Plant design and economics of rice husk ash exploitation as a pozzolanic material

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Introduction

Rice husk

is a byproduct of the rice industry, almost 20% of the rice paddy.
► It is burned, for the production of steam (for parboiled rice), heat & electricity.

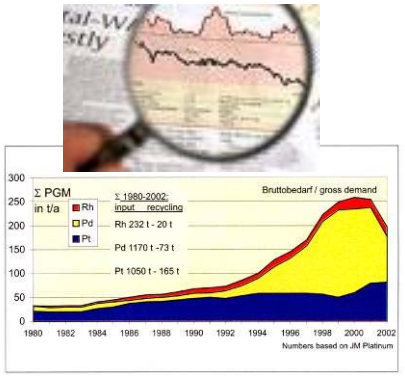
Rice husk ash (RHA)

is the solid residue from rice husk incineration, that contains all inorganic constituents of the rice husk and part of its organic constituents due to incomplete combustion. It contains about 75-95% SiO_2 (amorphous & crystalline) - *biosilica*.

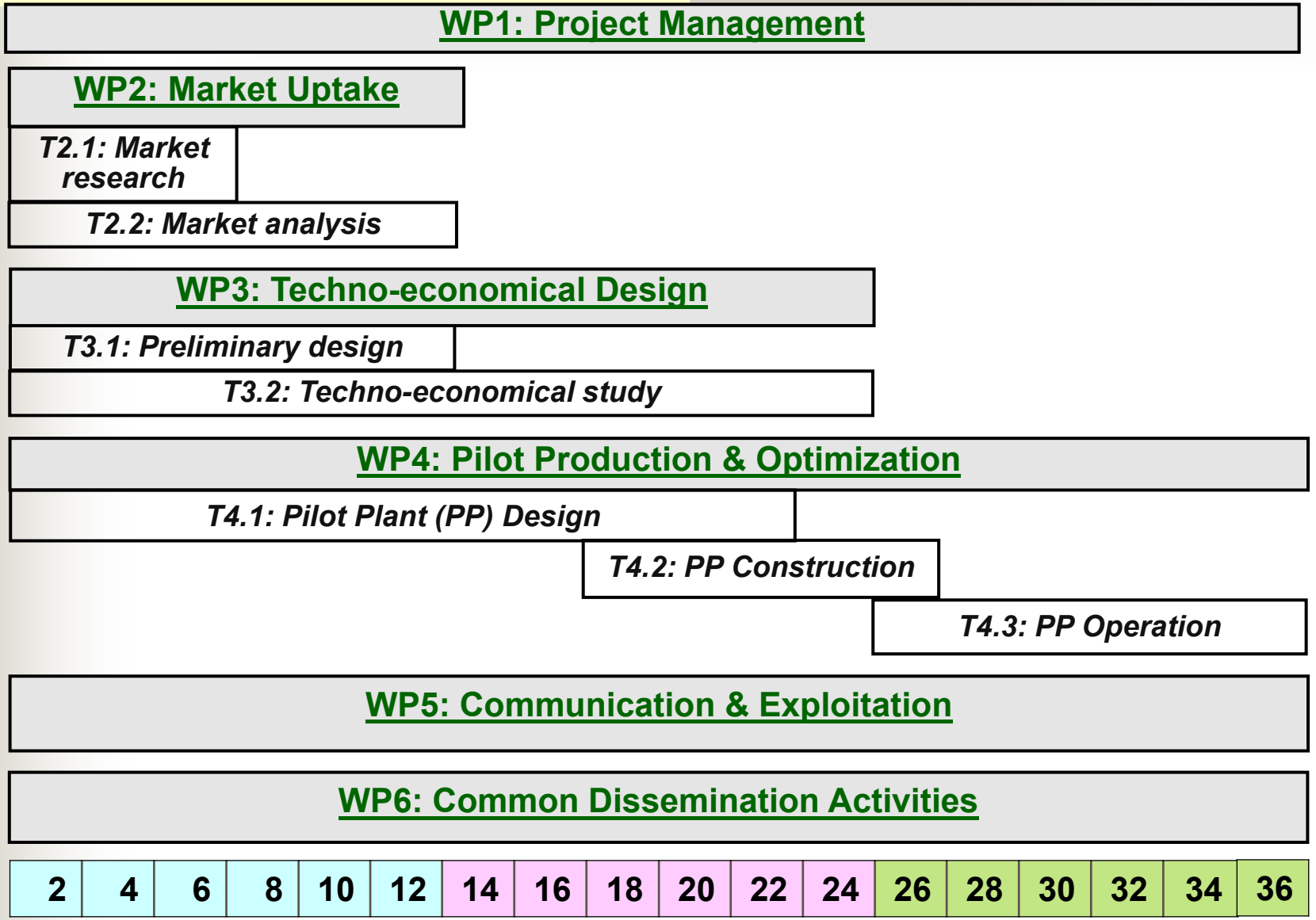
Objectives of the project PYRICE II

- The main objectives of the project *PYRICE II (ECO Innovation) "Techno-economical Design and Pilot Production of Advanced and High-Added Value Materials from Rice Husk Ash"* are: i) the development and pilot scale production of high-added value materials from RHA (insulators, pozzolans, zeolites) as well as the market approach (strategic objectives) and ii) technology transfer and market analysis (specific objectives).

- The specific work programme implemented to achieve the above goals includes market uptake & approach, techno-economical design, pilot production of RHA-derivatives optimization, communication, dissemination, and exploitation & business plan elaboration.



Project Flowchart



Study for converting RHA to pozzolanic material

1. Addition to Cement

ι) adding RHA as pozzolanic material: up to 30%

ιι) incorporating RHA in the low-embodied energy cement production, like belitics and other types.

2. Addition to concrete & mortars

Production of several concrete types as a direct reactive addition – as a fourth component in the mixture of raw materials of ready mixed concrete. Its' potential use, is particularly important and economically attractive in:

- High strength concrete (HSC)
- Shotcrete (Gunite)
- Self-compacted concrete (SCC)
- Repair mortars

Success key :

There is already a very good material on the market with exceptional properties: silica fume (Elkem Materials, 500 €/t)

- **The aim is to make RHA similar to (or replace) silica fume, thus *biosilica against microsilica (SF).***

Experimentation on perfecting product (RHA towards SF) at TITAN

RHA sample 9.09

Total SiO_2 = 87.66%
Insoluble residue = 4.41%
SiO_2 in IR = 4.23%
Reactive SiO_2 = 83.43%

Grinding in a pre-pilot sphere-mill up to 4 ½ hours
Average diameter up to 6.9μm (plateau)

The XRD analysis showed that all peaks are cristoballite, slightly better than quartz rock in the sense that it is less hard on the Mosh scale, hence less wear and less maintenance of the mill that will grind the RHA is required.

With the sample of 4 ½ hours, mortars were prepared (cement CEM I 42.5, w/c=0.5, c/a=0.33) and replaced 10% of cement and 20% of cement with RHA. **Strength Results (MPa):**

	Control	10% RHA	20% RHA
1 d	15.0	15.1	13.7
2 d	26.0	26.8	25.3
7 d	39.0	44.2	43.6
28 d	49.0	57.9	60.9

- **Experimentation on perfecting product (RHA towards SF) …**

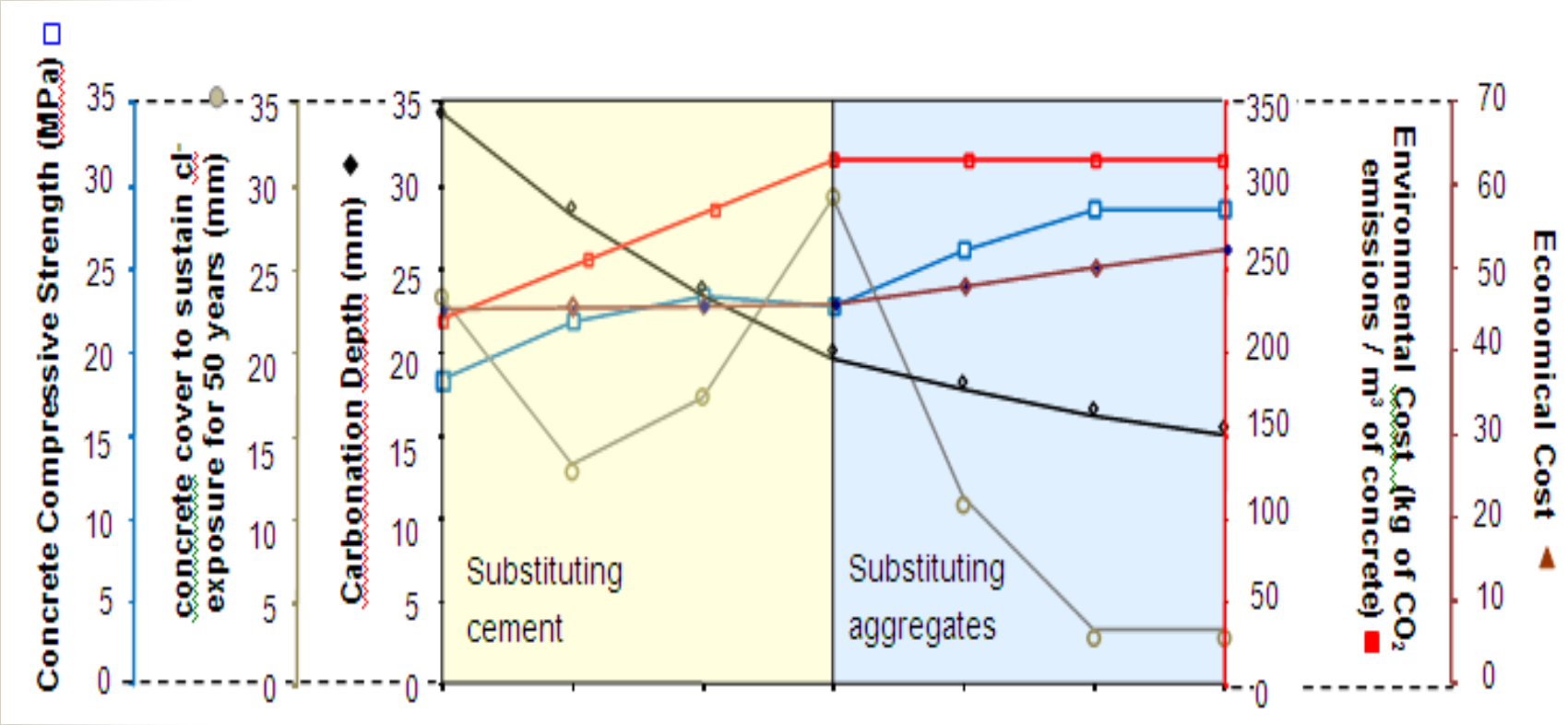
Summarizing:
Ground RHA replaces cement (up to 20-30%, k-value>1.2) and increases strengths ! → BEHAVES towards to silica fume !!!

-**Further improvements**, in plants for ultra-fine, sub-micron samples (pulverized in vibration mill, see following WP4): due to addition less water demand, RHA better than SF.

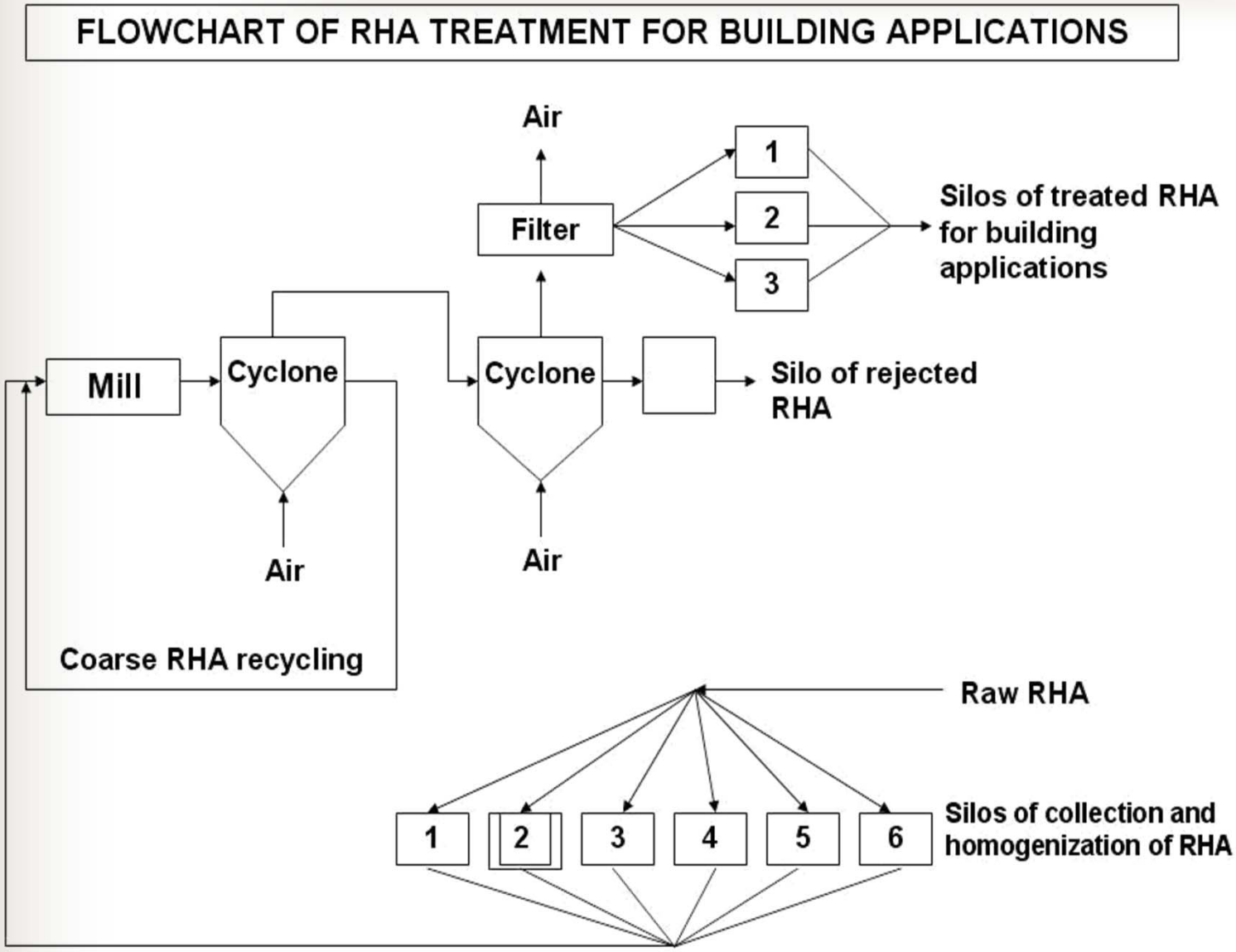
-Similarly, **a thorough monitoring of burners is being conducted (in plants) and sampling** as a function of various operating parameters (attempt to increase amorphous & decrease carbon): grates, temperature, air flow, cooling, fly & bottom ash, re-burning, etc.

-Development & application of a **Specific Programme for Capturing and Controlling Dust.**

Durability, strength and cost indicators for RHA concrete mixes



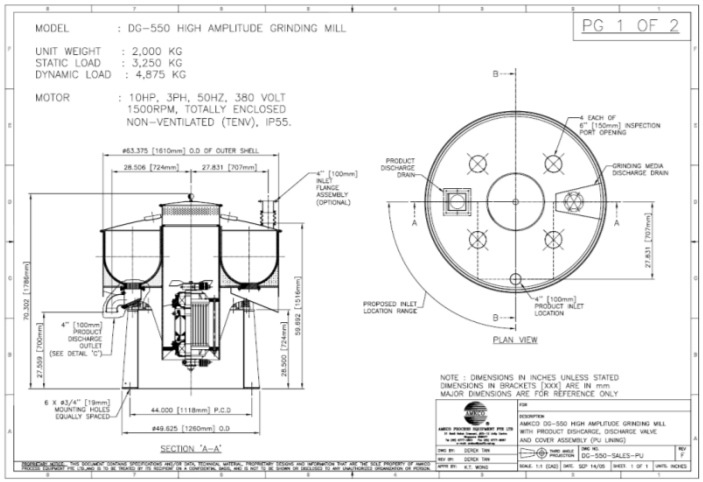
Process Flowchart



WP4: Pilot Production & Optimization
(1st – 36th month : 21/7/2009 – 20/7/2012)

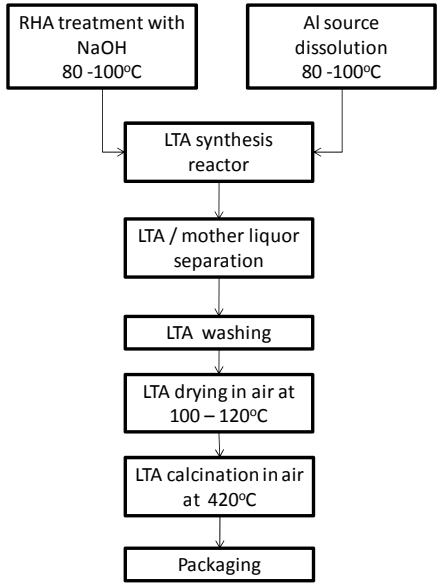
T4.1 Pilot plant design
(1st – 22nd month : 7/09 – 5/11)

- Design of two pilot plants (insulators, pozzolans, zeolites).

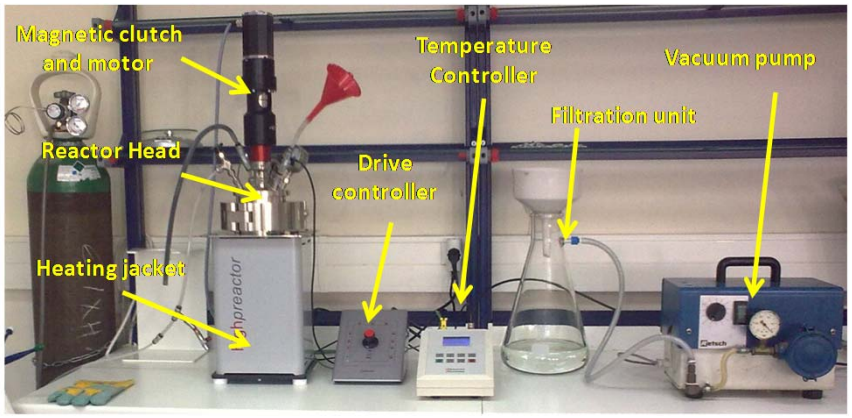


T4.2 Pilot plant construction
(17th – 26th month : 12/10 – 9/11)

- Pilot plant for production of insulators & pozzolans
- Semi-Pilot plant for production of zeolites



T4.3 Pilot plant operation & optimization
(25th – 36th month : 8/11 – 7/12)



- ✓ Pilot and full operation
- ✓ Optimization
- ✓ Quality tests of products

WP4 Results

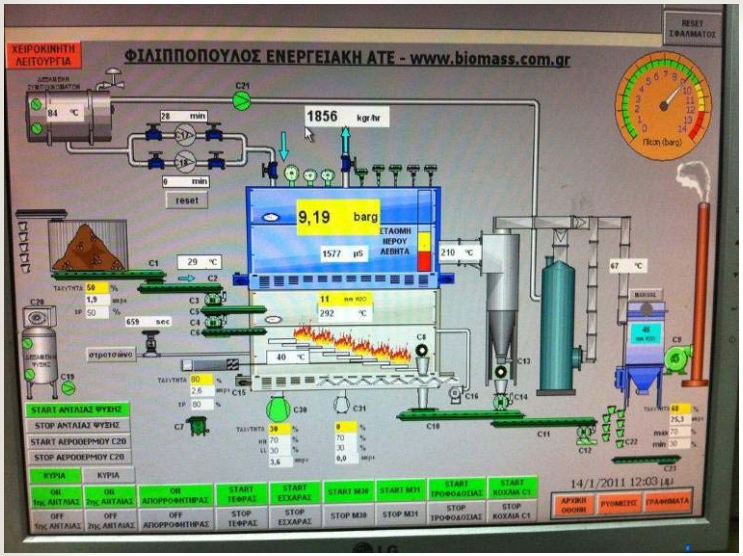
- **Pilot production of upgraded RHA for use as tundish material /insulator**
  - ► Design & construction of pilot plants
  - ► Pilot operation, shipments & testing

- **Pilot production of pozzolan (biosilica)**
  - ► Vibrating mill purchase and installation in plant II for RHA ultra milling (to sub-micron)
  - ► Trial operation and pilot production (1 t/hr)
  - ► Additionally, tests were conducted at existing mills in plant I: with satisfactory results
  - ► Use of activators (acid or alkaline solutions for higher amorphous ratio)

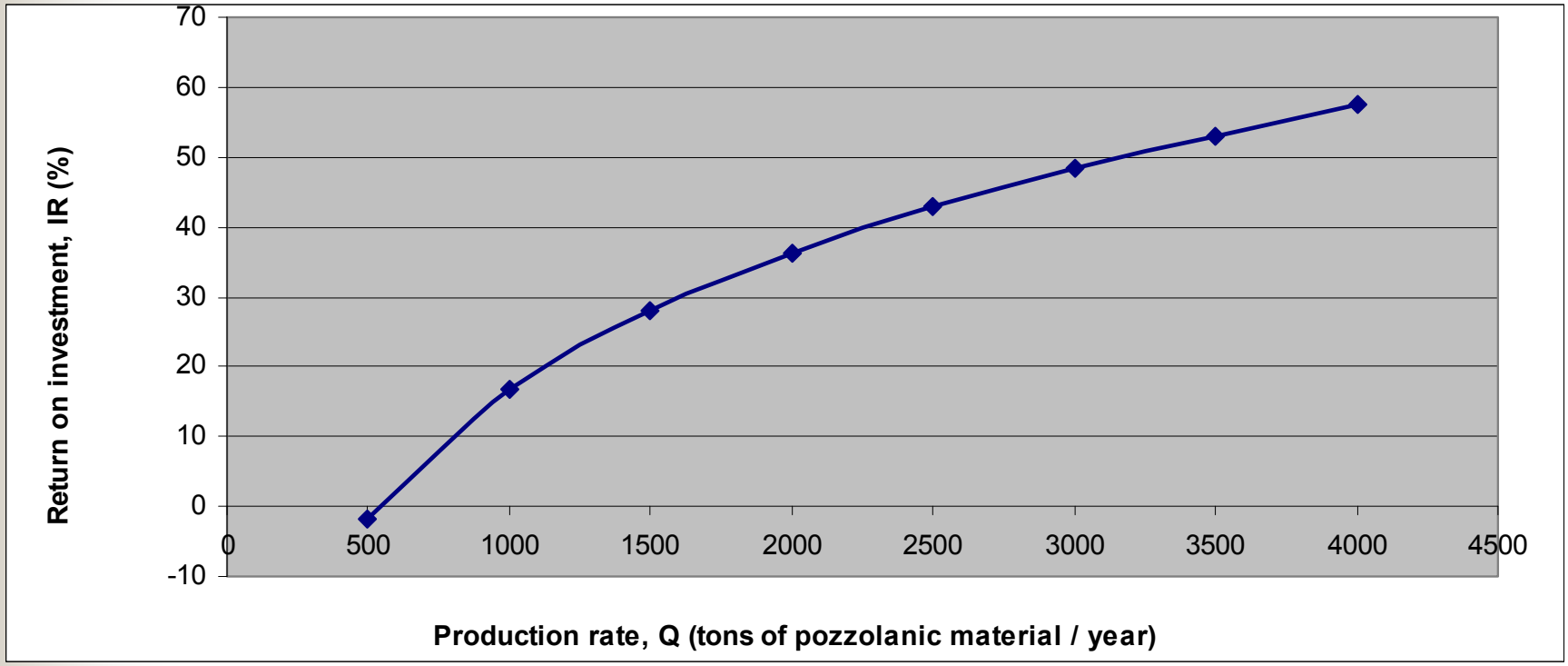
- **Pilot production of zeolites**
  - ► Subcontracted to FORTH/ICE-HT
  - ► Purchase, installation and operation of pre-pilot plant
  - ► Pilot operation, production and testing of LTA

Pilot Plant I

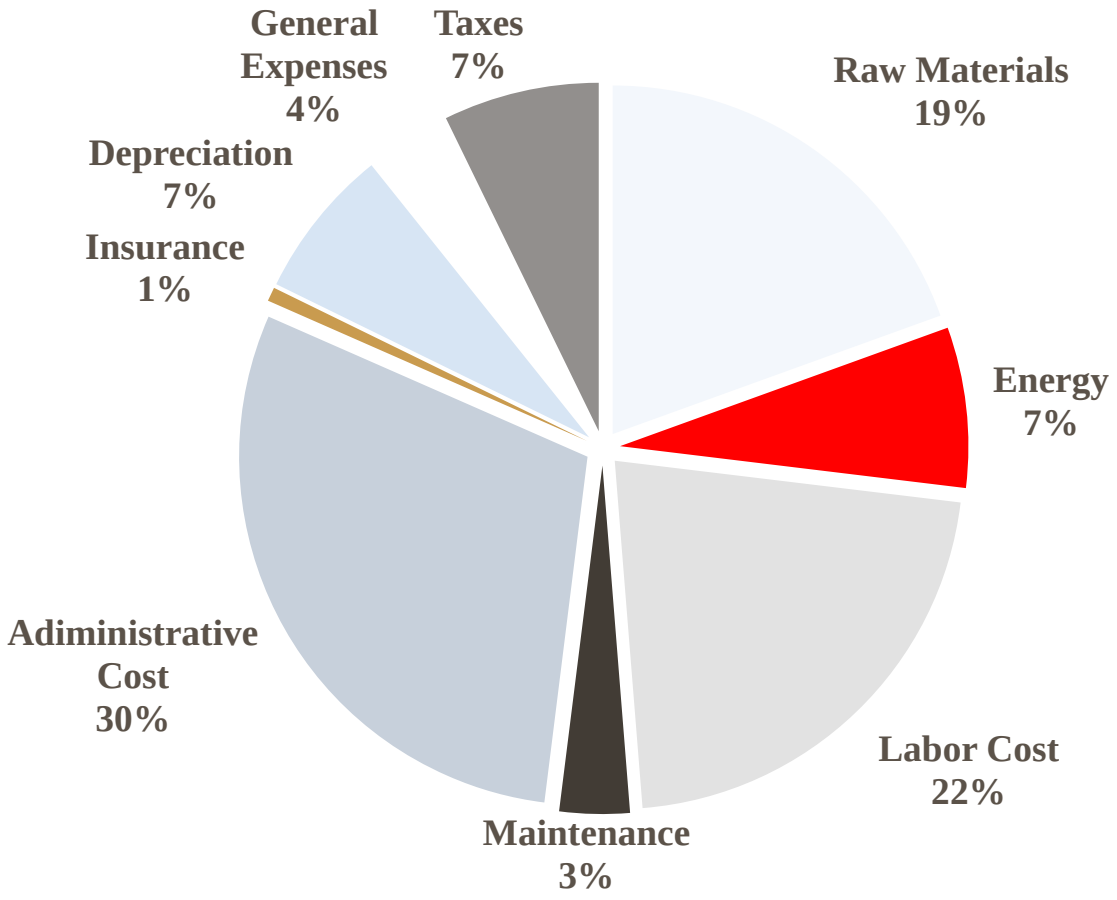
Pilot Plant II



Return on investment vs. production rate for pozzolanic material production from RHA



Comparative distribution of various operational components for pozzolanic material production from RHA (Q=1000 t/y, P=420 €/t)



Overview of main Results

Before PYRICE II, RHA cost in company: -40 €/t. Due to PYRICE II:

- **Solution A: Development of Treated & Standard RHA as tundish powder or insulator for steel industry, insulator producers, etc.**

  - Company has established collaborations with various steel industries and dealers selling upgraded RHA: 70-150 €/t

  - Contracts, specifications (low C, fineness)

  - Changes in RHA production in plants

- **Solution B: Development of Milled & Standard RHA as pozzolanic material for construction industry (mortar & building materials' industry, constructors, technical firms, etc.).**

  - Successful field test from a client: behavior 5-20% better than silica fume (that costs 500 €/t)

  - Suggestion of a price: 250-400 €/t

  - Contracts, specifications (low C, high fineness, blank colour)

  - Purchase of pilot mills & ovens.

- **Solution C: Development of various Zeolites from RHA for detergent producers, for environment rehabilitation companies, etc.**

  - Successful syntheses at laboratory & pre-pilot stage

  - Samples to potential customers : approval & interest

  - Mean international price for zeolite A (LTA): 1150 €/t

  - Cost-benefit analysis : not-economically viable (high level of break even point)

  - Suggestion to not undertake this investment

  - Exploration of side benefits from the above technical achievements: patents, alternative products (sodium silicate), production outsourcing, etc.

Conclusions & Achieved – Expected Results

- ***Environmental:*** **Significant protection from the disposal of a dangerous material. 100% conversion of RHA to useful materials. Improving of buildings' environmental footprint.**

- ***Company:*** **it is expected to have considerable benefits, because it enters a new market with substantial economic profit, it improves the quality of RHA by-product, and it limits environmental pollution.**

- ***Innovation:*** **The conversion of RHA into these advanced and high-added value materials (insulators/ pozzolans/ zeolites) comprises an innovation and originality for rice-industry at an international level.**

- ***Added value to European level:*** **The replication of the present results to the other rice-producers in many others countries of Europe are much easier. The potential extension to similar agricultural wastes, like biomass ashes from cotton grating sheds, sugar production, agricultural byproducts incineration, etc., creates substantial benefits. This project offers new modern perspectives in the agro-industry sector of the EU.**

Thank you for your attention !

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