Inorganic binder system to minimize emissions, improve indoor air quality, purify and reuse of contaminated foundry sand

LIFE17 ENV/FI/173 “Green Foundry LIFE”

Action C1 Project monitoring

De.C1.2 Assessment of the socio-economic impacts of the project actions

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Date: 30.6.2022

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1. Backround

The improvements in environmental impact via cleaning of the working place air quality and via emission decrease from the foundries is in correlation with the socio-economic impact of the population.

As a result, the inorganic binders will decrease the health issues of the foundry employees and population living next to foundries. As all industrial companies are going to minimize their environmental impact, the casting users also must use castings made by best processes.

In this project several inorganic binders available on commercial markets were tested.
The wider socio-economic impact is estimated based on the results in several pilot foundries.

Socio-economic impacts of the project directly on the foundries taking inorganic binders into use, and on their employees is assessed. The socio-economic impact is assessed regarding to economic, environmental and health aspects and their impact on the local economy and population. The socio-economic impact comes also indirectly via the foundries to casting users and to their customers when environmental aspects like carbon footprint is becoming more and more important in the purchasing decisions of the final consumers and of the casting user companies.

In case European foundries take this more environmentally friendly binder system into use before Asian and other competitors it will increase their market share in casting market towards imports, which improves socioeconomic situation globally.

However, in most cases the foundries must make minor or bigger changes in their production processes and equipment. In some situations, the companies have completely to re-engineer the foundry. This means major investments. It would be very beneficial, if the foundries could get some government supported so-called soft-loans or other support to speed up the change.

2. The European Ferrous Foundry Industry

In CAEF (the European Foundry Association) member states there are c. 4 000 foundries in 2020 with more than 249 000 employees. This included an estimation of app. 1 000 foundries located in densely populated areas in Europe.

The iron, steel, and ductile iron foundries of the CAEF member states produced 9,1 M tons of castings in 2020. The six countries that dominate the industry in terms of production volume, namely Germany, Turkey, France, Italy, Spain and Poland, account for 85.6 % of the production of ferrous metal castings.

The share of cast iron with lamellar graphite in the output total of ferrous castings is 49,3 %. Correspondingly, the share of ductile cast iron is slightly lower, 44.0 %. The steel sector logs a share of 6.7 %.

The number of people employed by the European ferrous foundry industry in 2020 was app. 131 000 of which 77% in the mentioned six countries.

All industries globally are seeking all possible ways to minimize their negative impact into nature. Concerning ferrous casting components, they already are very much re-cycled and green: main raw material is recycled scrap, sand is recycled internally, and all emissions are minimized. Change from organic binder to inorganic ones would be a very good addition to make ferrous casting manufacturing more environmentally friendly.

3. Environmental benefits of inorganic binder systems

The goals set for environmental benefits to be achieved form the use of inorganic binders at the start of the project were reached very well. Even above the targets. This is seen in KPI indicators:

6.1	Air – emissions	Benzene
6.1	Air – emissions	VOC
6.2	Air - quality	CO
6.2	Air - quality	CO
6.2	Air - quality	Other
6.2	Air - quality	Other

All the indicators showed reduction i.e., improvements between 30-98% - mainly above 90 %.

● Hazardous airborne emissions including ambient air improvement and reduction of local health risk and odour nuisance will be reduced by 90% for a given foundry;

● Indoor health will be improved by approximately 80% for a given foundry;

The waste management-based impact on environment and material usage can be improved by 70-80% by using inorganic binders. This was seen in following KPIs:

3.1	Waste management	j. Amount collected by project
3.1	Waste management	d. Mass reduction due to composting
3.1	Waste management	Mass of non-appropriately managed waste
3.1	Waste management	c. Mass reduction due to recycling

● Waste problem of hazardous surplus foundry sand will be reduced by recycling next to 75 %.

During the project it became obvious that sand reclamation methods for inorganic binder sands (reclaimed sand is reused in mould making) are still in development phase.

4. Economics of the inorganic binders

The binder system influences the costs of the foundry by many ways:

- the price of the binder materials themselves
- the equipment needed for the moulding by the used binder system
- the equipment such as vibration tables needed for breaking the moulds after cooling
- the cost of new foundry sand, sand recycling costs and waste foundry sand disposal and/or reuse costs
- casting quality costs e.g., extra repairing costs due to gas pinholes
- possible harmful emission abatement system costs
- the costs involved in occupational health due to the quality of working air and
- energy costs of ventilation and sand re-cycling.
- On positive side greener products can give more sales and better prices if the customers will appreciate smaller foot-print.

4.1 The cost of the inorganic binders

The cost of inorganic binders available on market during the start of the project was about 15% higher than the cost of currently used organic binders in ferrous foundries (= furan, phenolic Alphaset and green sand). To be economical inorganic binder systems should therefore give advantages in other cost categories. On the other hand, the prices of raw materials are currently in great turmoil and the costs of various oil or corn based organic binder systems can increase quickly, which can give an advantage to inorganic solutions.

4.2 The changes of the sand systems and mould and core making lines

The application of inorganic binders will normally include new investments to moulding and core making lines.

The main equipment in moulding lines are:

- sand storage, transportation, and dosing systems
- binder dosing systems mixers possible automatic moulding machines
- moulds transport and cooling tracks
- dust collecting and filtering system.

Cores are typically manufactured in separate machine units or production lines, using either self-setting binders, three component cold-box binder system using resin, hardener and amine gas addition or binders which require drying at elevated temperature (hot box line). The manufacturing steps which the binder has influence on are for. example:

- binder storage tanks and pipelines
- dosing pumps,
- mixing speed on time
- curing time before taking a core out from tooling (core-box)
- hardening time before coating the core
- drying method and time of coating material
- demands of the atmosphere like moisture and temperature to store the cores.

There are available two types of inorganic binder systems, which were tested and worked by certain limitations, which can be changed by minor investments:

- self-setting binders i.e., they harden at normal working temperature (above 10 ^{o}C) without need of any other action such as drying at elevated temperature or gas blowing
- the ones that need heating to elevated temperatures or need hot or warm air to be pushed through sand.

One type of the tested inorganic binder systems requires drying at elevated temperature to achieve the proper strength levels needed in ferrous casting. In case a foundry is not equipped by proper heating facilities, this would need investments. This would mean for example construction of new ovens or other heating equipment such as hot air blowing line into moulding area. There would be also high investment cost for the patterns and core boxes if they are partly made of wood or other heat sensitive material. Resin patterns and core boxes would damage at the needed temperatures of 160…200 C^{o}. Wooden patterns and core boxes are good insulators, so it would be impossible to get cores and moulds hardened and dried inside. The patterns and core-boxes should be replaced by new ones made of metallic or other heat resistant material.

As an example, investment into sand drying system at Karhula Foundry would cost about 0,5 million €. Patterns and core-boxes for a typical products like pump housings in sizes of 0,1 to 2 tons and impellers in sizes in 30 kilos to a few hundred kilos (with 5-7 different core boxes) would cost c. 50. -100.000 € per product. Karhula Foundry produces average 1200 different products per annum. To replace all patterns and core boxes would be an investment of 60-120 M€.

These extra costs would make the deployment of this kind of inorganic binder system at Karhula Foundry economically unusable.

This kind of inorganic binder systems are feasible without extra investment only to foundries or core suppliers which are already equipped with hot-box core lines.

The other type of the tested inorganic binder systems behaves similar way as e.g. organic Alphaset binder system, They are self-setting, which means that they achieve the needed strength levels without drying at elevated temperature, and they would be usable in the present moulding lines without any new investments. *This type of binders are the only ones possible to take into use in existing foundry by using existing wooden patterns and core boxes.* These binders include some components, so, they are not 100 % inorganic. However, they reduced organic impact by more than 80 %.

To be implemented on everyday practice inorganic binders must therefore give technical and environmental benefits to compensate higher initial cost.

Some specifications and acceptance limits regulations for inorganic surplus sand residuals need to be changed, so, that these waste sands would be easier to reuse than today's surplus sands with organic binders.

5. Actual socio-economic impacts of the Green Foundry project

5.1 Persons involved in the project

The project employed total or part time ca. 30 persons in 7 beneficiaries. Moreover 100 persons were involved in the project outside the project consortium. More than 100.000 people visited the web-sides of the project, so, information reached very well the foundry branch.

5.2 Employees in the pilot foundries

The workforce in the three pilot foundries of the Green Foundry LIFE project was totally ca. 350.
The production of the partner foundries is about 2,5 % of the ferrous casting production in EU.

5.3 The socio - economic impacts estimated by KPI factors

In the attached KPI Excel sheet (Table 1), the most important results can be seen in following KPIs:

1.5	Project area/length	
1.6	Humans (to be) influenced by the project	
3.1	Waste management	j. Amount collected by project
3.1	Waste management	d. Mass reduction due to composting
3.1	Waste management	Mass of non-appropriately managed waste
3.1	Waste management	c. Mass reduction due to recycling
6.1	Air - emissions	Benzene

6.1	Air - emissions	VOC
6.2	Air - quality	CO
6.2	Air - quality	CO
6.2	Air - quality	Other
6.2	Air – quality	Other
10.2.	Involvement of NGOs and other stakeholders in the project activities	Private for profit
11.1	Website (mandatory)	No. of unique visits
12.1	Networking (mandatory)	Members of interest groups / lobby organisations
14.2.4	Cost reduction expected in case of configuration/replication/transfer after the project	

The project estimated an impact of job growth in project management company and a great uptake in companies making environmental-friendly inorganic binders. As a result of the project, inorganic binder methods will have a rapid uptake due to their economic and environmental advantages. This will result in increase of EU market size on the global scene, as new innovation will boost the industry.

The process cost is estimated to decrease by 7% due to sand reclamation benefits, lowered waste sand disposal costs and expected efficiency in process. As a result, payback time for implementation of novel inorganic binders is expected to be 2 years.

The communication efforts via website reached more than 100 000 people in more than 1000 entities.
As a result - after the recommendations will be implemented - the project will greatly impact air quality and emission reduction in EU foundries.

The calculations are based on the production in 2 pilot foundries, which together produce 28 000 tons annually (25 000 tons and 3 000 tons). The total production in EU iron and steel foundries is 11.7 million tons annually. As a result, the project test results are estimated to represent 0.24% of existing production annually, providing positive impact during the 4 years of the project duration. The estimated impact in percentages is highly influenced by the production percentage of the pilot foundries.

Providing the green values will also been appreciated among casting users, the European ferrous foundries will increase their market share and increase sales and have a positive impact on employment. This naturally also needs that the steps towards installing necessary investments into inorganic binders will be taken by the owners of the foundries supported investors and funding organisations.

Table 1. The most important KPI results.

			START VALUE	END VALUE	BEYOND END VALUE	UNIT
1.5	**Project area/length**		**20**	**60**	**3000**	**km2**
1.6	**Humans (to be) influenced by the project**		**600**	**27000**	**900000**	**Number of residents within or near the project area**
1.6	**Humans (to be) influenced by the project**		**270**	**1330**	**40000**	**Number of non-resident persons regularly present within or near the project area (e.g. employees)**
3.1	Waste management	b. Mass reduction due to preparation for reuse	0	5	100	tn/year
3.1	Waste management	i. Mass reduction due to appropriate disposal	0	0	0	tn/year
3.1	Waste management	g. Mass reduction due to energy recovery	0	0	0	tn/year
3.1	**Waste management**	**j. Amount collected by project**	**0**	**82**	**2000**	**tn/year**
3.1	Waste management	f. Mass reduction due to incineration with no energy recovery	0	0	0	tn/year
3.1	Waste management	a. Mass reduction due to waste prevention	0	0	0	tn/year
3.1	**Waste management**	**d. Mass reduction due to composting**	**0**	**114**	**2000**	**tn/year**
3.1	**Waste management**	**Mass of non-appropriately managed waste**	**2000**	**1871**	**0**	**tn/year**
3.1	Waste management	h. Mass reduction due to appropriate storage	0	0	0	tn/year
3.1	Waste management	e. Mass reduction due to digestion	0	0	0	tn/year
3.1	**Waste management**	**c. Mass reduction due to recycling**	**0**	**10**	**1500**	**tn/year**
6.1	**Air - emissions**	**Benzene**	**67**	**34**	**1**	**kg/day**
6.1	**Air - emissions**	**VOC**	**70**	**31**	**1**	**kg/day**
6.2	**Air - quality**	**CO**	**25**	**0**	**0**	**no. of exceedances/year**
6.2	**Air - quality**	**CO**	**30**	**6**	**6**	**ppm**
6.2	**Air - quality**	**Other**	**10**	**3**	**3**	**µg/m3**
6.2	**Air - quality**	**Other**	**1**	**0**	**0**	**no. of exceedances/year**
10.2	Involvement of non-governmental organisation	Private for profit	9	12	15	number of stakeholders involved due to the project
10.2	Involvement of non-governmental organisation	Public body/bodies	2	6	10	number of stakeholders involved due to the project
10.2	Involvement of non-governmental organisation	NGO	10	30	40	number of stakeholders involved due to the project
10.2	**Involvement of non-governmental organisa**	**Private for profit**	**6**	**8**	**10**	**number of stakeholders involved due to the project**
11.1	**Website (mandatory)**	**No. of unique visits**	**3547**	**82200**	**100000**	**No. of unique website visits**
12.1	**Networking (mandatory)**	**Members of interest groups / lobby organisations**	**10**	**220**	**300**	
13	Jobs	Jobs	0	0	12	No. of FTE
14.1	Running cost/operating costs during the project and expected in case of continuation/replication/transfer after the project period		10000	2140000	2600000	€
14.2.4	**Cost reduction expected in case of continuation/ replication/transfer after the project end**				**500000000**	
14.3	Future funding	Beneficiary own contribution			100000	