

The logo for ENEA, featuring the word "ENEA" in a bold, white, sans-serif font. To the left of the text is a stylized graphic of a sun or starburst with a bright yellow center and a blue, glowing aura.

ITALIAN NATIONAL AGENCY  
FOR NEW TECHNOLOGIES, ENERGY AND  
SUSTAINABLE ECONOMIC DEVELOPMENT

# ENEA experiences in R&D of eco-innovation: “Ecoinnovation Sicily” project

Dr Grazia Barberio  
Senior researcher

ENEA - Italian National Agency for New Technologies, Energy  
and Sustainable Economic Development

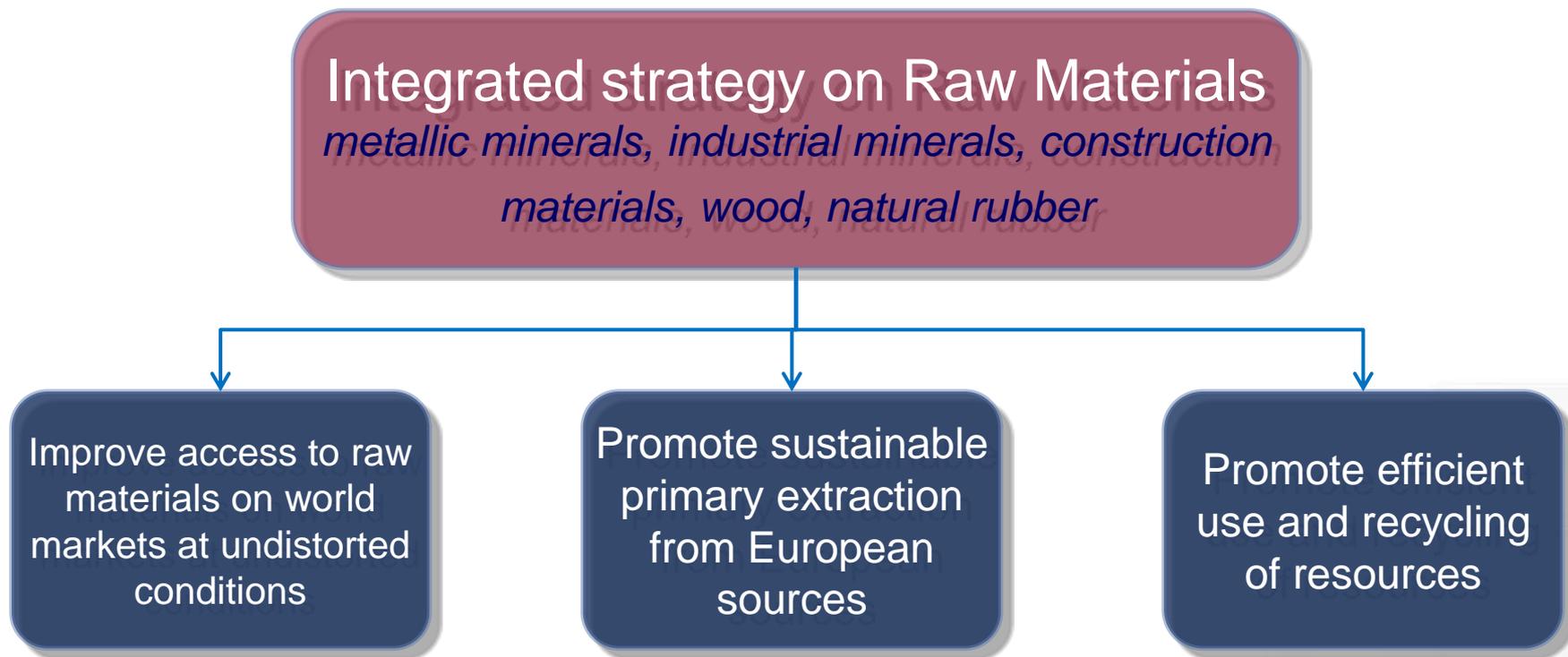
**Hi-tech&Ambiente – Circular economy**

# Why? Moving towards resource efficiency

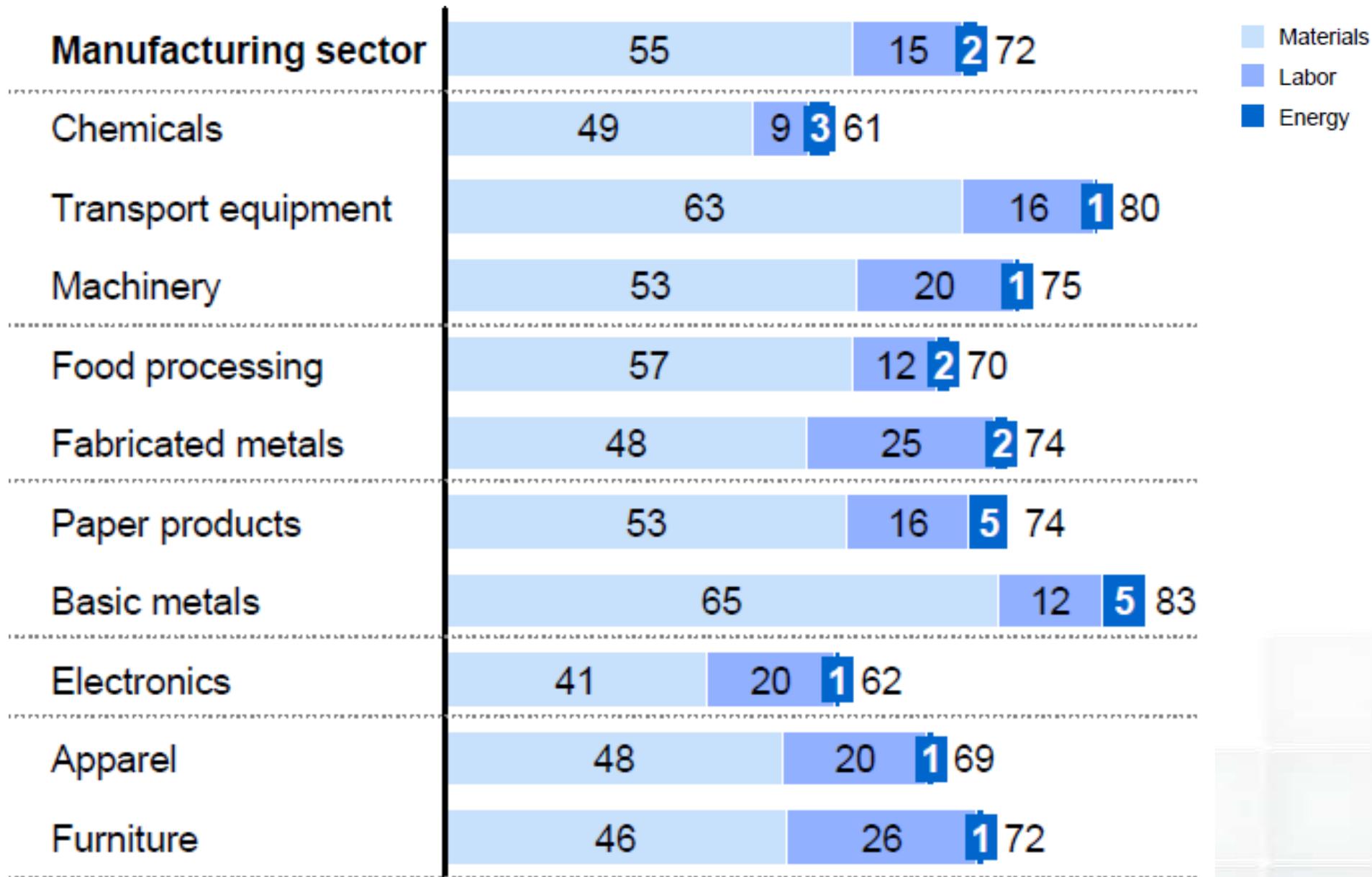
**Resource efficiency** has become priority for:

- environmental reasons (resource preservation),
- economic reasons (growth and competitiveness)
- strategic reasons (ensuring supply).

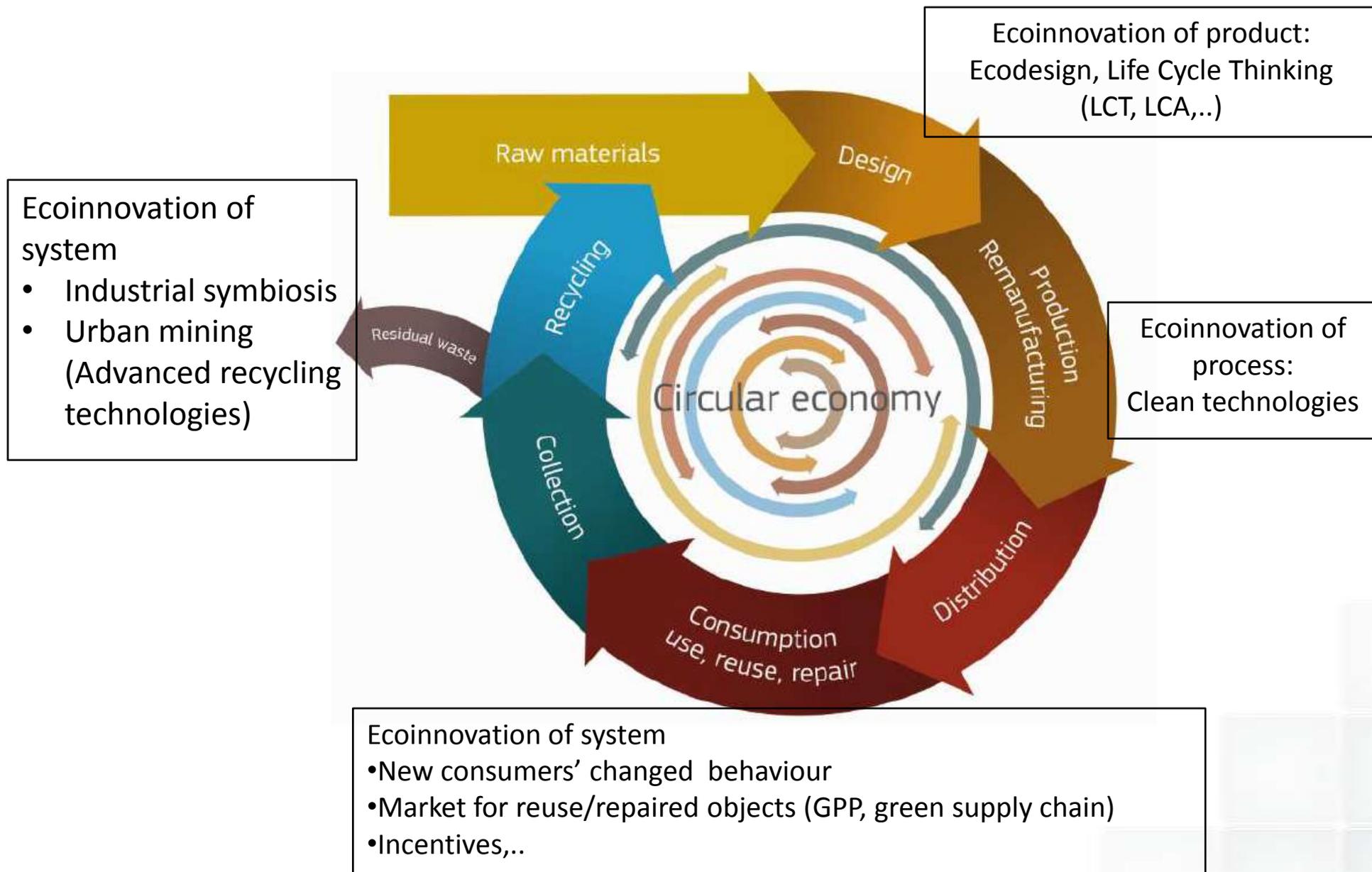
European Initiative on Raw material: identifying a strategic implementation plan for the safe and sustainable supply of raw materials).



# Costs over Sale price (%)



# From linear economy to circular economy



# Urban waste: problem or resource?

## Urban Mining

Goal: Monetize Urban Waste Streams



# «Ecoinnovation Sicily» project

Funded by Italian Government (art. 2 - c.44, financial law. 2010)



## Strategic objectives: sustainability and competitiveness

Facilitating the promotion innovative methodologies and technologies, in order to enable the industrial development of Southern Italy

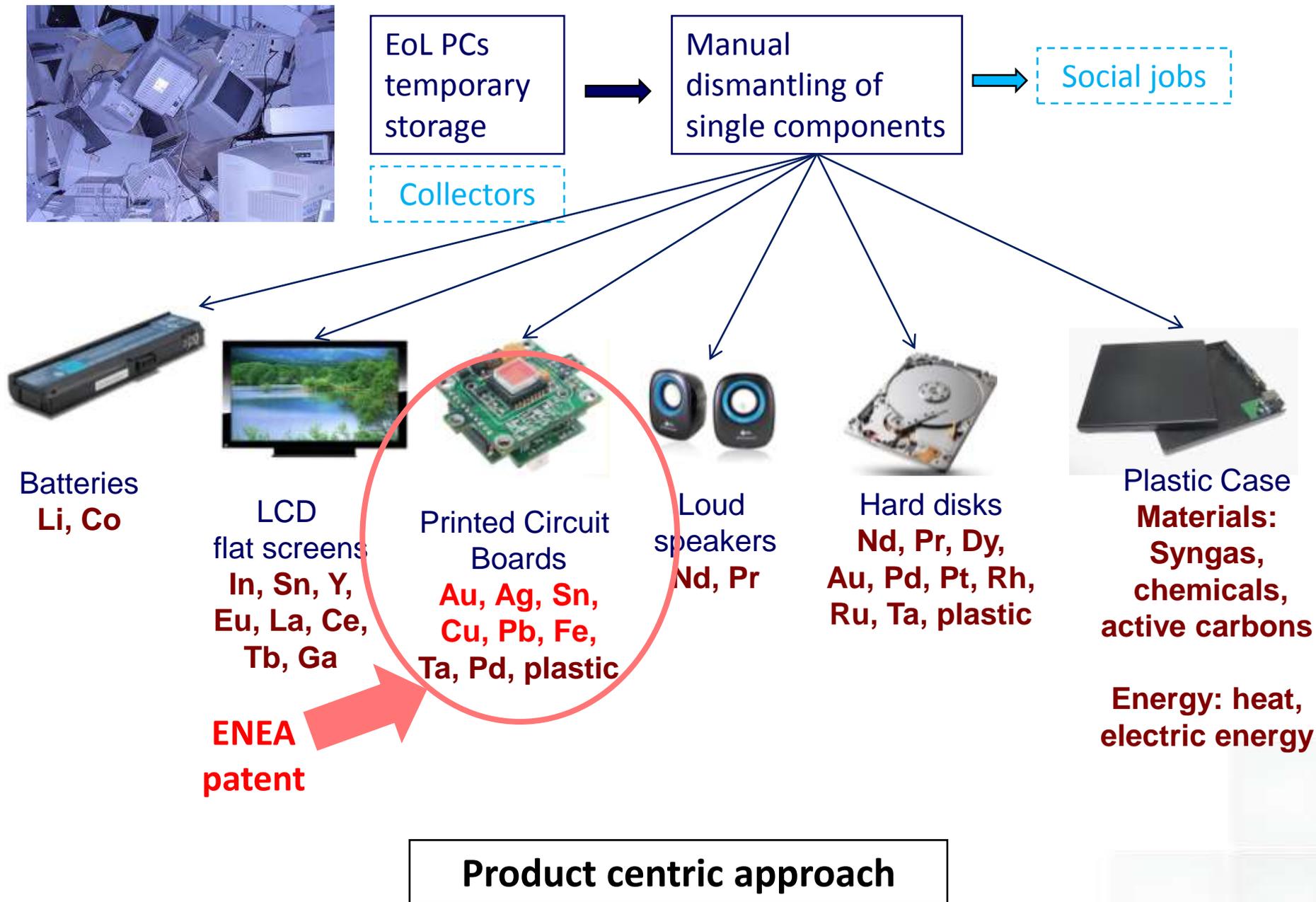
Promoting the eco-sustainability of some significant sectors of the region of Sicily, encouraging environmentally friendly business strategies that foster their **competitiveness** through the implementation of a series of research, development, promotion and through technological tools and methodologies.

The project also raises **awareness** of particularly SMEs, about the need to interact with each other and create a system of available knowledge and skills.

## Focus: two main sectors of the Sicilian region

- 1) the recycling industry, and in particular the field of electrical and electronic equipment (WEEE) and plastics for recovering valuable raw materials and energy, which is also the first application of the principles of the methods and tools of 'industrial symbiosis' in Italy;
- 2) sustainable tourism in the Egadi islands (in particular Favignana), developed in a 'Smart Island' perspective.

# URBAN MINING: Example of recovery from waste electric and electronic equipments (WEEE)



# Urban mining from WEEE: potential and emissions



	Primary extraction in 2011 [t]	Estimated world reserves [t]	Potential secondary recovery from WEEE [t]	Average content in medium grade ore [g/t]	Average content in printed circuit boards [g/t]
Gold	2.700	51.000	4.000	5 - 10	80 - 1000
Silver	23.800	530.000	10.000	200 - 400	200 - 3.300
Platinum	192	66.000 (PGMs)	1.000	4 - 6	20 - 40
Palladium	207	66.000 (PGMs)	2.500	4 - 12	50 - 120
Copper	16.100.000	690.000.000	8.000.000	6.000 - 45.000	160.000 - 345.000

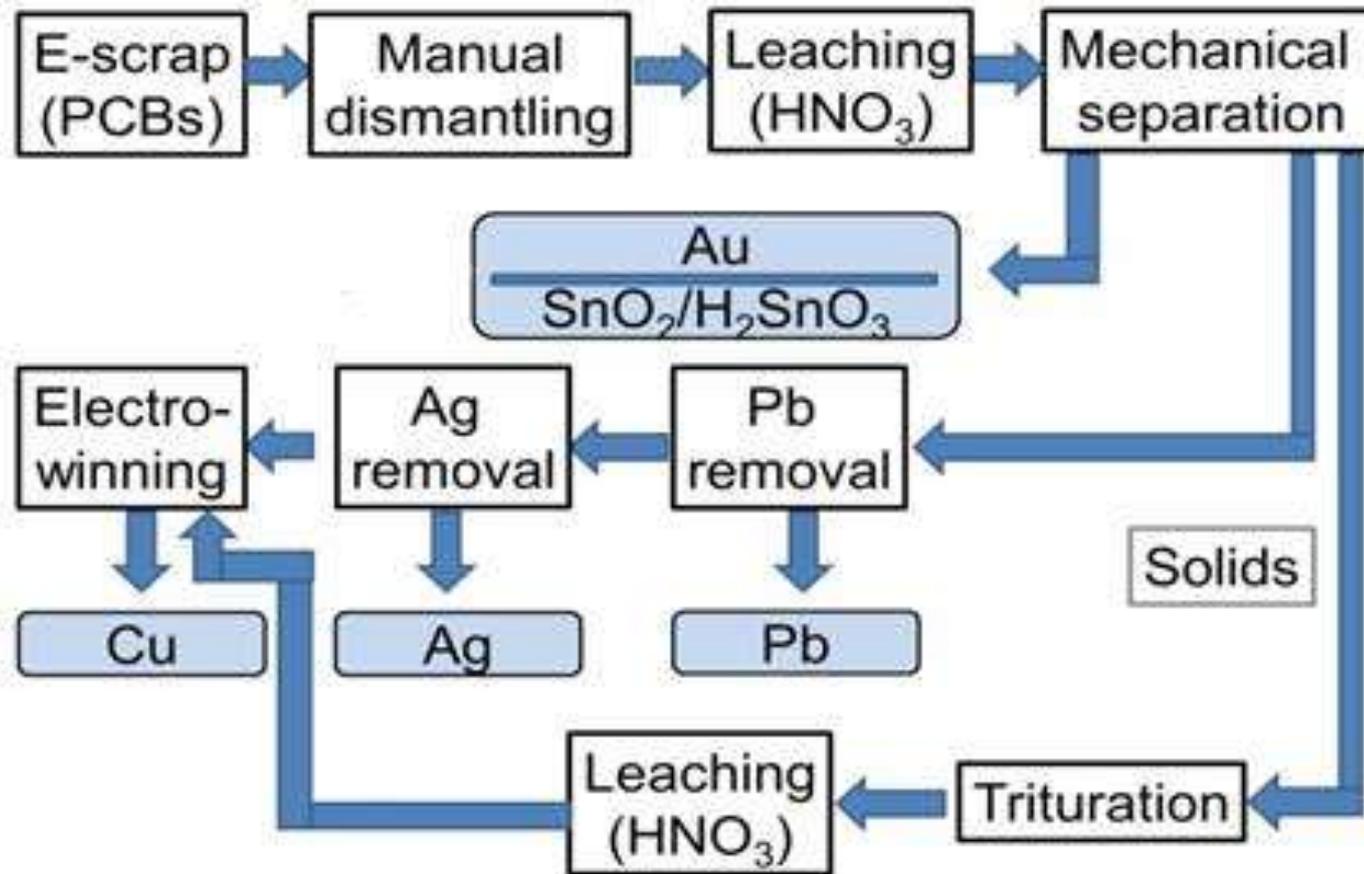
Source: E Waste Lab, Remedia, PoliMI, 2012; Effective electronic waste management and recycling process involving formal and non-formal sectors, 2009

## Emissions per metal in ton of CO<sub>2</sub>

Metal	Scenario 1 primary mining	Scenario 2a Manual dismantling/smelted India	Scenario 2b Mechanical dismantling/smelted India	Scenario 2c Manual dismantling/smelted Europe	Scenario 2d Mechanical dismantling/smelted Europe
Aluminium	10	0,87	0,94	0,75	0,82
Nickel	20	4,8	6,7	4,7	6,6
Copper	3,4	1,2	1,5	0,98	1,2
Gold	17.000	710	1.330	690	1.300
Silver	140	20	40	20	40
Palladium	9.400	210	730	200	720

Source: Carbon Footprint of E-waste Recycling Scenarios in India: Frederik Eisinger Ronion Chakrabarti, Christine Kruger, Johannes Alexeew; 2011

# ENEA Patented process for Recycling Of METals by hydrOmetallurgy



ENEA's Hydrometallurgical process for the recycling of gold, silver, tin, copper and lead from waste printed circuit boards

# *Demonstration plant ROMEO - Recycling Of METals by hydrOmetallurgy*



On the basis of the patented process, a pilot plant ROMEO (Recycling Of METals by hydrOmetallurgy), was designed and will be realized at ENEA Research Center by the end of 2015.

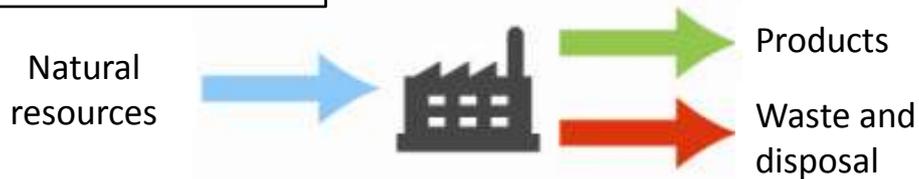
The pilot plant, specifically studied for treating up to 150kg of electronic circuit boards per day, will allow checking the process operation, its technical and economic efficiency, including risks-benefit analysis.

## **Advantages and Innovations**

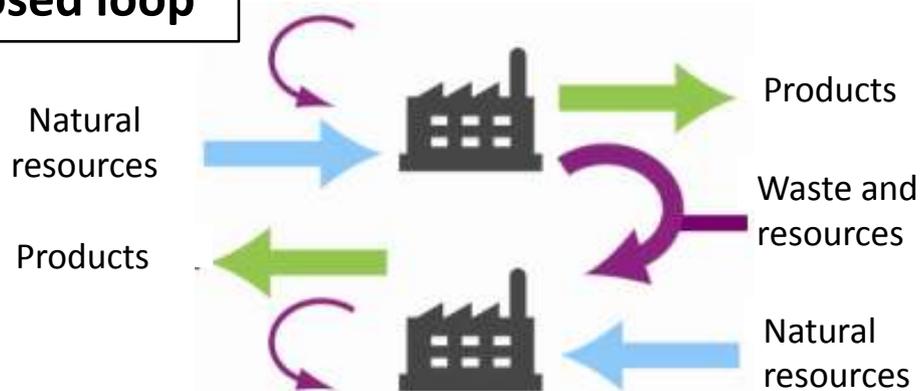
- Possibility to treat the whole circuit board
- Possibility to recover Au and Sn at the first process step
- Possibility to obtain recovered materials at a various purity grade according to the demand (thus being an ideal test-bench for the development of the recovering processes of metals of strategic interest).
- Possibility to be applied on small plants, as a consequence being socially acceptable and bringing a lower environment impact with respect to most common pyrometallurgic plants.
- Possibility to be applied to different waste

# Pills of Industrial Symbiosis

## Open system



## Closed loop



## Economic advantages:

- costs reduction for raw materials and energy supply and for landfilling;
- creation of business network and new market opportunity.

## Environmental advantages:

- optimizing the use of resources
- mitigation of pressure on environment, saving emissions and landfilling.

## Social advantages:

- occupation (green jobs);
- cultural change (sharing economy).

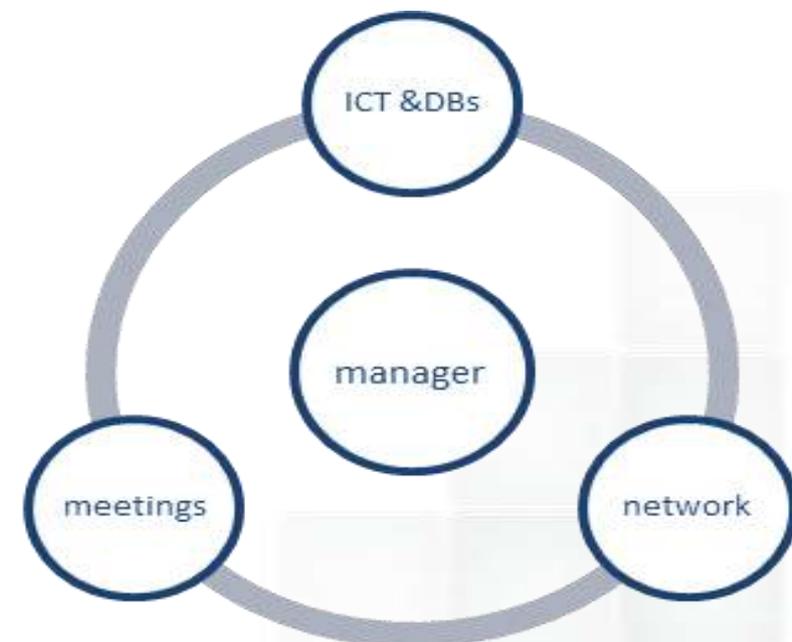
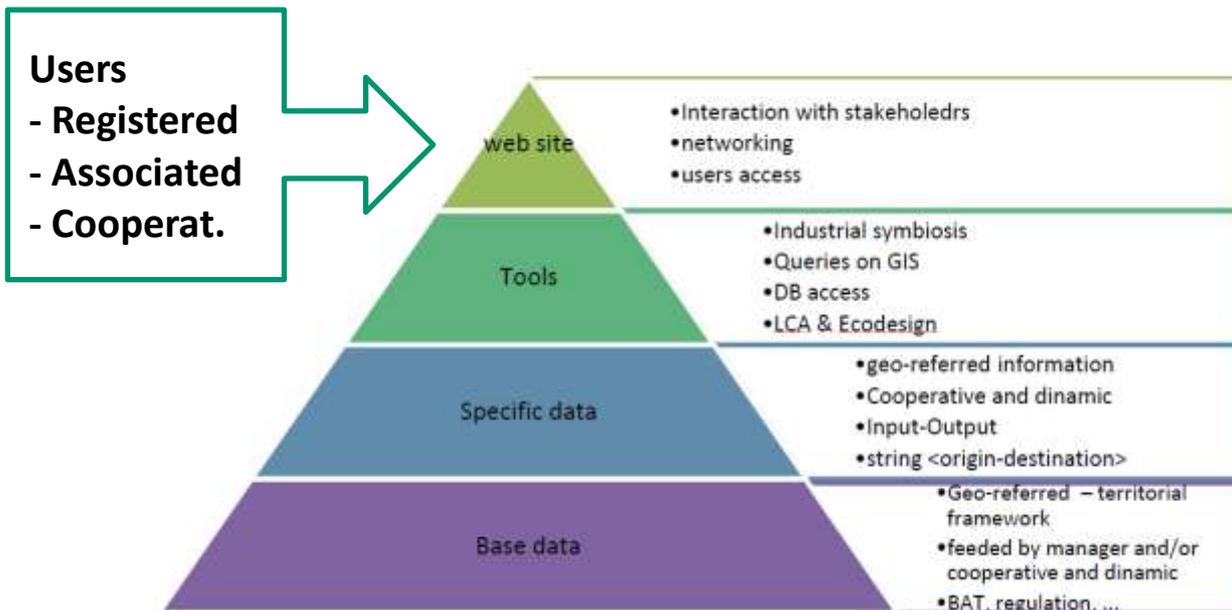
*“Industrial symbiosis engages **traditionally separate industries and other organisations in a network to foster innovative strategies for more sustainable resource use (including materials, energy, water, assets, expertise, logistics etc)**”*  
(Lombardi & Laybourn, 2012)

Waste from one industry can become resource for other industries ( “synergy” )

# Methodology: the ENEA Industrial Symbiosis Platform



- **Network** (including companies, innovators, entrepreneurs, regulators, academics, regional government);
- **Data** (geo-referred): general DBs, local framework; specific DBs, available resources;
- **Skills**: including technical and scientific, which allow the identification of possible synergies (identify connections, facilitate communication across sectors, deal with technical, financial or regulatory barriers);
- Participation of **users**: the interface with potential users through a web portal and dissemination and promotion activities.



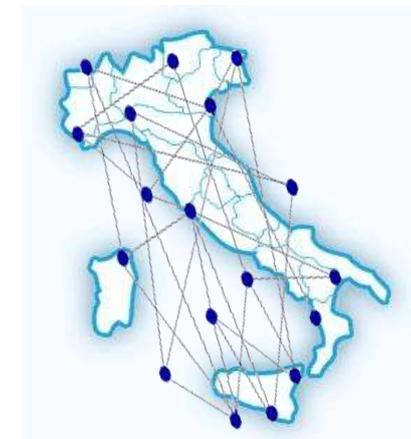
# ENEA ongoing activities on Industrial Symbiosis



Industrial Symbiosis **platform**:  
[www.industrialsymbiosis.it](http://www.industrialsymbiosis.it)



Symbiosis Users **Network**: Italian network of  
Industrial Symbiosis, promoted by ENEA.  
[www.sunetwork.it](http://www.sunetwork.it)



Eur-ISA, launched on November 6<sup>th</sup> 2013, aims to connect the industrial symbiosis **networks across European** member states.

ENEA is a founding member (with Belgium, Denmark, England, Finland, Hungary, Ireland, Netherlands, Northern Ireland and Turkey). [www.eur-isa.org](http://www.eur-isa.org)

# ENEA activities citation in EcoInnovation Observatory (EIO)



Citation in «Eco-Innovation Observatory- EIO. Country report 2014. Eco-innovation in Italy»  
(P. Markianidou)

ENEA Industrial Symbiosis  
Platform cited as «Selected eco-  
innovation areas and  
new trends”

**Industrial symbiosis Network:** Industrial symbiosis has recently been recognised as part of the European strategy for the efficient use of resources. The term industrial symbiosis is the exchange of resources between two or more different industries, intending "resources" as not only those of a natural material (by-products or waste), but also waste energy, services and expertise. It is a strategy for closing resource cycles and optimising their use in the context of adequate territorial economic revenue. There are many implications resulting from the effective realisation of industrial symbiosis programmes that can affect the possible productive uses of waste and by-products, processes of exploitation and transformation of by-products and waste with a view to re-using them, instruments and data banks, technical-administrative procedure and regulations. In Italy there are examples of industrial symbiosis, including an ENEA initiative for the creation of the first regional platform of industrial symbiosis in Sicily. It is a three-year project as part of the support for the productive development in the regions of southern Italy.<sup>10</sup>

#### Eco -innovation Sicily

The project 'Eco -innovation Sicily' started as an initiative of the Italian government aiming at facilitating the promotion of coordinated projects in the field of environmental protection and the development and promotion of innovative methodologies and technologies, in order to enable the industrial development of Southern Italy. The project focuses on some significant sectors of the Sicilian region: 1) the recycling industry, and in particular the field of electronic equipment and plastics, with a pilot project for energy and recovery of valuable raw materials from waste from electrical and electronic equipment (WEEE) and those from plastics, which is also the first application of the principles of the methods and tools of 'industrial symbiosis' in Italy, and 2) sustainable tourism with a pilot project in the Egadi islands, with particular reference to the island of Favignana, developed in a 'Smart Island' perspective.



«Ecoinnovation Sicily» cited in  
«Good practice examples»

# Thanks for your attention



**ENEA – Technical Unit for environmental technologies**



**[grazia.barberio@enea.it](mailto:grazia.barberio@enea.it)**



web sites:

[www.enea.it](http://www.enea.it)

[www.sunetwork.it](http://www.sunetwork.it)

[www.industrialsymbiosis.it](http://www.industrialsymbiosis.it)



**SUN** Piattaforma Simbiosi industriale - ***Symbiosis Users Network***

# ENEA projects on Industrial Symbiosis



Name

**“Ecoinnovation Sicily”**

**“Green–Industrial Symbiosis”**

**“EcoIndustrial Park Rieti”**

Main aim

Actions for sustainability and competitiveness of tourism and industrial areas

Cross-relations between production sectors, industrial research and territory

A green development opportunity for the Rieti's industrial cluster

Territory

Sicily region

Emilia-Romagna region

Industrial Cluster: ASI Rieti Lazio

Funding

Funded by Italian Government (art. 2 - c.44, financial law. 2010)

Unioncamere Emilia Romagna and ASTER

PhD co-funded by ENEA and Tuscia University

Duration

05.2011 – 05.2015

1° phase 10.2013 - 02.2014 ;  
2° phase 10.2014 - 06.2015

09.2014 – 03.2016

Stakeholders

Confindustria Sicilia, Chamber of Commerce (ENEA= technical and scientific coordination)

Unioncamere Emilia-Romagna and ASTER (ENEA= technical and scientific coordination)

Consortium for industrial development in Rieti province (ENEA= coordination)

Value chain

Regional waste (WEEE, plastics, agrifood, construction,..)

Agro-industrial waste and residues

Local waste (WEEE, plastics, agrifood, construction,..)

Main results

Successful cooperative approach!  
90 participating companies are geo-referred and provide about 400 I/O; 600 potential synergies

Successful cooperative approach!  
10 companies are geo-referred and provide about 100 I/O; 90 potential synergies

Creation of companies DB to select the suitable ones  
Work in progress...

«Network» model

«Industrial Park» model