

Monica Bianco - **“The BioLand Project: research challenges beyond the current technological frontier”**

International Virtual Workshop on CRM Innovation Frontiers - EIT Raw Material South Italy

Abstract

The focus of circular economy is the passage from a linear economic model to a circular approach. This shift requires a much stronger commitment to sustainable management of waste and resources. Deposition of waste on soil still has a crucial role as a final sink for closing materials loop according to “Back to earth principle”. The regulations of landfilling at international level seems quite outdated, as is still promoting unsustainable approaches without any consistent control of long term environmental risks. The aim of the BioLand project is to seek new technological frontiers and explore innovative path that goes beyond landfill.



The goal of the BioLand project is to explore technological frontiers and innovative path that goes beyond landfill. Circular Research Foundation is committed to promote collaborative research proposal with industrial and institutional partners.

The topics of my presentation are the follows:



Beyond landfill: towards circular economy

- CRF: Mission and Vision
- Back to Earth principle: The issue
- Challenges
- Bio.Land Project
- Research Proposal for circular economy

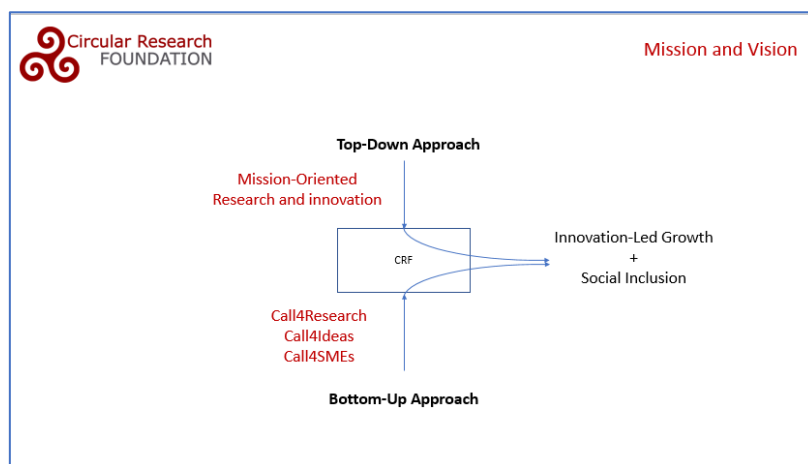
Mission and Vision

Circular Research Foundation is a research body whose Mission is Restanza. Restanza is a glocal development model combining research challenges and innovations to create new opportunities and qualified job at Regional Scale.

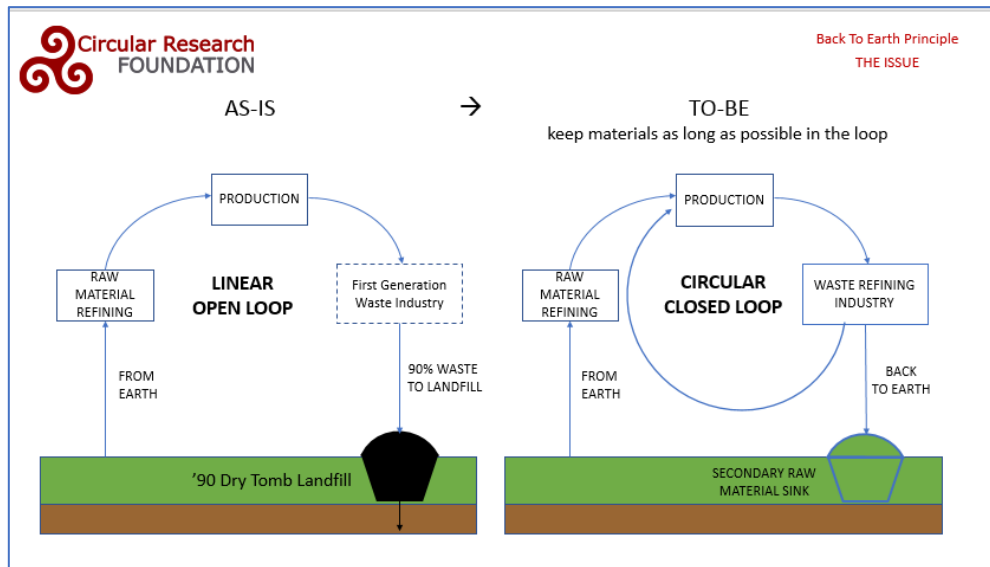
We believe in the power of communities. Communities have the capacity to drive a more sustainable and inclusive social and economic model, in respect of the European Community demand of social stability at a regional level.

CRF is a Mission-Oriented Research & Innovation body, focusing on a problem-solving approach to fuel innovation-led growth. CRF is also a Startups incubator.

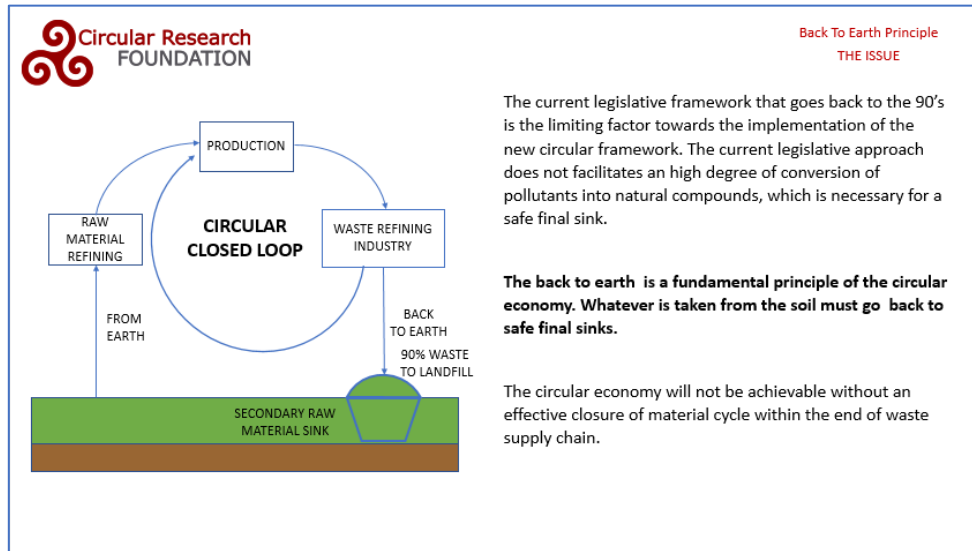
The business model is based on an integration of a top-down and bottom-up approach. The top-down approach is a mission oriented research whilst bottom-up approach is focusing more on generative idea. We believe that only the combination of both approaches lead to Innovation growth and social inclusion and consequently a better sustainable welfare.



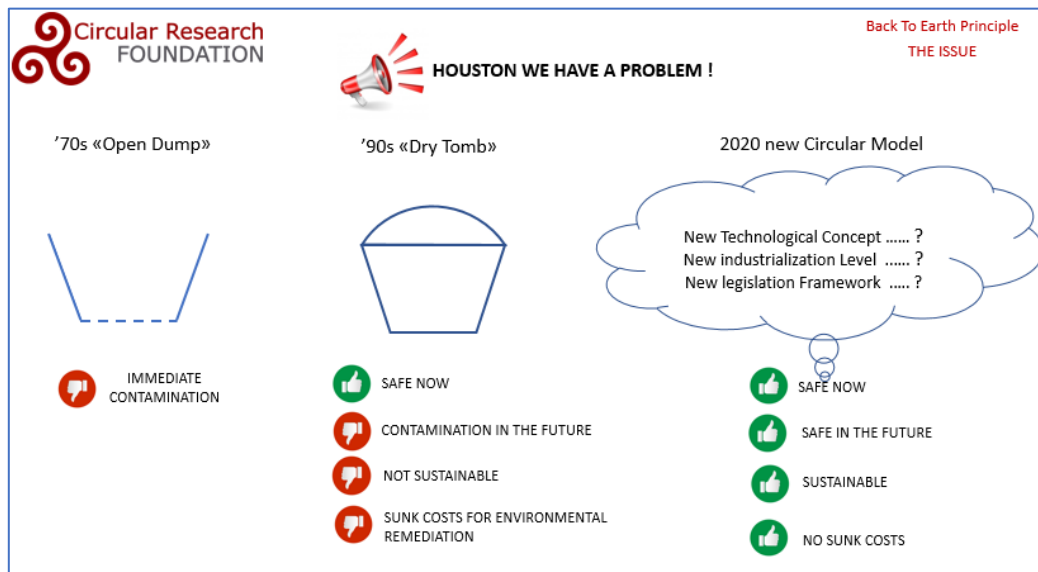
Back To Earth Principle: The issue



The focus of circular economy is the passage from a linear economic model (**AS-IS**) to a circular approach (**TO-BE**). This shift requires a much stronger commitment to sustainable management of waste and resources. The actual economic model arise from 90s regulatory framework legitimate the development of a first generation waste industries. The old regulations of landfilling base on a “dry tomb” landfill model, seems quite outdated, as is still promoting unsustainable approaches without any consistent control of long term environmental risks. Is advisable to develop a **new technological and economic closed loop, model based on main recirculation streams that keeps materials as long as possible in the inner loop, and secondary-minor streams, that guarantee a safe material sinks.**



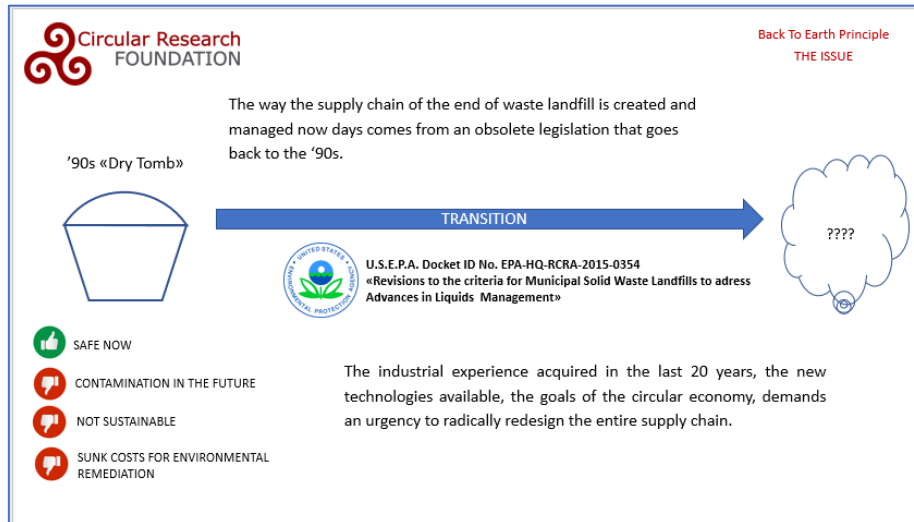
The back to earth is a fundamental principle of the circular economy, whatever is taken from the soil must go back to safe final sinks. The current legislative framework is the limiting factor towards the implementation of the new circular economy framework. The current legislative approach does not allows an high degree of conversion of pollutants into natural compounds, which is necessary for a stable and safe final sink. Therefore, we need to acknowledge that deposition of waste on soil, still has a crucial role as a final sink for closing materials loop according to “Back to earth principle”. So, the circular economy will not be achievable without an effective closure of material cycle within the end of waste supply chain.



Looking back to the 70s open dump, there was an immediate risk of contamination. The 90s regulation response to an ecological demand for a better environment was the dry tomb model. The dry tomb is based on a containment strategy that has generated a long timeframes problem, before landfill will reach a point where no active management is needed (which is called completion point). Although the 90s model is surely much safer than the previous one, is still not sustainable mainly for two reasons:

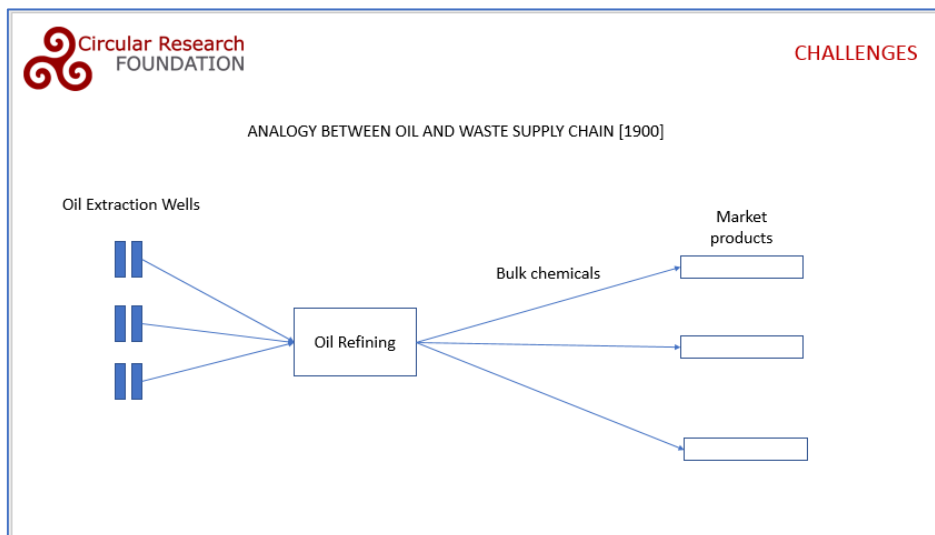
- A risk of contamination in the future
- And high, hidden sunk costs for environmental remediation offloaded to future generations.

The new Circular model approach is to go beyond landfill, this will require a new and more advanced Technological Concept, and a new legislation framework that can lead to a new industrialization level. Once this is done, we can reach a sustainable safe now and safe in the future economic model with no hidden sunk costs.

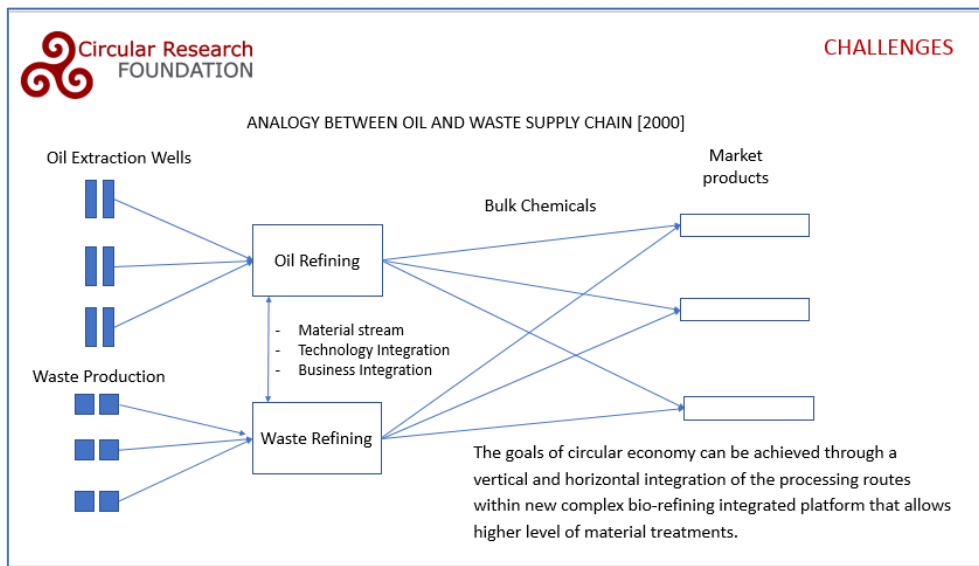


Challenges

The industrial experience acquired in the last 20 years, together with the new technologies available, demands an urgency to radically redesign the entire supply chain. Nowadays there is a scientific consensus on the urgent needs to address this problem. In fact, this issues has been recognized by U.S.E.P.A. in 2019 who launched a public inquiry finalized to change the actual regulation framework. We appreciated EPA inquiry and we sent them our proposal.

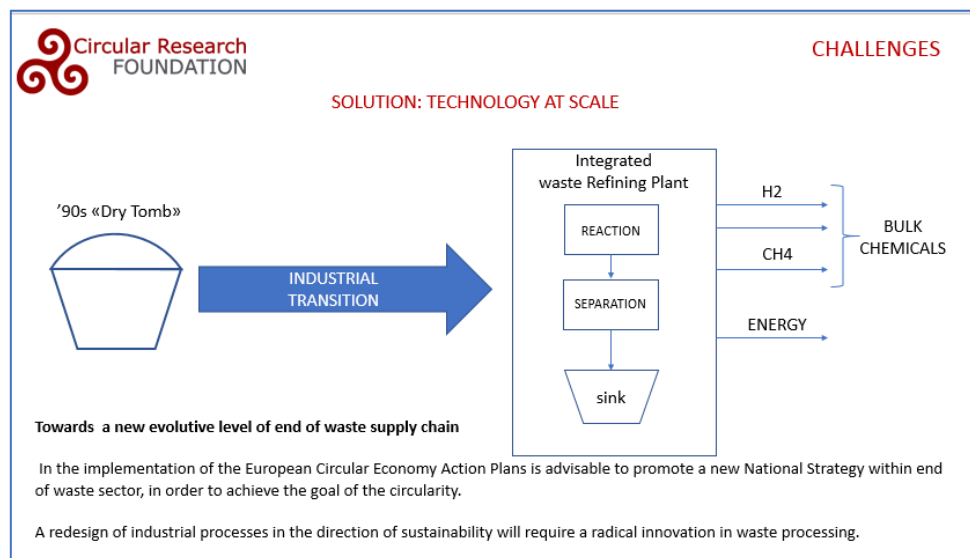


Looking at the structure of the well-known oil supply chain we can clearly see an analogy with waste industry. The crude-oil is not less complex than a waste material stream. Having said that, if we can refine the crude oil, we can absolutely doing the same with waste materials.



So, by analogy, we can think at a new industrial waste refining system, where some problems can be fixed thanks to research and innovation but also with scaleup investments and integration of processes within complex refining plants.

The goals of circular economy can be achieved through a **vertical and horizontal integration of the processing routes** within new **complex bio-refining integrated platform**, that allows higher level of material treatments. As you can see from the slide there is a potential **sector integration between oil and waste sector**, in terms of material streams, technology integration, Logistic Infrastructures and so a potential overall industrial integration. For example **ENI Energy Company** has put in place several **waste to fuel** projects.



The aim of this new industrial era is not to solve a public hygiene problem, but **how to produce fuel from waste**, or other chemicals, materials and energy from waste. At a conceptual Level the problem is simple. We need to shift from an unsafety storage unit to an Integrated waste refining plant Inside this complex refining plant, the solution is always an integration of unit operations: reaction plus separation plus storage.

Circular Research Foundation - E.T.S.

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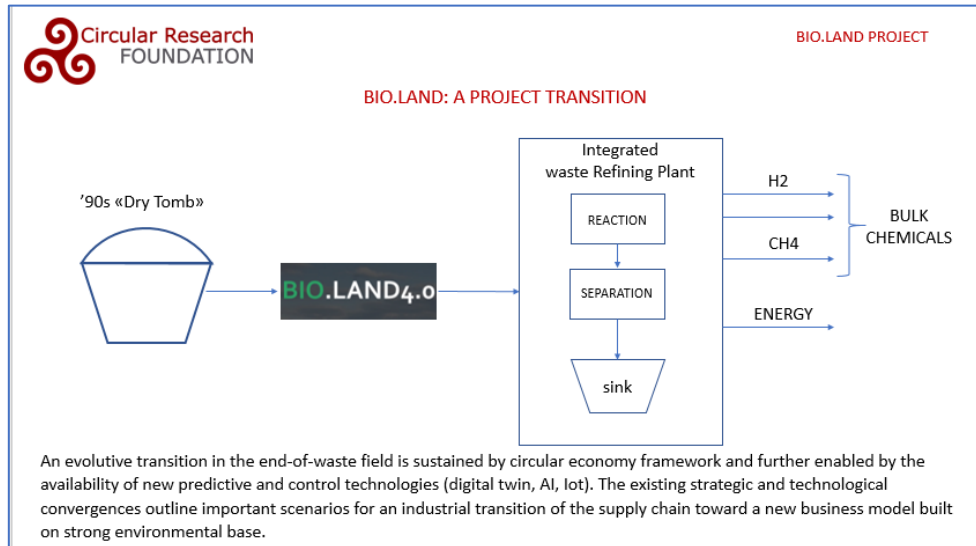
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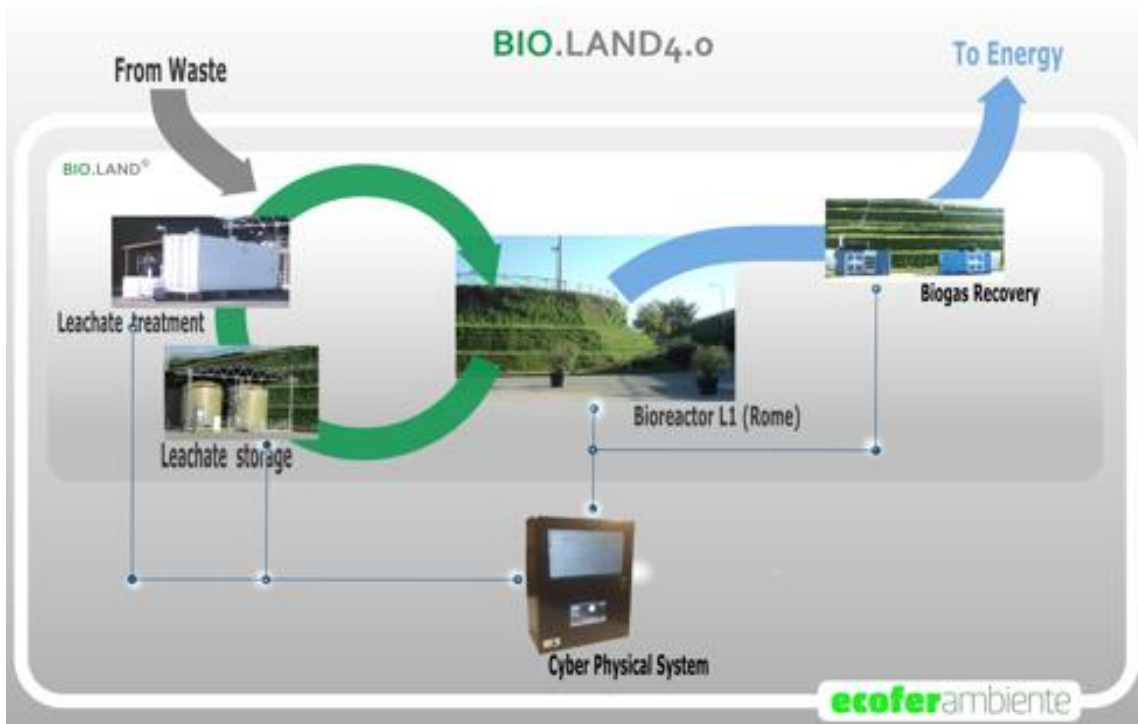
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The BioLand project



The Bio.Land 4.0 is a **“conceptual transition project”** towards the development of alternative process strategy in the direction of circular economy. An evolutive transition in the end-of-waste field is sustained by circular economy framework and further enabled by the availability of new predictive and control technologies (digital twin, Artificial intelligence, IoT). The existing strategic and technological convergences, outline important scenarios for an industrial transition of the supply chain toward a **new business model built on strong environmental base**. The first stage of the project was born in 2014 and completed in 2019.



The BioLand Project has been developed inside the Ecofer Ambiente S.r.l. plant located in Rome. The ecofer plant is authorized to treat hundred and fifty thousand ton per year of hazardous and non hazardous waste. The plant is composed by three functional sub-lots. The plant operates an uncommon car-fluff mono-material landfill. The composition of waste stored in Ecofer landfill is mainly plastics, but despite so, there is a **significant production of biogas, associated with anaerobic degradation processes**. The sub-lot L1 has been designed as a bioreactor and equipped with:



- Leachate storage and a leachate treatment plant, based on membrane reverse osmosis;
- A section of Horizontal Trench for recirculation of liquid phase;
- A system of biogas extraction wells;
- An energy recovery section from biogas.

Over a period of nearly 5 years, several research projects have been carried out finalized to the validation of a new concept. Among the others i would like to mention:

- Validation of membrane process for reverse osmosis, carried out by University of Rome “La Sapienza”;
- An Experimental campaign, carried out by Depura company, in regards leaching test in different pH condition;
- Enviromental and Sanitary Risk assessment. The study, carried out by LeMa consulting, while confirming an accettable risks level in the short term, has outlined the opportunity to change management operations in the direction of a final stabilization of the storage.
- A process study, carried out by lema consulting, based on material balances, has highlighted dynamics of the reactor, characterized by high “time constants”. Bioreactor is characterized by strong dynamics, evolutionary processes, emerging behaviours and uncertainties. Unforeseen conditions may arise during the life of the

reactor, but at the same time, evolutionary and **adaptive processes toward bio-stabilization emerged as endogenous property.**

Project Results



BIO.LAND RESULTS:

Reactor Plantwide Controllability: biological processes inside the reactor are stable and can be controlled. System dynamic is characterized by the existence of a final stable-attractor represented by an equilibrium state with external environment.



There are meta-stable states that can last for an indefinite time depending of the way the process is regulated.

The current operation management, in accordance with the existing regulations, push the system towards a meta-stable state which determine a freezing of stabilization processes for indefinite time.

The goal of the Bioland Project is committed to design a knowledgeable system to enhance the predictive capacity of reactor dynamics, either in the planning and design stage as well as the operating stage, with the purpose of speed up the achievement of the FSQ (Final storage quality) of the sink.

An important result of Bio.Land project is the demonstration of plantwide and reactor controllability. Process Study showed that biological processes inside the reactor are **stable and can be engineering controlled**. The presence of metastable states can last for an indefinite time, depending on the way the processes are managed. **So is very important to select the right control strategy to by-pass metastable states in order to accelerate waste stabilization.**

Innovation Frontiers and Legislation barriers



INNOVATION FRONTIERS:

The research highlighted the existence of a technological frontier. Reactor is characterized by slow dynamics coupled with fast transition and shut-off of reactions against non optimal control strategies.

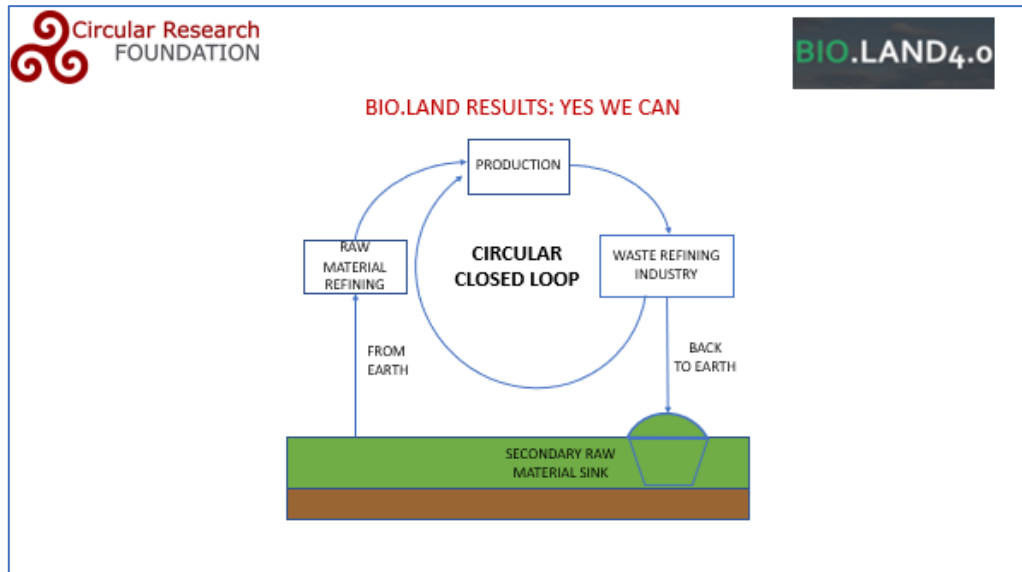
It is therefore necessary to have in place a **digital twin of reactor with forecasting capabilities based on predictive modelling and control**. To overcome this technological frontier, **Hymos Dynamics** startup has been created. The focus of this startup is to develop a cyber physical system (C.P.S.) for predictive control of highly variable dynamics.

LEGISLATION BARRIERS:

The way the supply chain of the end of waste landfill are created and managed nowadays, comes from an obsolete legislation that goes back to the 90's. **In the implementation of the European Circular Economy Action Plans is advisable to promote a new National Strategy within end of waste sector in order to achieve the goal of the circularity.**

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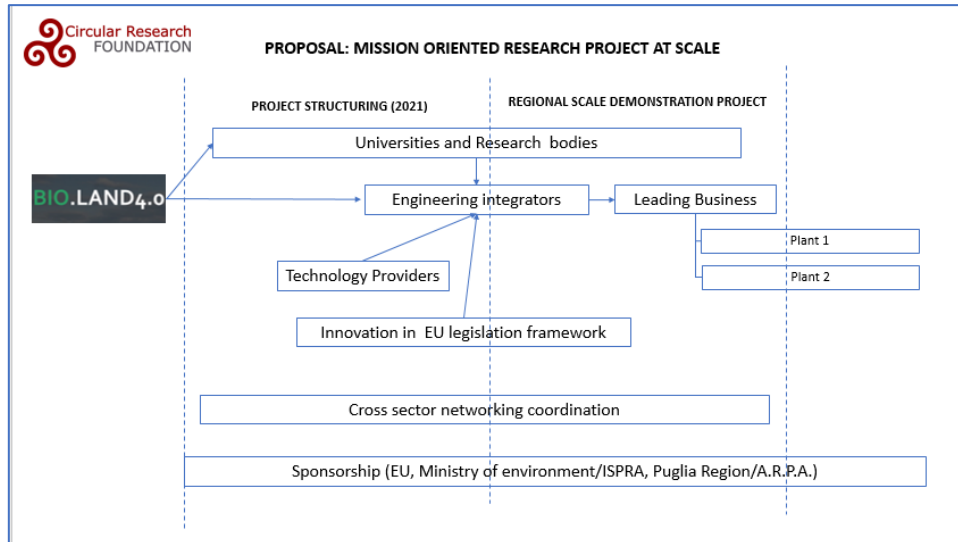
Results



Based on our research, it's easy to say that a new circular, **closed loop model, is possible and technically achievable**, but there is an urgent need of investments for radically changing the industrial model and regulation framework. Unfortunately, I have to remark that nothing has changed over the years. The populations nimby syndrome "Not in my backyard" and the Istituzioni Nimto syndrome "no to all industrial initiative" has generated a BANANA syndrome that is "build absolutely nothing anywhere near everething or anyone". Having said that, waste industrial sector must embrace a new era of real investments to modernizing and improve industrial know-how. We think the industry is ready to take on board all the issues to achieve the desired solution.

So, in the implementation of the European Circular Economy Action Plans is advisable to promote a new National Strategy within end of waste sector in order to achieve the goal of the circularity.

The Research and Industrial Proposal



Circular Research Foundation is committed to promote collaborative research proposal with industrial and institutional partners. **Our proposal for the Community is a Mission oriented research project at scale, integrated with an industrial transition project**, with the support of all the actors involved (research and university, industry, engineering partner, technological providers, regulatory institutions) in a cross sector networking coordination program, **to overcome the industrial frontiers highlighted in my presentation**. Right Now is the moment to join all the forces to accomplish an ecological transition project, and **run to be ready** to use in a very intelligent way the available Next Generation EU funds.

The research project has been financed thanks to private funds from Ecofer Ambiente S.r.l.

