H2O + hydrogen peroxide	Hydrogen peroxide - liquid	-	Electricity	by hand - 8 minutes/12 lamps
Dry mixing 5	Hydrogen peroxide - liquid	Wet mix	-	Electricity	0,025
Hydrogen peroxide preparation	H2O + silver	Silver - liquid	-	Electricity	0,033333333
Wet mixing 1	H2O + zinc oxide	Wet mix	-	Electricity	0,041666667
Silver preparation	Wet mix	Molded lamp body	-	Electricity	0,05
Wet mixing 3	Molded lamp body	Dried lamp body	Steam - 500 g	Electricity	0,411428571
Injection of mix into molds	Dried lamp body	Final lamp body	-	Electricity	
Drying	Leds, cables, metal parts and mechanical components	Electrical system	Electrical components scraps (cables, metal, etc.)	Electricity	0,083333333
Product finishing	Lamp body + electrical system	Lamp	-	Electricity	0,083333333
Connection of electrical system with lamp body	Lamp body + electrical system	Lamp	-	Electricity	0,083333333

2.2 TRADITIONAL BUZZI PROCESS

Raw materials and electrical components Traditional BUZZI material			
	Functional UNIT: 1 YIN LAMP		
	Material / component	Quantity [kg]	Notes
LAMP BODY - RAW MATERIALS	Zinc oxide	0,05	*It is almost completely insoluble in water but is very soluble in acidic or alkaline solutions. Dangerous for the environment and especially for aquatic organism.*
	Calcium Hydroxide	0,04	*At room temperature it appears as a white and odorless solid. It is an irritant compound.*
	Sodium nitrate	0,07	*Sodium nitrate is the sodium salt of nitric acid, It is a harmful, irritating compound. Because of its high oxygen content it has oxidative properties.*
	Silicon oxide (silicio)	0,05	*Because of its microparticles it has a risk of inhalation toxicity.*
	Zirconium oxide	0,2	*The main use of zirconia is in the manufacture of ceramics, but there are many other uses including the protective coating on titanium dioxide pigment particles. Irritating to inhalation and skin.*
	H20	0,40 l/kg	
	Hydrogen peroxide	50 ml litro (volume al 2%)	*Reactive oxygenated forms; may irritate the respiratory tract. Corrosive, it can cause skin burns.*
	Calcium sulphate beta	0,24	*low quality standard calcium sulphate*
	Titanium dioxide finish painting	0,05	*spray painting applied at the finishing process step*
	PRIMER finish similar EPSIL 00S: composition	5 ml	*Isopropylidenedicyclohexanol Metilisobutilchetone Xilene Metanol Dibutilestagnolaurato* — *applied at the finishing process step*
	Marble powder	0,35	
ELECTRICAL COMPONENTS	Led	1 led - 78 lm/W	*Strongly improved in AIRCORAL+ lamps in respect with standard lamps.*
	Cables	30 cm	
	Metal parts - galvanized steel	160 g	

Process steps Traditional BUZZI material					
	Input materials	**Output materials**	**By-product / waste**	**Energy sources (fuel, electric energy, biomass..)**	**kWh**
Stage	Calcium sulphate beta + marble powder	Dry mix	-	Electricity	0,075
Dry mixing 1	Silicon oxide	Dry mix	-	Electricity	0,025
Dry mixing 2	Sodium nitrate	Dry mix	-	Electricity	0,008333333
Dry mixing 3	Calcium oxide	Dry mix	-	Electricity	0,016666667
Dry mixing 4	Zirconium oxide	Dry mix	-	Electricity	0,008333333
Dry mixing 5	H2O + hydrogen peroxide	Hydrogen peroxide - liquid	-	Electricity	by hand - 8 minutes/12 lamps
Hydrogen peroxide preparation	Hydrogen peroxide - liquid	Wet mix	-	Electricity	0,025
Wet mixing 1	H2O + silver	Silver - liquid	-	Electricity	0,033333333
Silver preparation	H2O + zinc oxide	Wet mix	-	Electricity	0,041666667
Wet mixing 3	Wet mix	Molded lamp body	-	Electricity	0,05
Injection of mix into molds	Molded lamp body	Dried lamp body	Steam - 500 g	Electricity	0,411428571
Drying	Dried lamp body	Final lamp body	-	Electricity	by hand - 90 minutes/12 lamps
Product finishing	Painting with mix of water and tinanium	Final lamp body		Electricity	0,12
Coating fixing	Spray coating for titanium fixing	Final lamp body		Electricity	0,8
Electrical components assembling, including mechanical Machining	Leds, cables, metal parts and mechanical components	Electrical system	Electrical components scraps (cables, metal, etc.)	Electricity	0,083333333

2.3 AIRCORAL +

Raw materials and electrical components AIRCORAL+				
	Functional UNIT: 1 YIN LAMP			
	Material / component	**quantity [kg]**	**notes**	
LAMP BODY - RAW MATERIALS	**Titanium dioxide (ANATASE)**	0,06	*NoX reduction, increasing performance in bulk (not as spray), no waste,high capacity antipollution*	
	Calcium sulfate hemihydrate (ALFA)	0,70	*increasing performance agoinst old process with calcium beta*	
	Calcium sulfate dihydrate	0,10		
	Silver	0,1 ml	*solution in distilled water 1%*	
	Marble powder	0,12		
	Water	0,283 litri	*water saving*	
ELECTRICAL COMPONENTS	**High efficiency leds**	1 led - 130 lm/W	*Strongly improved in AIRCORAL + lamps in respect with standard lamps.*	
	Cables	30 cm		
	Metal parts - galvanized steel	160 g		
	Mechanical components	60 g		
PACKAGING	**Self-expanding packaging - polyethylene**	600 g	*Saving volume of material that occupies storage space and sometimes goes obsolete.*	

Process steps AIRCORAL+					
Stage	**Input materials**	**Output materials**	**By-product / waste**	**Energy sources (fuel, electric energy, biomass..)**	**kWh**
Dry mixing - one step	Titanium dioxide (ANATASE) , calcium sulfate hemihydrate (ALFA), calcium sulfate dihydrate, iron hydroxide, marble powder, water	Dry mix	-	Electricity	0,075
Wet mixing	H2O	Wet mix	-	Electricity	0,025
Injection of mix into molds	Wet mix	Molded lamp body	-	Electricity	0,008333333
Drying	Molded lamp body	Dried lamp body	Steam - 500 g	Electricity	0,1152
Product finishing	Dried lamp body	final lamp body	-	Electricity	By hand - 90 minutes/12 lamps
Electrical components assembling, including mechanical machining and automatic wiring	Leds, cables, metal parts and mechanical components	Electrical system	Electrical components scraps (cables, metal, etc.)	Electricity	0,083333333
Connection of electrical system with lamp body	Lamp body + electrical system	Lamp	-	Electricity	0,083333333
Lamp packaging					

3. LCA RESULTS

3.1 MARKET STANDARD RESULTS

The following figures and tables show the LCA results obtained in terms of kg CO2eq (with the method IPCC 2007 100a) and impact categories (with the method IMPACT 2002+) for the industrial process of the MARKET STANDARD material.

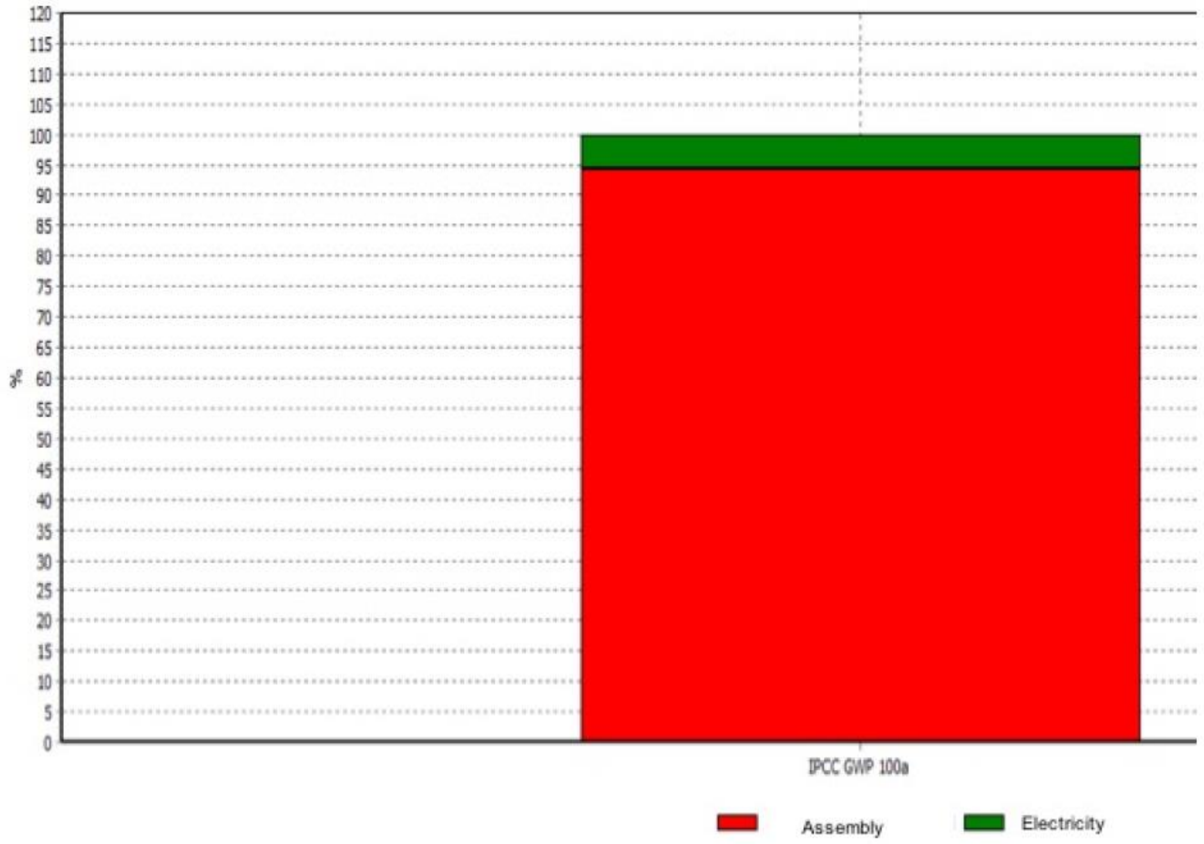

Figure 1: kg CO2 eq for Market standard process; Method IPCC 2007 100a (V1.1 Characterization)

Impact category	Unit	Total	Assembly	Electricity
IPCC GWP 100a	kg CO2 eq	39.5	37.6	1.92

Table 1: TOTAL kg CO2eq Market standard process

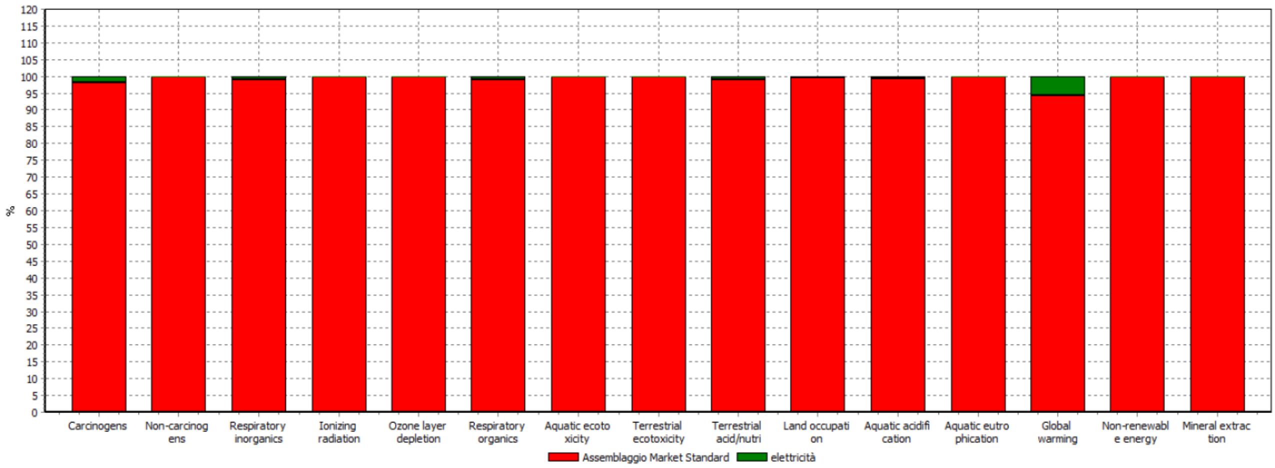

Figure 2: Impact Categories; Method IMPACT 2002+ (V2.05)

Impact category	Unit	Total	Assembly	Electricity
Carcinogens	kg C2H3Cl eq	0.592	0.582	0.0103
Non-carcinogens	kg C2H3Cl eq	0.612	0.611	0.000382
Respiratory inorganics	kg PM2.5 eq	0.0276	0.0273	0.000235
Ionizing radiation	Bq C-14 eq	1.51E3	1.51E3	0.29
Ozone layer depletion	kg CFC-11 eq	0.000185	0.000185	6.23E-9
Respiratory organics	kg C2H4 eq	0.0262	0.026	0.000249
Aquatic ecotoxicity	kg TEG water	6.95E3	6.95E3	3.54
Terrestrial ecotoxicity	kg TEG soil	597	596	0.886
Terrestrial acid/nutri	kg SO2 eq	0.496	0.491	0.00501
Land occupation	m2org.arable	0.183	0.182	0.000544
Aquatic acidification	kg SO2 eq	0.178	0.177	0.000968
Aquatic eutrophication	kg PO4 P-lim	0.00285	0.00285	3.79E-7
Global warming	kg CO2 eq	33.6	31.7	1.91
Non-renewable energy	MJ primary	591	589	1.38
Mineral extraction	MJ surplus	8.65	8.65	0.000118

Table 2: Impact Categories Market standard process

3.2 BUZZI TRADITIONAL RESULTS

The following figures and tables show the LCA results obtained in terms of kg CO2eq (with the method IPCC 2007 100a) and impact categories (with the method IMPACT 2002+) for the industrial process of the BUZZI standard material.

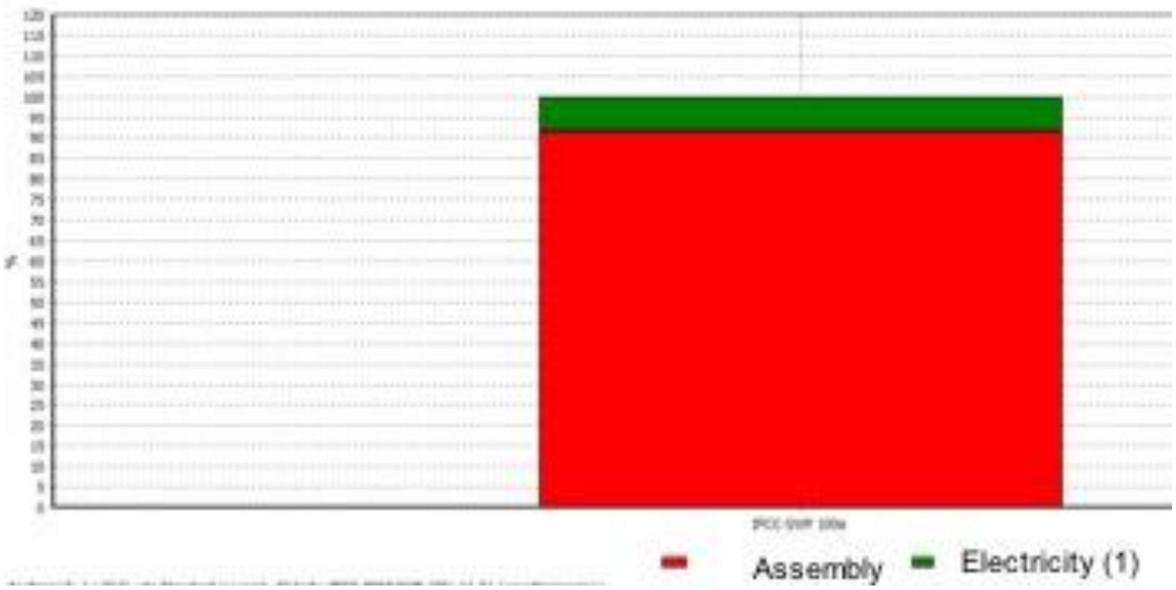

Figure 3: kg CO2eq for the BUZZI standard process; Method IPCC 2007 100a (V1.1 Characterization)

Impact category	Unit	Total	Assembly	Electricity (1)
IPCC GWP 100a	kg CO2 eq	42.4	37.6	3.6

Table 3: TOTAL kg CO2eq for the BUZZI standard process

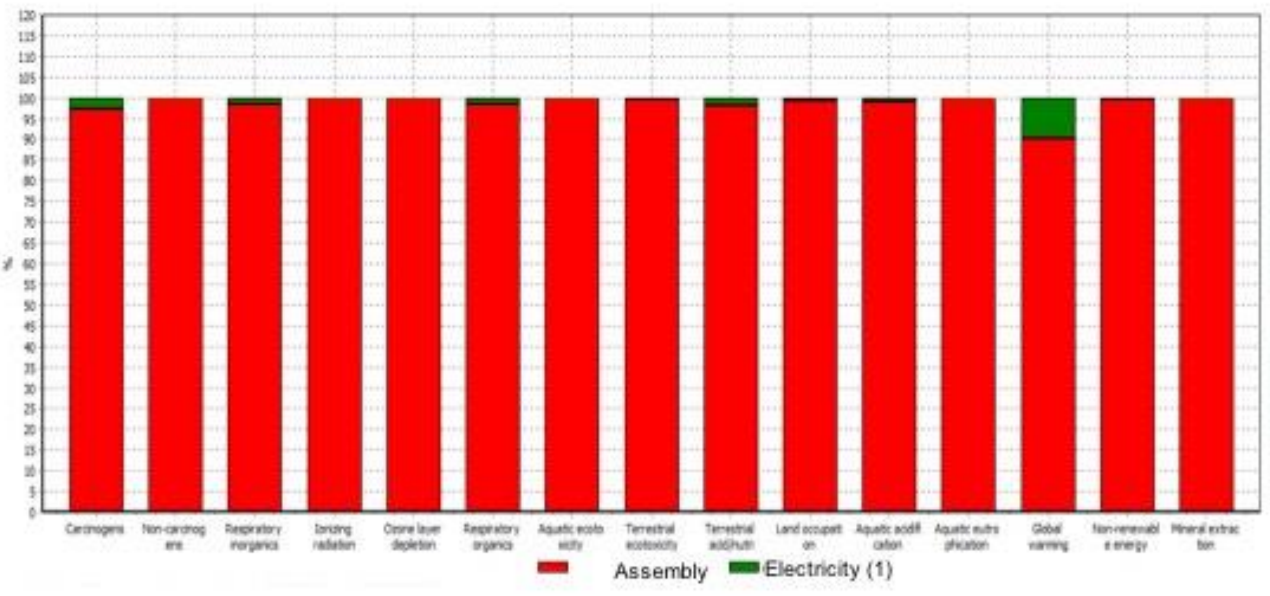

Figure 4: Impact Categories of the BUZZI standard process; Method IMPACT 2002+ (V2.05)

Impact category	Unit	Total	Assembly	Electricity (1)
Carcinogens	kg C2H3Cl eq	0.722	0.483	0.0192
Non-carcinogens	kg C2H3Cl eq	0.633	0.633	0.000716
Respiratory inorganics	kg PM2.5 eq	0.0283	0.0278	0.000441
Ionizing radiation	Bq C-14 eq	1.55E3	1.55E3	0.543
Ozone layer depletion	kg CFC-11 eq	0.000185	0.000185	1.17E-8
Respiratory organics	kg C2H4 eq	0.0271	0.0266	0.000467
Aquatic ecotoxicity	kg TEG water	7.06E3	7.05E3	6.64
Terrestrial ecotoxicity	kg TEG soil	639	638	1.66
Terrestrial acid/nutri	kg SO2 eq	0.513	0.504	0.00938
Land occupation	m2org.arable	0.185	0.184	0.00102
Aquatic acidification	kg SO2 eq	0.179	0.177	0.00181
Aquatic eutrophication	kg PO4 P-lim	0.00289	0.00289	7.11E-7
Global warming	kg CO2 eq	36.4	32.9	3.58
Non-renewable energy	MJ primary	617	615	2.58
Mineral extraction	MJ surplus	8.68	8.68	0.00022

Table 4: Impact Categories of the BUZZI standard process

3.3 AIRCORAL + RESULTS

The following figures and tables show the LCA results obtained in terms of kg CO2eq (with the method IPCC 2007 100a) and impact categories (with the method IMPACT 2002+) for the industrial process of the AIRCORAL+ material.

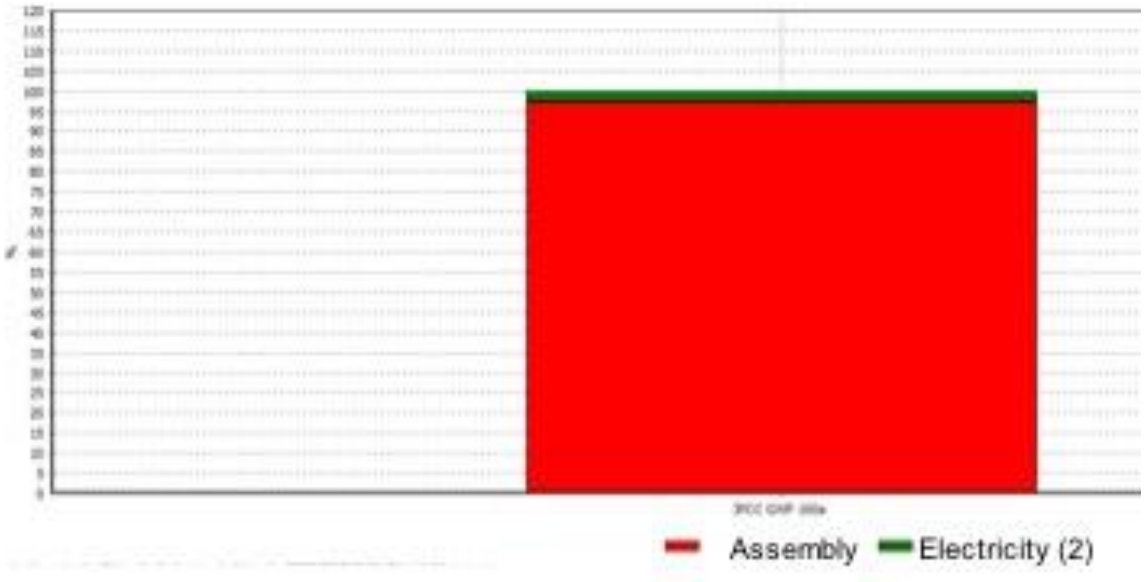

Figure 5: kg CO2eq for Buzzi & Buzzi AIRCORAL+; Method IPCC 2007 100a (V1.1 Characterization)

Impact category	Unit	Total	Assembly	Electricity (2)
IPCC GWP 100a	kg CO2 eq	28.7	27.9	0.789

Table 5: TOTAL kg CO2eq for AIRCORAL+

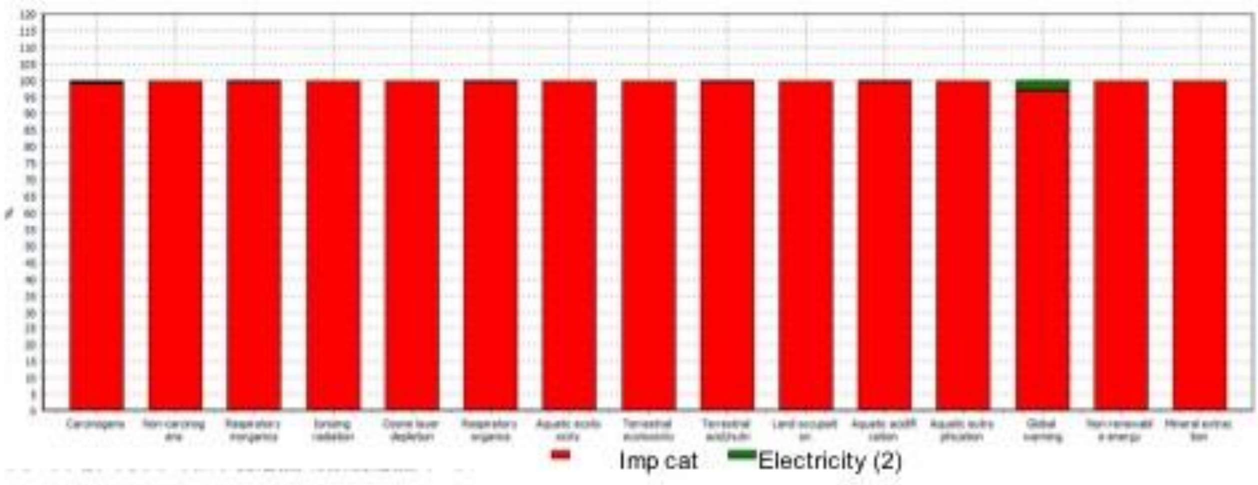

Figure 6: Impact Categories of AIRCORAL+; Method IMPACT 2002+ (V2.05)

Impact category	Unit	Total	Assembly	Electricity (2)
Carcinogens	kg C2H3Cl eq	0.387	0.383	0.00422
Non-carcinogens	kg C2H3Cl eq	0.566	0.566	0.000157
Respiratory inorganics	kg PM2.5 eq	0.0232	0.0231	9.65E-5
Ionizing radiation	Bq C-14 eq	1.19E3	1.19E3	0.119
Ozone layer depletion	kg CFC-11 eq	0.000112	0.000112	2.56E-9
Respiratory organics	kg C2H4 eq	0.0217	0.0216	0.000102
Aquatic ecotoxicity	kg TEG water	6.6E3	6.6E3	1.45
Terrestrial ecotoxicity	kg TEG soil	520	519	0.364
Terrestrial acid/nutri	kg SO2 eq	0.398	0.396	0.00206
Land occupation	m2org.arable	0.156	0.156	0.000223
Aquatic acidification	kg SO2 eq	0.152	0.152	0.000397
Aquatic eutrophication	kg PO4 P-lim	0.00205	0.00205	1.56E-7
Global warming	kg CO2 eq	25	24.2	0.785
Non-renewable energy	MJ primary	445	445	0.566
Mineral extraction	MJ surplus	7.93	7.93	4.83E-5

Table 6: Impact Categories of AIRCORAL+

3.4 COMPARISON BETWEEN THE DIFFERENT PROCESSES

The results obtained in terms of CO2eq and impact categories for the three different cases have been compared and in the following figures the results of the comparison is reported.

- In red we indicate the values of the MARKET STANDARD
- In green the values of AIRCORAL+
- In yellow those of the TRADITIONAL BUZZI

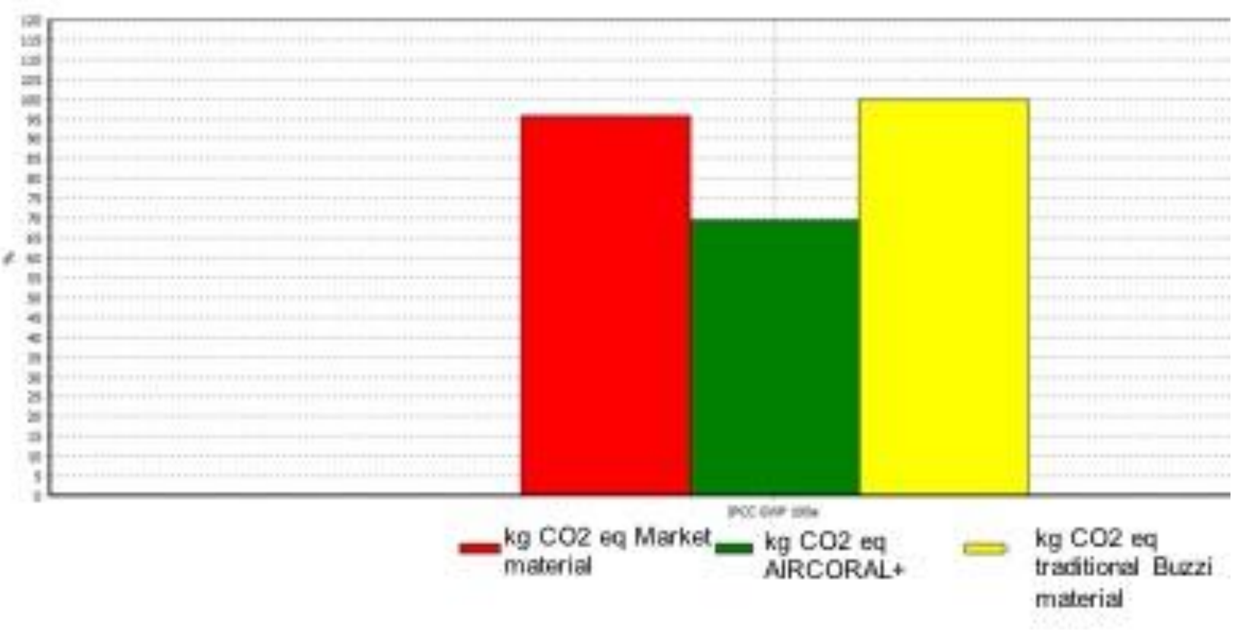

Figure 7: kg CO2eq for the three processes analyzed

Impact category	Unit	Market material	AIRCORAL +	Buzzi Traditional
IPCC GWP 100a	kg CO2 eq	39.5	28.7	41.2

Table 7: TOTAL kg CO2eq for the three processes analyzed

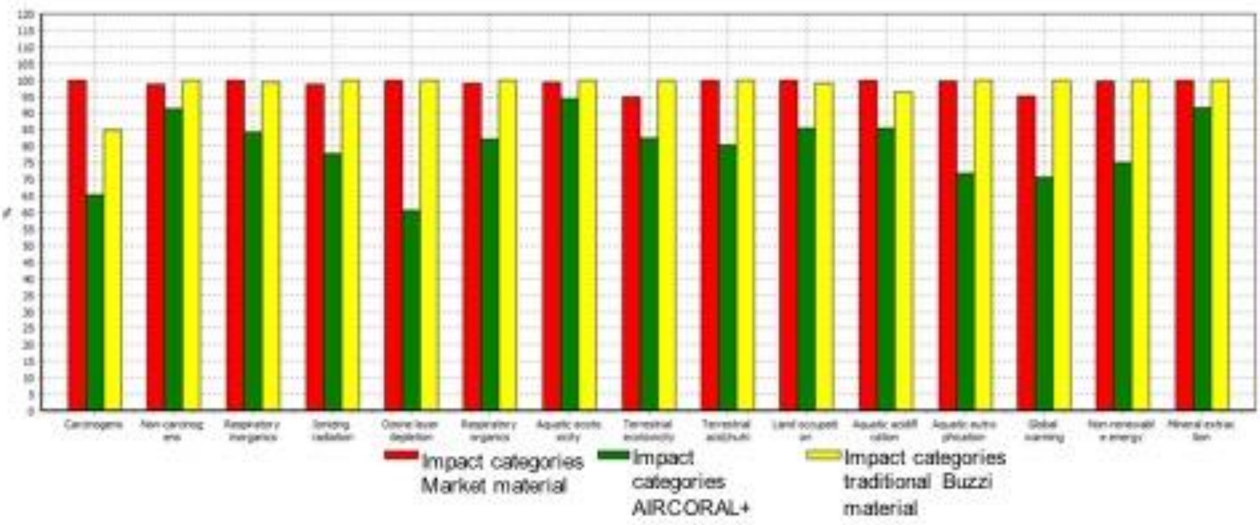

Figure 8: Impact categories for the three processes analyzed

Impact category	Unit	Market material	AIRCORAL +	Buzzi Traditional
Carcinogens	kg C2H3Cl eq	0.592	0.387	0.502
Non-carcinogens	kg C2H3Cl eq	0.612	0.566	0.62
Respiratory inorganics	kg PM2.5 eq	0.0276	0.0232	0.0274
Ionizing radiation	Bq C-14 eq	1.51E3	1.19E3	1.53E3
Ozone layer depletion	kg CFC-11 eq	0.000185	0.000112	0.000185
Respiratory organics	kg C2H4 eq	0.0262	0.0217	0.0265
Aquatic ecotoxicity	kg TEG water	6.95E3	6.6E3	7E3
Terrestrial ecotoxicity	kg TEG soil	597	520	629
Terrestrial acid/nutri	kg SO2 eq	0.496	0.398	0.495
Land occupation	m2org.arable	0.183	0.156	0.181
Aquatic acidification	kg SO2 eq	0.178	0.152	0.172
Aquatic eutrophication	kg PO4 P-lim	0.00285	0.00205	0.00286
Global warming	kg CO2 eq	33.6	25	35.3
Non-renewable energy	MJ primary	591	445	593
Mineral extraction	MJ surplus	8.65	7.93	8.66

Table 8: Impact categories for the three processes analyzed

3. CONCLUSIONS

The LCA of the three products analyzed, shows that **the innovative material (AIRCORAL+) has the lowest environmental impact.**

The IPCC GWP 100a method highlights the lower emissions in terms of CO2eq for the 'AIRCORAL+' process as following summarized:

- **28.7 kg CO2eq of the AIRCORAL+ material process.**
- **39.5 kg CO2eq of the MARKET STANDARD material process**
- **41.2 kg CO2eq of the TRADITIONAL BUZZI process.**

The results outline also that there is a considerable difference between AIRCORAL+ and the competing solutions.

The Impact 2002+ method also highlights the benefits of AIRCORAL+ in the following four macro areas of interest:

- **'Human resources';**
- **'Damage to man';**
- **'Environmental damage';**
- **'Climate impact'.**

In all 15 items analyzed the 'AIRCORAL+' has a lower environmental impact. **It is important to notice that in the category 'Carcinogens', AIRCORAL+ also shows a significant improvement.**

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6. CURRICULA

Prof. Barbara Marchetti, PhD

She is Associate professor working on the following main research topics: assessing the impact of renewable energy systems on local sustainability; energy production from renewables; LCA, innovative technique for recycling; numerical and experimental study of multiphase flow of hydrocarbons. In 2015 she was appointed as expert evaluator of quality from the Italian Ministry of University and in 2014 as expert for scientific projects founded by Italian government.

She was member of the Steering Committee of the European Technology Platform "Renewable Heating and Cooling" (RCH platform).

In 2002-2003-2004, she worked at the Naval Research Laboratory (www.nrl.navy.mil) of Washington DC, as a researcher in the Experimental Techniques Section, Physical Acoustics Branch, Acoustics Division. This section carries out a wide-range of research in the areas of micro/nano-acoustics, physical acoustics, structural acoustics, and fluid-structure interactions. During the period spent at the Naval Research Laboratory she was the responsible for the Italian team of the Capitol Pilot Project: a cooperative pilot study of the feasibility of using LDV to find structural defects in artwork that was founded by the US senate and by the architect of the Capitol. During the project a large-scale survey (~700 m2) of frescos and wall paintings was undertaken in the U.S. Capitol Building in Washington, D.C. to identify regions that may need structural repair due to detachment, delamination, or other defects. She received an award from the US Senator Trent Lott on behave of the US senate for the successful activity that she carried out as researcher during her period at Naval Research Laboratory in the United States.

She has been working with ENEL Green Power in a project which aim was the development of a new methodology for recycling thin film photovoltaic panels. The main innovation consists in the elimination of thermal processes and in the reduction of chemical treatments in comparison with the current available methods. Another important characteristic is the high level of automation that allow to reduce labour costs and safety issues.

Currently, a large proportion of end users, waste disposers as well as supervising authorities only have a very limited knowledge of the potential risks associated with a wrong management of the end-of-life PV modules and are not fully aware of their resource potential. Presently a large proportion of the valuable material is not recovered.

Over the last years, many processes for managing the end of life of thin film photovoltaic panels have been proposed but only three of these are currently managed on an industrial scale and they present a considerable use of thermal and chemical treatments. To offer the opportunity to make the PV energy a “double-green” technology also the end-of-life managing process must be sustainable.

Prof. Francesco Corvaro, PhD

Francesco Corvaro graduated cum laude in Mechanical Engineering at Università Politecnica delle Marche. He is Associate Professor in Applied Physic (Scientific Sector ING-IND/10) at the Department of Industrial Engineering and Mathematical Science of the Università Politecnica delle Marche. In December 2005, he received his PhD in "Reliability, Security and Environmental Sustainability in the exercise of industrial plants" from the Università Politecnica delle Marche. In 2004, he became a qualified engineer for environmental acoustics and fire prevention certification. From May to December 2008, he was technical consultant of S.TRA.TE.G.I.E S.r.l., a Spin Off of Polithecnic University of Marche for the development of models for the realization of local energy-environmental plans. In 2013, with four other partners, he established the Academic Spin-Off GreenTech Srl, with the role of Technical Manager.

His research activity is focused on issues related to the heat transfer applied (experimental and numerical). The experimental analysis is out by holographic interferometry, for the determination of thermal fields, and by the Particle Image Velocimetry (PIV) for the study of dynamic magnitudes. The numerical research is performed through CFD codes (eg Fluent). Another research field is the multiphase thermo-fluid dynamics and in this field, he took part in an experimental project regarding the sand transport in multiphase pipes. He also carried out a number of numerical and experimental studies in the field of lighting engineering. He has also been active in the field of renewable energy sources, with particular attention to photovoltaic and solar thermal systems coming to draft guidelines for regional, provincial and municipal territory currently in force. Another field of research is related to the study of innovative fluids in refrigeration and biofuels. From 2009 to 2012, he was appointed project manager and safety coordinator for the removal of asbestos from a building of the Ancona Provincial Government. He is the manager on behalf of the DIISM (Industrial Engineering and Mathematical Sciences) of a group of more than 25 experts for the evaluation of more than 24000 rebate applications related to photovoltaic systems installation submitted to the GSE.

Dr. Mariella Leporini, PhD

Mariella Leporini, Postdoctoral Researcher in Energy Science at the Politecnico Milano (Milan) and Research Assistant at the Università Politecnica delle Marche (Department of Industrial Engineering and Mathematical Sciences, Ancona) graduated cum laude in 2010 from the Università Politecnica delle Marche with a master degree in Thermomechanical Engineering. In March 2014, she obtained her PhD in Energy Science defending a thesis titled: "Design and Optimisation of a Steam Assisted Gravity Drainage (SAGD) Facility for Improved Recovery from Canadian Oil Sands". The work of thesis is composed of three principal activities: technic, economic and environmental analysis of the new plant. In particular, a new tool has been developed to conduct the LCA analysis. As promising young researcher, she won a fellowship found by Enel SpA (2013) and for her university career, she has been awarded as one of the best sons of Fiat SpA employees receiving a scholarship (2012). Sha has been awarded by Enel SpA to study the management of the end of life of thin film photovoltaic from an environmental point of view and the SimaPro tool has been used in order to carry out this study. At present, she is carrying out an LCA analysis for the evaluation of possible solutions for the reconversion of offshore platforms at and of life stage.