Festival della Scienza

November 3, Genoa - International workshop

Where are WEEE going?

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Festival della Scienza

Full Recovery End of Life Photovoltaic

Project LIFE12 ENV/IT/000904

“FRELP”

“Full Recovery End of Life Photovoltaic”

RESEARCH PRODUCTION ENVIRONMENT

SSV

PV CYCLE

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PROJECT SITE:

Brusnengo - Biella – Piemonte (Italy)
Murano – Venezia – Veneto (Italy)
Bruxelles (Belgium)

BUDGET:

Total amount: 4,887,035 €
Fee LIFE+ assigned amount: 2,383,517 € (50%)

TERM: Start: 01/07/13 - End: 30/04/2016

PROJECT PARTNERS:

Coordinator: Sasil S.r.l.
Partners: Stazione Sperimentale del Vetro S.c.p.A. (SSV)
European Association for Recovery of Photovoltaic Modules (PV Cycle)

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OBJECTIVES

The FRELP project aims to test and develop innovative technologies for full recycling of end-of-life PV panels in an economically viable way.

Two main environmental solutions are proposed:

- the recovery of high quality extra clear glass, to be used in the hollow and flat glass industry, thus implying very significant energy and CO_2 emission savings in the glass melting process;
- the recovery of (metallic) silicon, to be used as ferrosilicon in iron silicon alloys or, if pure enough, transformed into amorphous silicon for the production of thin films, thus greatly reducing energy consumption and CO_2 emissions associated with the production of primary silicon.

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Full Recovery End of Life Photovoltaic

BACKGROUND

1. Soon there will be 30,000 tons per year of solar panels to be dismantled; in 20 years we will reach 500,000 t / year
2. Since 2012: mandatory recovery from the producers through their management bodies
3. Currently are not highly valued for problems related to the different types of panels which require differentiated technologies for the recovery

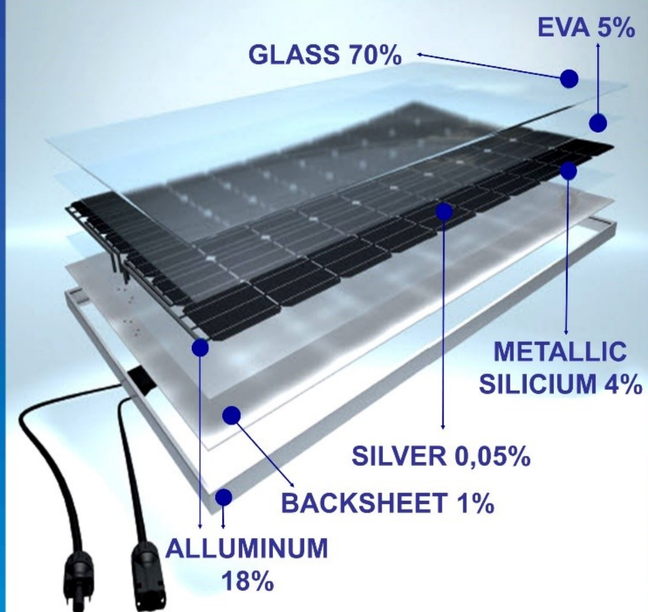
ACTIONS

1. Analysis of the components of the photovoltaic panels with silicon technology
2. Development and construction of a prototype for the separation of aluminum and glass from the sandwich containing the silicon
3. Pyrolysis of the plastic in order to obtain gas and oil and having the silicon wafer as ash
4. Use and adaptation of known technologies to enhance the silicon and metal conductors present in the ash pyrolysis

EXPECTED RESULT

Full recovery of the entire solar panel component materials and their exploitation for reuse total: aluminum, glass, plastic, silicon, metal wire connector.

To enhance to "salable products" the 98% by weight of the components of the silicon-based photovoltaic panels.



ENERGY PARAMETERS OF REFERENCE

Energy consumption to **PRODUCE** a standard silicium panel of 250 WATT = **750 kWh**

Energy consumption to **RECOVER** a standard silicon based panel of 250 WATT = **5 kWh**

Project realized with the contribution of the LIFE program of the CE (for information: eventi@sasil-life.com – www.sasil-life.com)

CHALLENGES

At the end of 2015 90 GW of photovoltaic panels of about 8 million tons were installed in Europe.

18 GW, equivalent to 1.6 million tons, were installed only in Italy.

Of these 90 GW, 80%, i.e. 72 GW are constituted by panels characterized by mono-and/or polycrystalline technology, that is the technology which lends itself to the recovery proposed by Sasil.

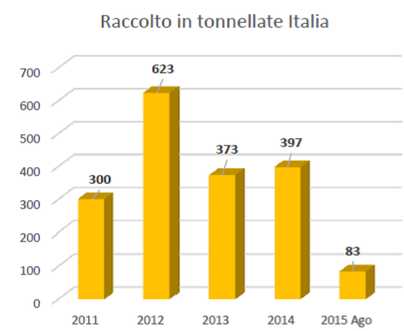
As in 5 years the first PV modules that were installed since 2000 will be dismantled and in 15 years the majority of those installed around 2010 will be obsolete, it is expected that in 2030, only in Italy, will be needed a treatment capacity of up to 160.000 tons, that equals 20 times the dimension of the prototype object of the FRELP project.

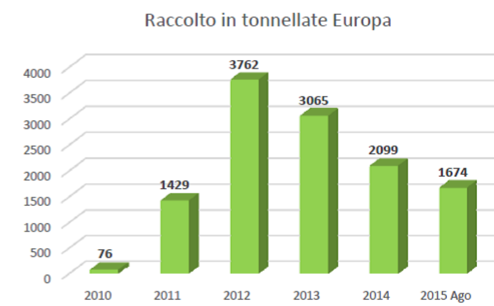
In 2012, when FRELP project was presented, the statistical projections foresaw that large amounts of photovoltaic panels at the end of life would be recovered in 2016 so such an ambitious project was justified.

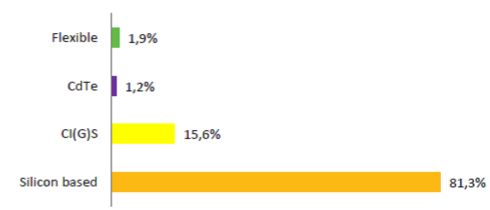
The actual collection in Europe and in Italy of the panels at the end of their life in recent years is detectable in the following charts:

PV CYCLE

RACCOLTO PV CYCLE







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PROPOSED SOLUTION

Initial phases of the project were as follows:

I. Robotized mechanical detachment of the aluminum profile sections, of the glass connectors and the sandwich (RAC + REV)

II. Pyrolysis of Eva to retrieve the metal silicon and other metals (PES)

III. Acid leaching by filtration to separate the silicon from other metals (ALF)

IV. Electrolysis to recover the copper and silver and neutralization of acid waters (OME)

During testing, because of the presence of fluorinated and chlorinated plastics in the sandwich, the pyrolysis process, which would have resulted in emissions of fluorine and chlorine with the cracked fuel, was abandoned, and it was opted for the incineration of the sandwich, to be performed at an outside company (TES).

The decisive trials for the choice of combustion instead of pyrolysis were carried out by the Italian expert centre Stazione Sperimentale dei Combustibili.

In practice, the results of the trials permitted to confirm the validity of the initial project, with the only variant of controlled combustion with heath recovery instead of pyrolysis.

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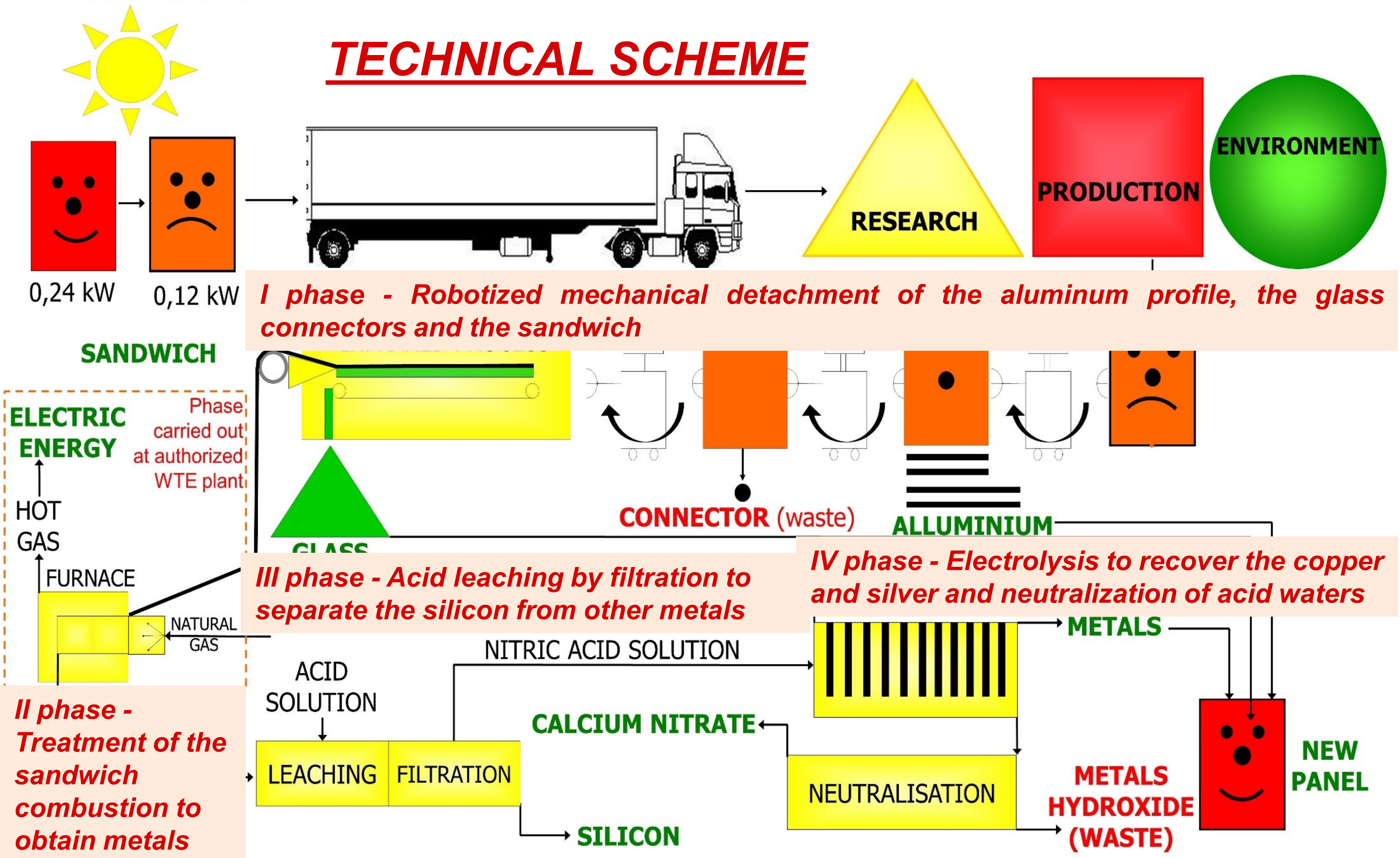
TECHNICAL SCHEME



SOLUTION FOUND FOR THE SUSTAINABLE RECOVERY OF 98% OF PV PANELS AT THEIR END OF LIFE

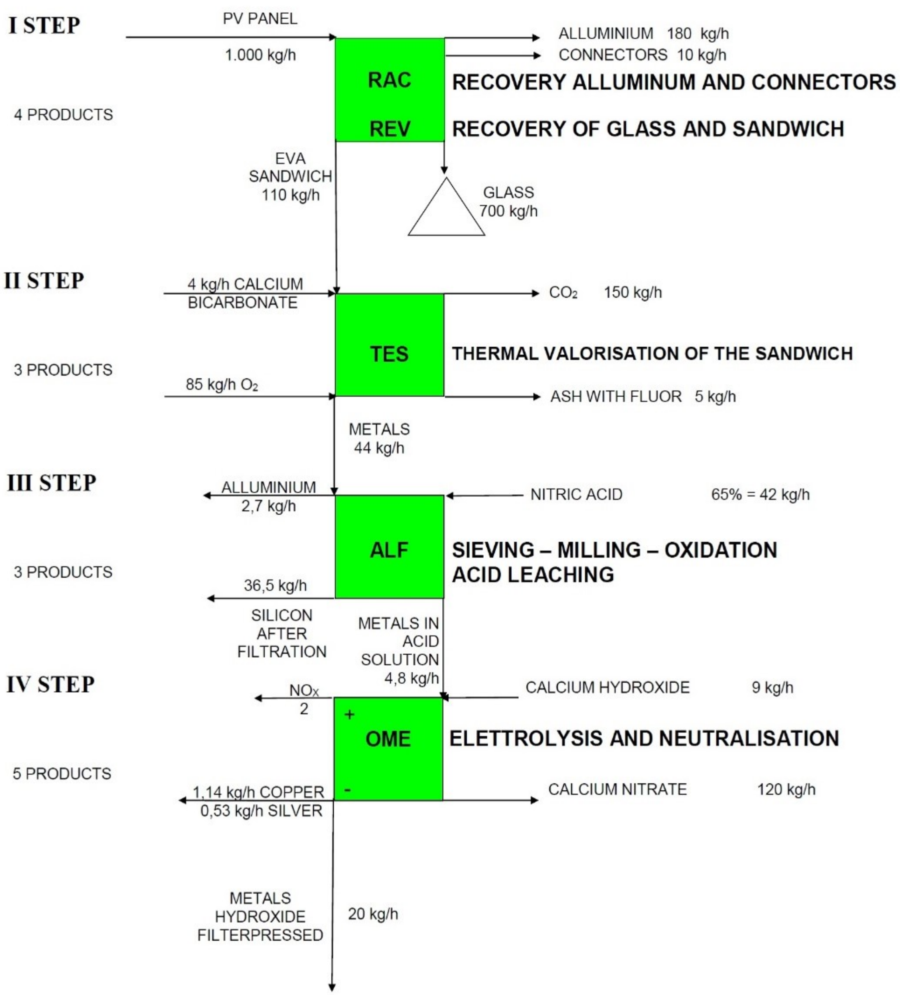
From the *quantitative* point of view, the aim was to design and manufacture a pilot plant capable of treating up to 1.000 kg/h of 1.000 x 1.660 mm standard format panels with an average weight of 20 kg, or about 50 panels/hour.

From a *qualitative* point of view, the aim was to achieve a series of products valued at commercial level in order to be fully re-used in various production sectors.

In particular, 5 products alone are:

- Aluminum 18.2% recovered through the phase I (RAC + REV)
- Glass 70.0% recovered through the phase I (RAC + REV)
- Silicon 3.65% recovered through the phase III (ALF)
- Copper 0.10% recovered through the phase IV (OME)
- Silver 0.05% recovered through the phase IV (OME)

The goal should be achieved with the development of a prototype plant divided into the following phases:



Phase I Mechanical treatment for aluminum and connectors recovery

Thermal and mechanical treatment for the separation of glass from the sandwich

Optical treatment for the enhancement of the glass

Phase II Treatment of the sandwich combustion to obtain metals (operation outside the Sasil plant)

Phase III Mechanical treatments of sieving and grinding of metals for recovery of coarse metals

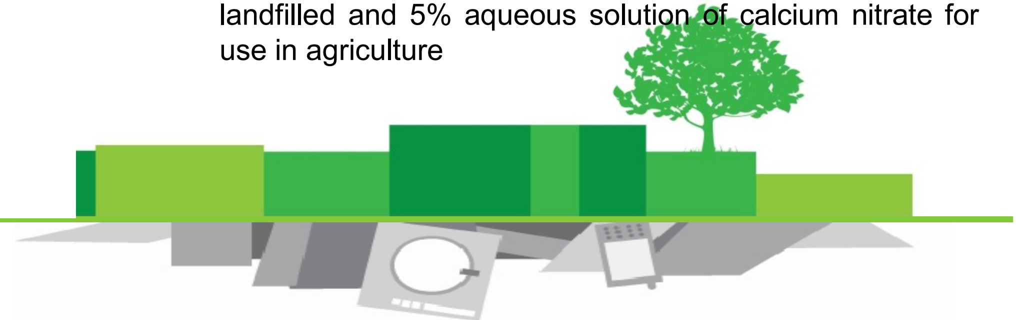
Thermal oxidation treatment for ground metals

Treatment of acid leaching with nitric acid to send the oxidized metals in solution

Filtration treatment for the recovery of the metallic silicon

Phase IV Differentiated electrolysis treatment for the recovery of copper and silver from the acid solution leaving the filtration cycle of phase III

Neutralization treatment of the residual acidic waters of the electrolysis to obtain metal hydroxide sludge to be landfilled and 5% aqueous solution of calcium nitrate for use in agriculture



DESCRIPTION OF THE ACTIVITIES

All experimental actions were carried out with encouraging results, except from the action of *pyrolysis* that we chose to replace, as said, with the combustion.

This picture shows the design of prototype machine of EVA-glass detachment after the phase of the aluminum and connectors detachment.

Prototype machine of EVA-glass detachment (B7 action)

RESULTS

These actions have helped to develop the following activities with the consequent results:

- Manufacture and patent of a detachment system of the glass from the sandwich so as to recover 95% of glass
- Manufacture and installation of a prototype for the enhancement of glass recovered for glass industry use in super-white containers and ultra-clear flat glass
- Design of an automated system for the separation of aluminum profile sections and connectors from the photovoltaic panels, with a processing capacity of 1,000 kg/hour (about 50 panels per hour)
- Testing of a controlled combustion cycle to recover the ashes containing the metallic silicon and the metal conductors contained within the sandwich
- Testing of an acid leaching cycle with nitric acid so as to send the metals in solution and recover as the silicon metal not attacked by the acid as a bottom body
- Testing at a specialized firm, of the electrolysis cycle, to verify the possibility of differential recovery of two main metals: silver and copper
- Study of the abatement system of the residual electrolysis liquid to get from one side calcium nitrate for agricultural use and from the other side sludge of metal hydroxides to landfill
- Project of the treatment cycle starting from the leaching of the ash to the recovery of metal silicon and of the two principal metals, silver and copper, as well as to the recovery of the eluate of pyrolysis to have a neutral environmental impact.

CONCLUSIONS

The certainly valid result of the Frelp project is the demonstration that the overall treatment technology foreseen in the 4 phases is sustainable economically and environmentally.

The Frelp Project was stopped in April 2016 because the availability of PV panels at the end of life was insufficient to ensure the sustainability of the prototype for the manufacture expected from the project.

Already at the beginning of the project, it was expected a minimum of 3.500 t/year of available panels at end of life, manufactured with mono- and poly crystalline silicon technology, in order to pursue the overall prototyping.

FOLLOW UP

Based on the business plans drawn up by Sasil, this is still an amount that could be valid if there had been the Life contribution.

Without contribution we think that the annual quantity should be double, i.e. 7,000 t/year, and certainly, this amount will be achieved within the next 10 years.

Based on the two business plans prepared by Sasil, one for phase I and one for the phases II, III, IV, it appears that it would be only sustainable for stage I, completely tested at the pre-prototype level by Sasil within the Frelp project.

It must be said that this phase allows the recovery and improvement of 88% of the total weight of the photovoltaic mono- and/or polycrystalline silicon panels with a negative impact of the only sandwich that is 12% of the weight.

The economic return of phase I could be accomplished with an amount of only 2.000 t/year of panels, equal to a work shift.

The economic return of phases II, III, IV instead requires a minimum of 7.000 t/year of panels as the processing cycle is provided continuously, all around the clock.

The technology developed by Sasil also allow to separate the phase I from the other phases in the sense that, for reasons of logistics, more of a phase I activities could be distributed throughout the territory, and the activity of phases II, III, IV requiring more investment and a greater environmental impact should be concentrated in only one pole.

The LCA study has allowed us to understand that the removal of fluorinated and/or chlorinated plastics in the back sheet of photovoltaic panels could reduce the environmental impact of their disposal.

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