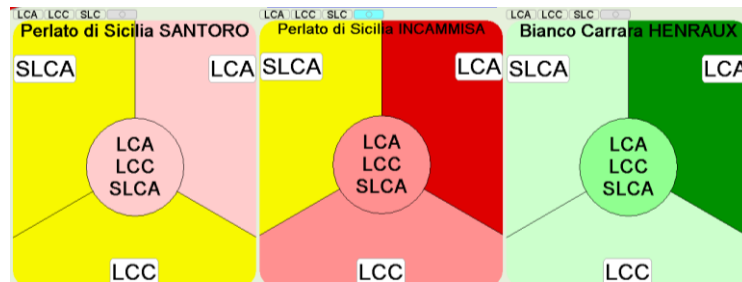




Life Cycle Sustainability Assessment - a tool for supporting decision makers



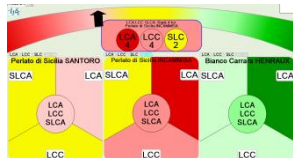
Workshop - Social Aspects of Products
Over the Whole Life Cycle
Dr. Ing. Marzia Traverso



Technische Universität Berlin
Department of Environmental Technology
Chair of Sustainable Engineering

- Presenting a methodology that manages to integrate the three pillars of sustainability for supporting decision-making process in the evaluation of products and services. It is called Life Cycle Sustainability Dashboard.
- Showing the applicability, practicability and still limitations of the methodology introduced here by presenting the application of LCSD to different kinds of marble

$$\text{LCSA} = \text{LCA} + \text{LCC} + \text{S-LCA} (*)$$



(*) Kloepffer W. 2003, Kloepffer W. 2008,
Finkbeiner M et al 2008, Finkbeiner et al., 2010.



- When you want to use the LCSA results for supporting decision-making procedure, we have to handle with their complexity. As matter of the fact the decision-making process usually involves people with different knowledge and background.

We need an understandable, yet comprehensive presentation of LCSA results.

Which product is better? What does it mean?

The results presentation should address:

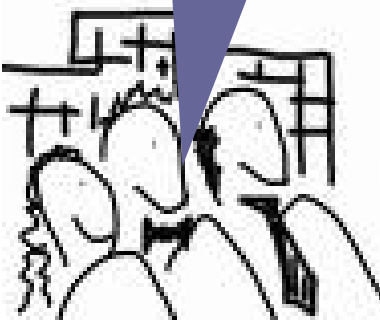
- experts expectations on relevance and level of detail
- non-expert expectations on easy interpretation
- flexibility and suitability for the implementation in decision making processes
- trade-offs
- challenges on the selection and weighting of indicators.
- comparability of results among several products



GWP 74.5 $\text{KgCO}_{2\text{eq}}/\text{m}^3$
EE 498.7 $[\text{MJ}/\text{m}^3]$



GWP 37.4 $\text{KgCO}_{2\text{eq}}/\text{m}^3$
EE 1414.7 $[\text{MJ}/\text{m}^3]$












- The LCSD adapts the Dashboard of sustainability to LCA, LCC and S-LCA.

Dashboard of sustainability (Hardi and Semple 2000, Jesinghaus 2000)

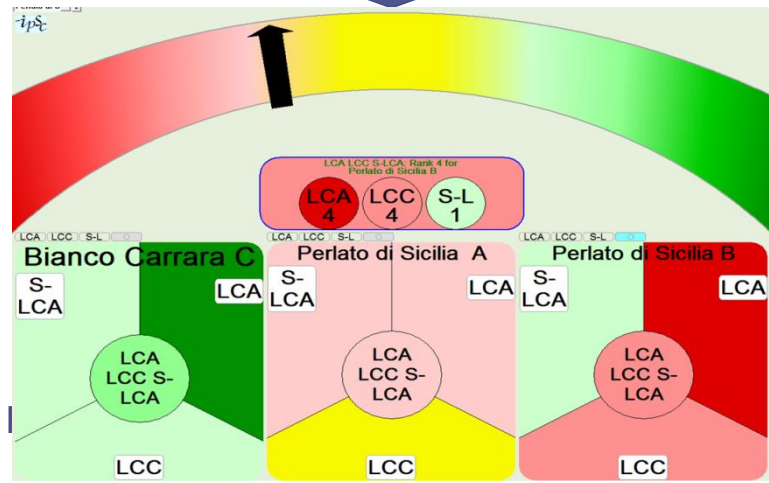
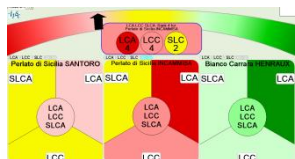
- The performance is displayed through a seven-colour code ranging from dark red ("critical") over yellow ("average") to dark green ("best").
- **At the indicator level:** The valuation is relative to the products using a point system, ranging from 0 (worst case, dark red) to 1000 points (best case, dark green). All other values are calculated by linear interpolation.
- **At the topic level:** the topic value for each product is calculated by a weighted average of the indicators values.
- **The Overall Index:** is the arithmetic mean of all Topic values.

| Policy valuation: | |
|---|-----------|
|  | very good |
|  | good |
|  | ok |
|  | medium |
|  | bad |
|  | very bad |
|  | crisis |

$$\text{LCSA} = \text{LCA} + \text{LCC} + \text{S-LCA} (*)$$



| ELCA | | | | | | | LCC | | | | | | SLCA | | | | | | |
|------------------|--------------------------|---------------------------|--------------------------|---------------------------------|---------------------------|---------------------------|--------------------------|---------------------------|---------------------------------|---------------------------|---------------------------|---------------------------|--------------------------------|--------------------------------|---|---|---|---|---|
| E01 | E02 | E03 | E04 | E05 | E06 | E07 | L01 | L02 | L03 | L04 | L05 | L06 | S01 | S02 | S03 | S04 | S05 | S06 | S07 |
| Source | Source | Source | Source | Source | Source | Source | | | | | | | | | | | | | |
| min | min | min | min | min | min | min | min | min | min | min | min | | | | | | | | |
| EE | GWP | ODP | HTP | POCP | AP | EP | EC01 | EC02 | EC03 | EC04 | EC05 | EC06 | S01 | S02 | S03 | S04 | S05 | S06 | S07 |
| Exhaust Emission | Global Warming Potential | Ozone Depletion Potential | Human Toxicity Potential | Photochemical Oxidant Potential | Acid Potential | Eutrophication | Global Warming Potential | Acid Equivalent Potential | Photochemical Oxidant Potential | Human Toxicity Potential | Ecotoxicity Potential | Resource | Number of workers for assembly | Number of workers for assembly | Number of workers with collection/transport | Number of workers with collection/transport | Number of workers with collection/transport | Number of workers with collection/transport | Number of workers with collection/transport |
| Mt/FU | CO ₂ e/FU | kg CFC-11/FU | kg CFC-12/FU | kg SO ₂ e/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU | kg CO ₂ e/FU | kg SO ₂ e/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU | kg CO ₂ e/FU | kg SO ₂ e/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU | kg PO ₄ -eq/FU |
| 1868.85 | 200.11 | | 0.53 | 0.03 | 0.77 | 0.05 | 37 | 66 | 7 | 11 | 3 | 33,195,800.00 | 0.147 | 0.005 | | 0.002 | 0.00 | | |
| 498.68 | 74.48 | | 0.30 | 0.0033 | 0.2845 | 0.0002 | 34 | 25 | 0 | 12 | 2 | 95,000,000.00 | 0.008 | 0.003 | | 0.0002 | 0.0 | | |
| 698.66 | 103.9 | | 0.37 | 0.015 | 0.425 | 0.0037 | 49 | 40 | 0 | 1 | 2 | 20,300,000.00 | 0.00736 | 0.00017 | | 0.000228 | 0.0015747 | | |
| 1814.77 | 37.4 | | 0.36 | 0.025 | 0.703 | 0.038 | 6 | 0 | 0.33 | | 1 | 45,000,000.00 | 0.00032 | 3.56667E-05 | | 2.333E-05 | 6.1422E-06 | | |





- Natural stone production is a meaningful productive sector of Sicilian Region
- 2004-2005 => Life Cycle Assessment of Perlato di Sicilia (one of the most important marble produced in Sicily) - primary data from B company(*)
- 2007-2008 => Life Cycle Assessment of Bianco Carrara (one of the most famous marble from Massa & Carrara basin)- primary data from two different companies
- 2009 => Life Cycle Sustainability Assessment and Dashboard of Natural Material stones (Perlato di Sicilia, Volcanic Stone from Etna and Bianco Carrara Marble, LCC and SLCA by sector and regional data (**))
- **2010 => Life Cycle Sustainability Assessment and Dashboard of Perlato di Sicilia - Primary data and comparison of Bianco Carrara products (social and economic secondary data)**

(*) Traverso M., Rizzo G., Finkbeiner M., 2010. *Environmental performance of building materials: Life Cycle Assessment of a typical Sicilian marble*, IJ of LCA, Vol 15, No.(2010), 104-114, ISSN 0948-3349.

(**) Traverso M. and Finkbeiner M., 2009. *Life Cycle Sustainability Dashboard. Proceedings of the 4th International Conference on Life Cycle Management, 6-9 September 2009. Cape Town, South Africa.*

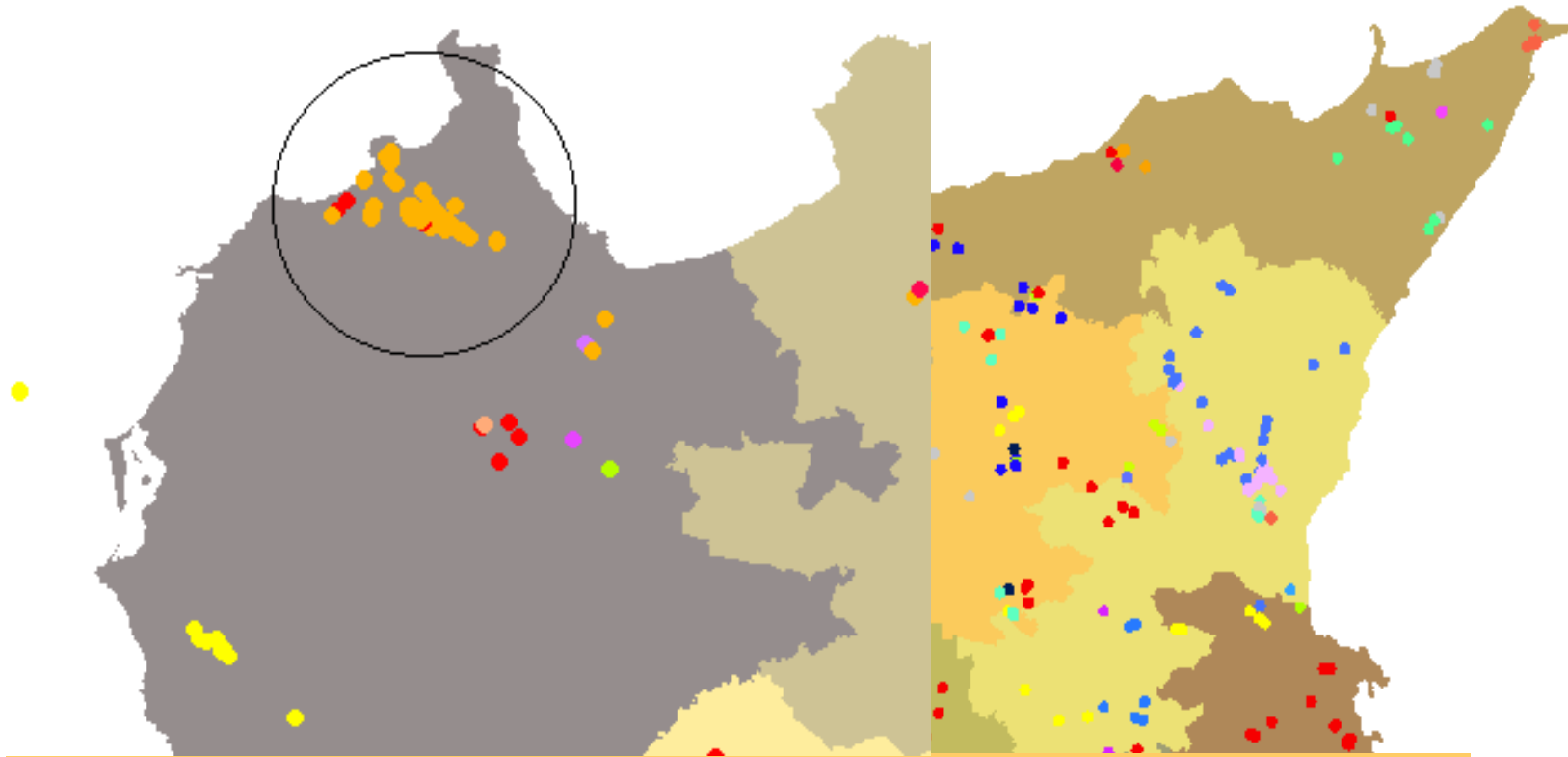
Why marble from Custonaci Basin?



Legenda tipi di cave

- Alabastro granaio
- Arenaria
- Argilla
- Biancote
- Calcareo
- Calcareo (Olivio Ormanno)
- Calcareo da Ornatico
- Calcareo dolomitico
- Calcareo e Striato
- Calcareo imbricato
- Calcareo marmo
- Calcareo marmoso
- Calcareo
- Calcareo ornato
- Baso
- Striato
- Striato
- Leve da frantumato
- Leve da taglio
- Marmo
- Marmo
- Mat. Alabastro
- Marmorati
- Pietra Ornamentale
- Porrato
- Quarzenario
- Quarzenario (Lico D)
- Reticolato di colli
- Sabite
- Sabite Calcareo
- Sabite e conglomerato
- Sabite e Striato
- Sabite e glaciali
- Sabite affine
- Tuffo Calcareo
- Tuffo vulcanico

The Custonaci Basin is different of natural Stones material
85 marble quarries produced of 60 tkm²



Case studies:

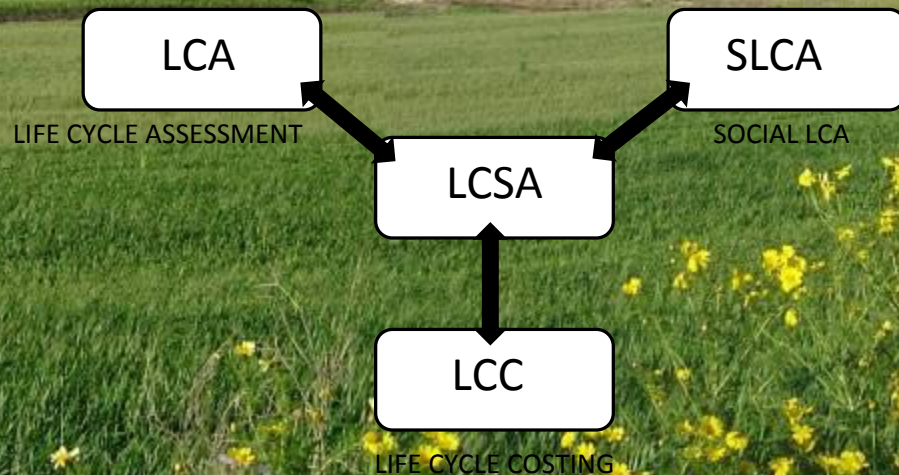
"Custonaci Basin"

LCSA of Custonaci Marble

“Perlato di Sicilia”

Assumptions of the Life Cycle Sustainability Assessment:

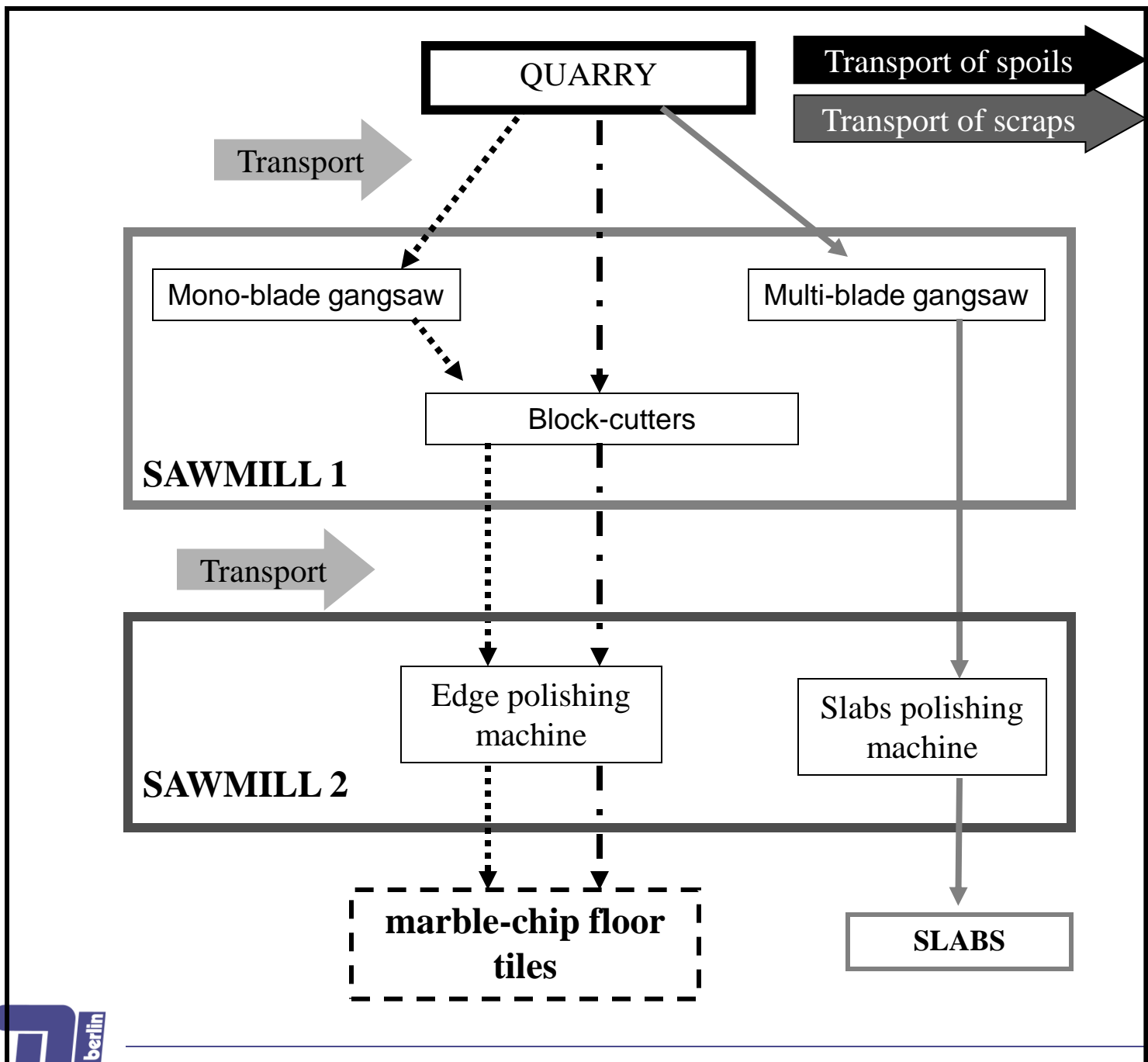
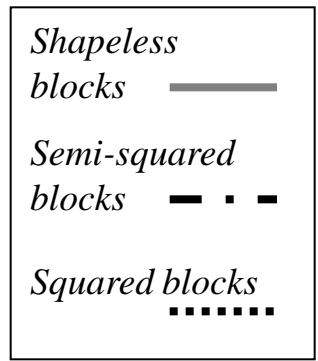
- The same system boundary has been considered in LCA, LCC and S-LCA;
- All results are related to the same Functional Unit = m³



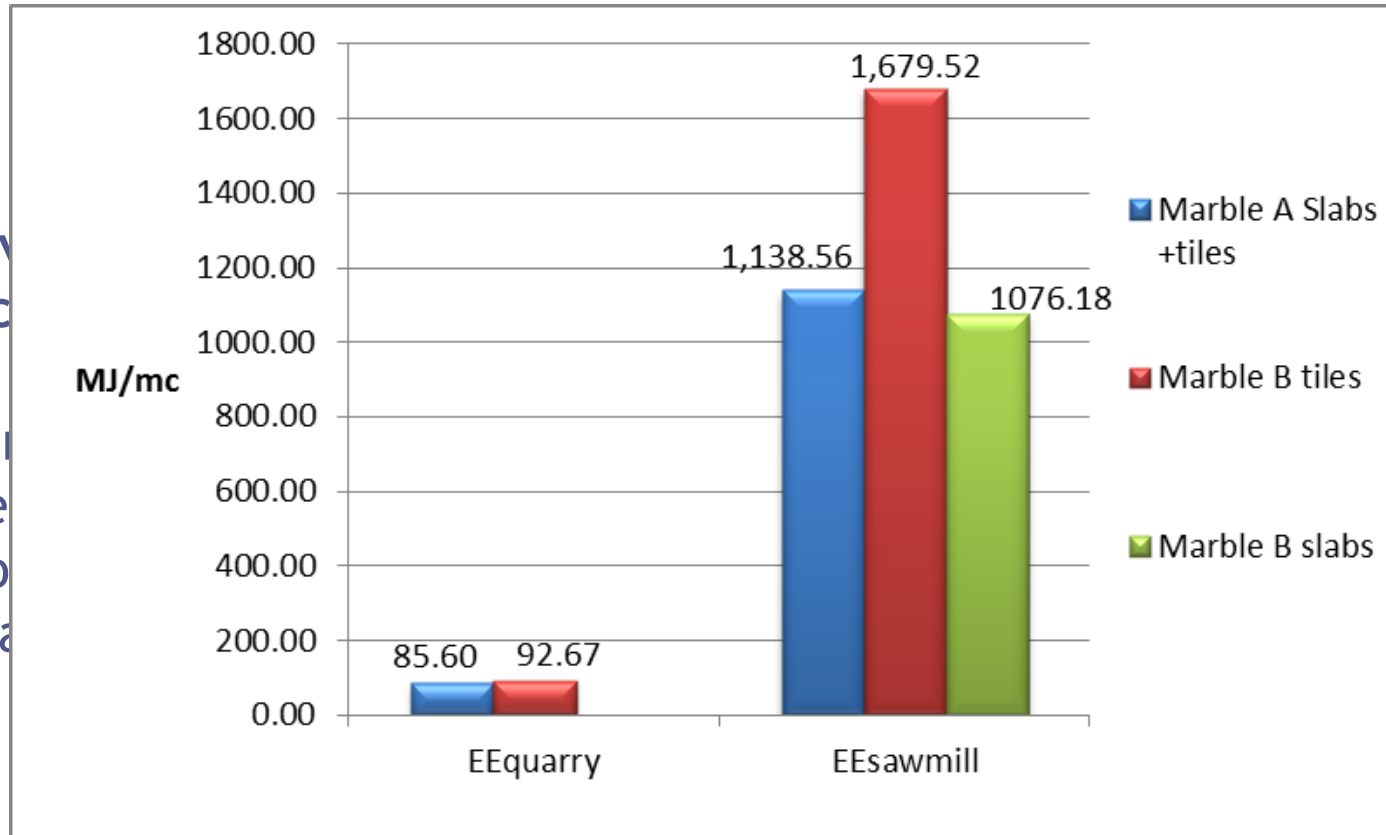


Relevant Landfills

The product life cycle from extraction material to manufacturing of product



Results of the embodied energy



Involv
sourc

- Electr
- Diese
- Explo
- Metha



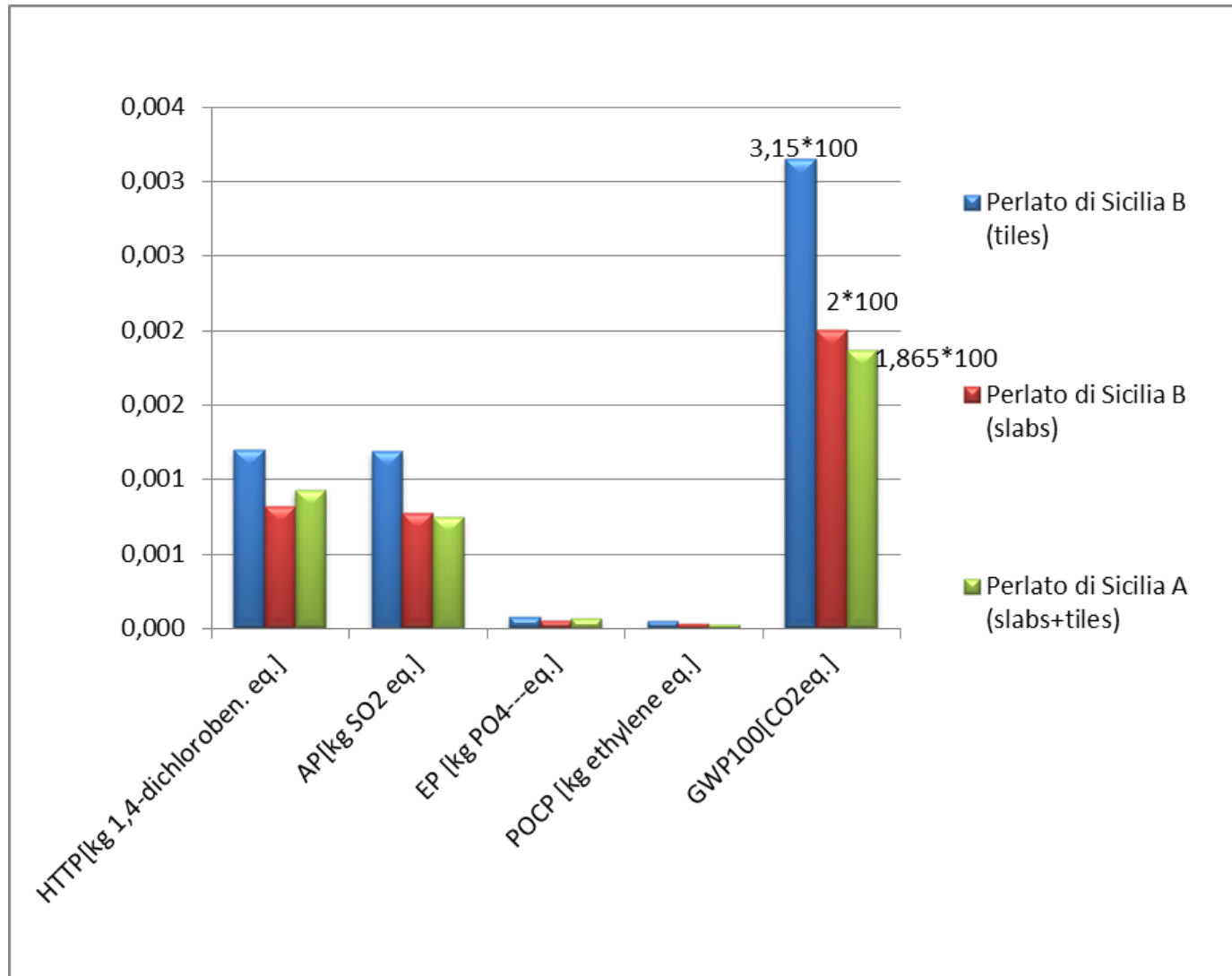
✓ Global Warming Potential (GWP₁₀₀)

✓ Human Toxicity Potential (HTTP)

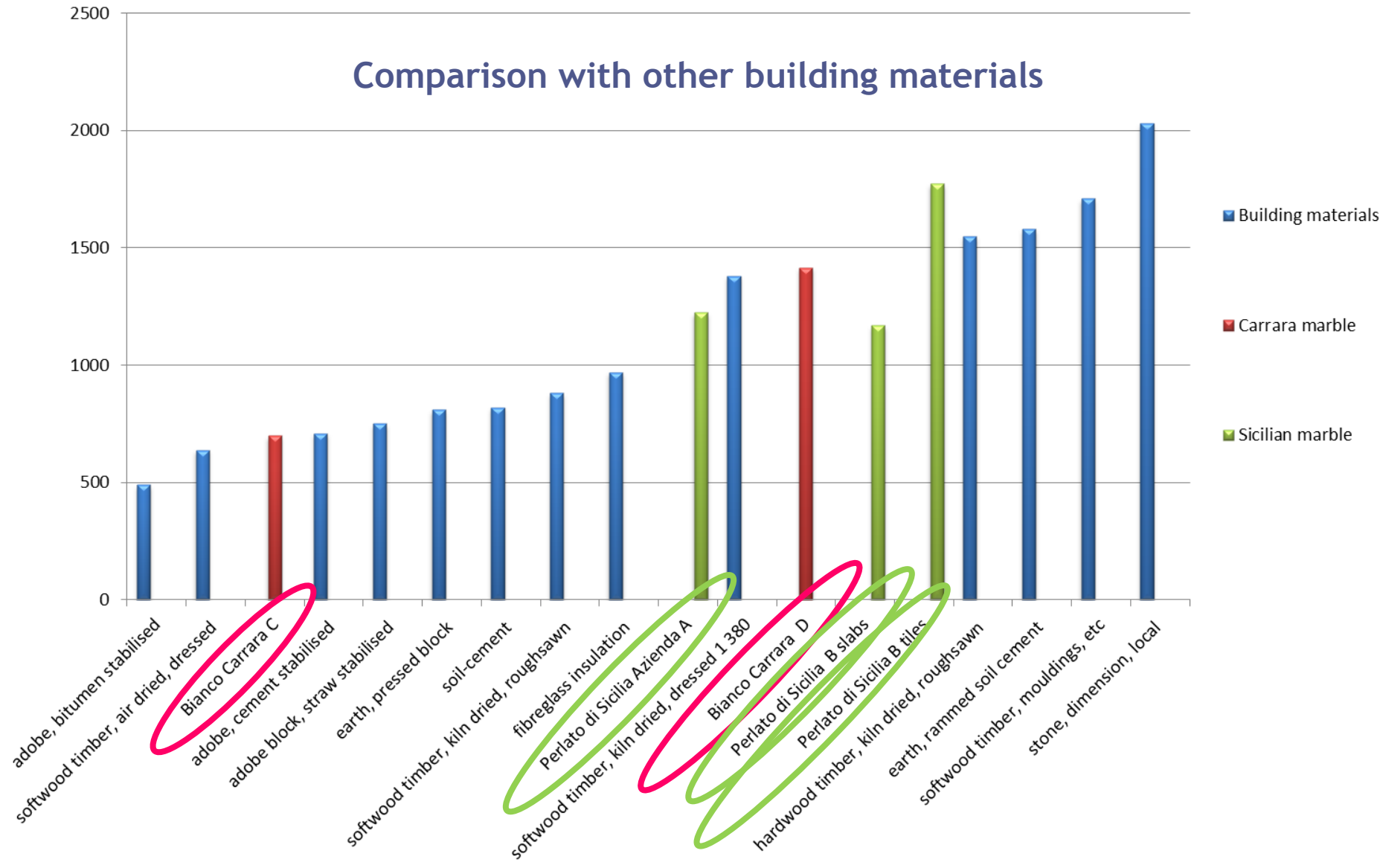
✓ Acidification Potential (AP)

✓ Eutrophication Potential (EP)

✓ Photochemical Oxidation (POCP)

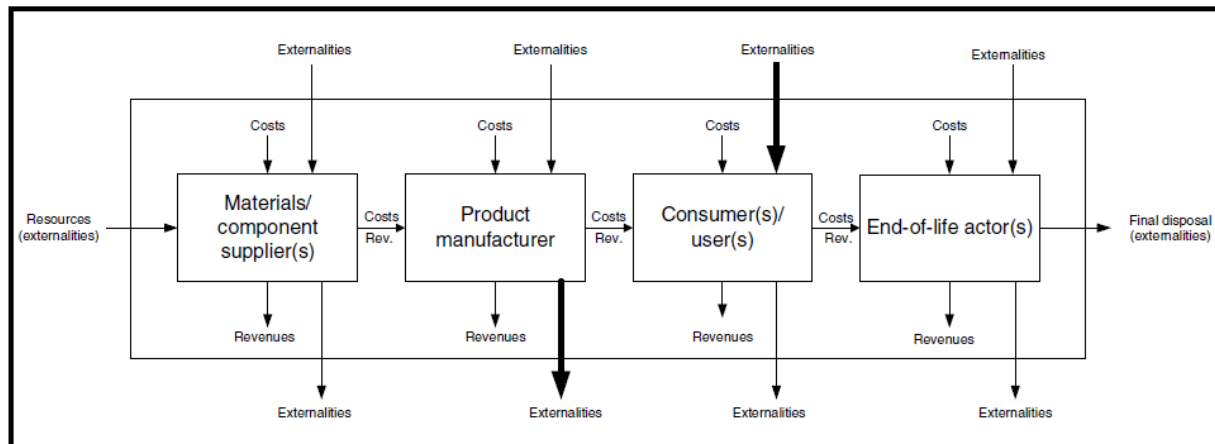



Comparison with other building materials






What about Life Cycle Costing?



 Economic system = boundaries of LCC

 Social and natural system:
boundaries of social and environmental assessment

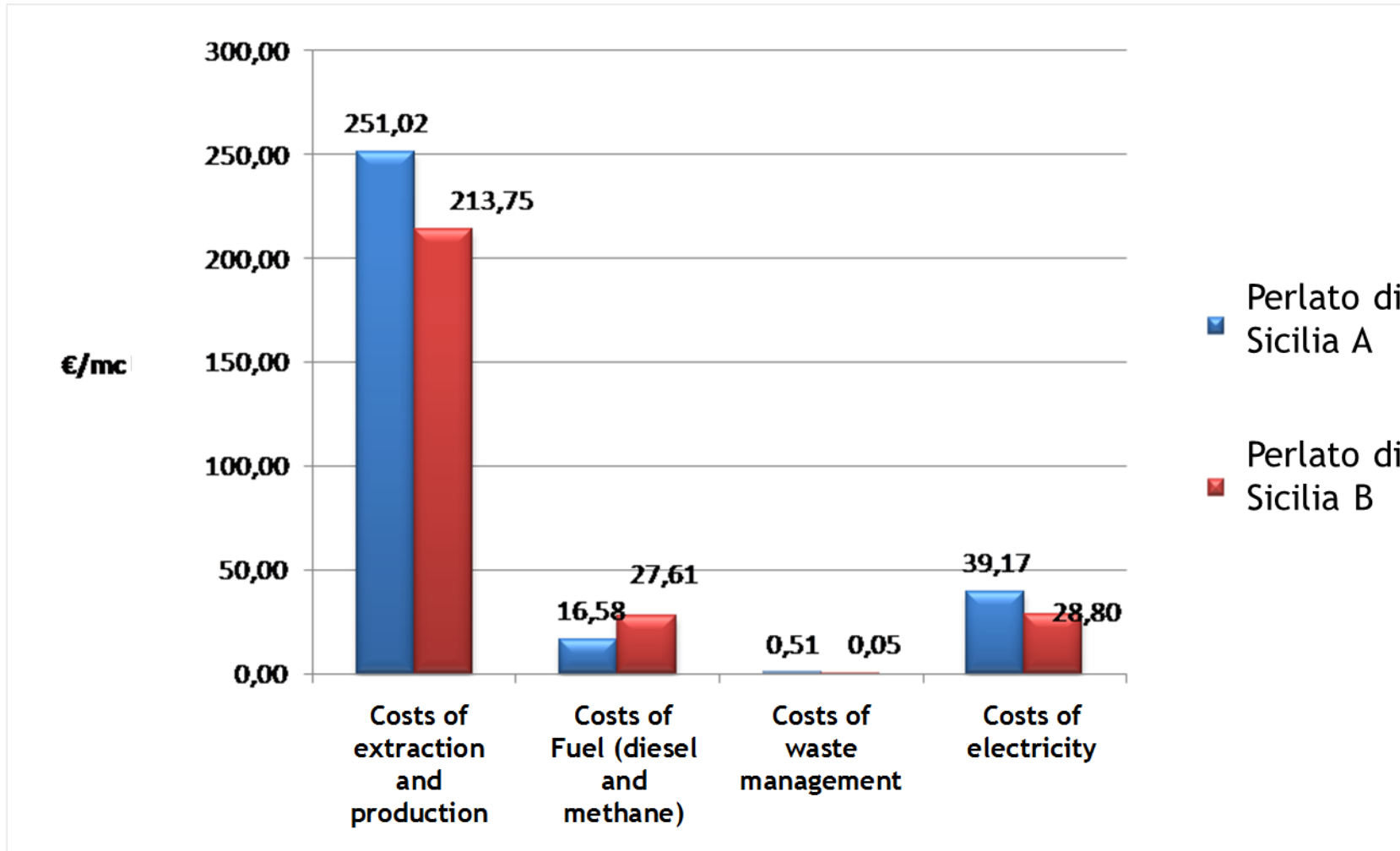


LIFE CYLCE COSTING DATA:

- Equipments
- Energy sources
- Force labour
- Cost or rent of the land
- Other taxes and expenses

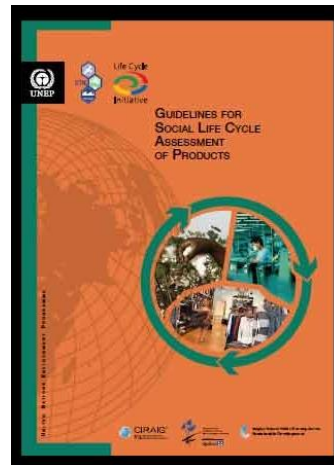
Data have been collected for all steps of the considered product life cycle

(*) Swarr, T.E. et al. Environmental Life Cycle Costing: A Code of Practice, SETAC,2011 - ISBN-10:1-880611-87-2





What about Social LCA?





- The indicators and impacts are related to the stakeholder categories;
- Indicators could be qualitative semi-quantitative, quantitative.
- Strong geographic characterization of the values and relative impacts;

| Stakeholder categories | Subcategories |
|--|---|
| Stakeholder "worker" | Freedom of Association and Collective Bargaining Child Labour Fair Salary Working Hours Forced Labour Equal opportunities/Discrimination Health and Safety Social Benefits/Social Security |
| Stakeholder "consumer" | Health & Safety Feedback Mechanism Consumer Privacy Transparency End of life responsibility |
| Stakeholder "local community" | Access to material resources Access to Immaterial resources Delocalization and Migration Cultural Heritage Safe & healthy living conditions Respect of Indigenous rights Community engagement Local employment Secure living conditions |
| Stakeholder "society" | Public commitments to sustainability Issues Contribution to economic development Prevention & mitigation of armed conflicts Technology development Corruption |
| Value chain actors* not including consumers | Fair competition Promoting social responsibility Supplier relationships Respect of Intellectual property rights |

Table 3 – Stakeholder categories and subcategories

Indicators and data considered in the SLCA



Stakeholder “worker”

| | |
|---|---|
| 1. Freedom of Association and Collective Bargaining | |
| 2. Child Labour | ✓ |
| 4. Wage | ✓ |
| 5. Working Hours | ✓ |
| 6. Forced labour | |
| 7. Equal opportunity/Discrimination | ✓ |
| 8. Health and Safety | ✓ |
| 9. Social Benefits and Social Security | ✓ |

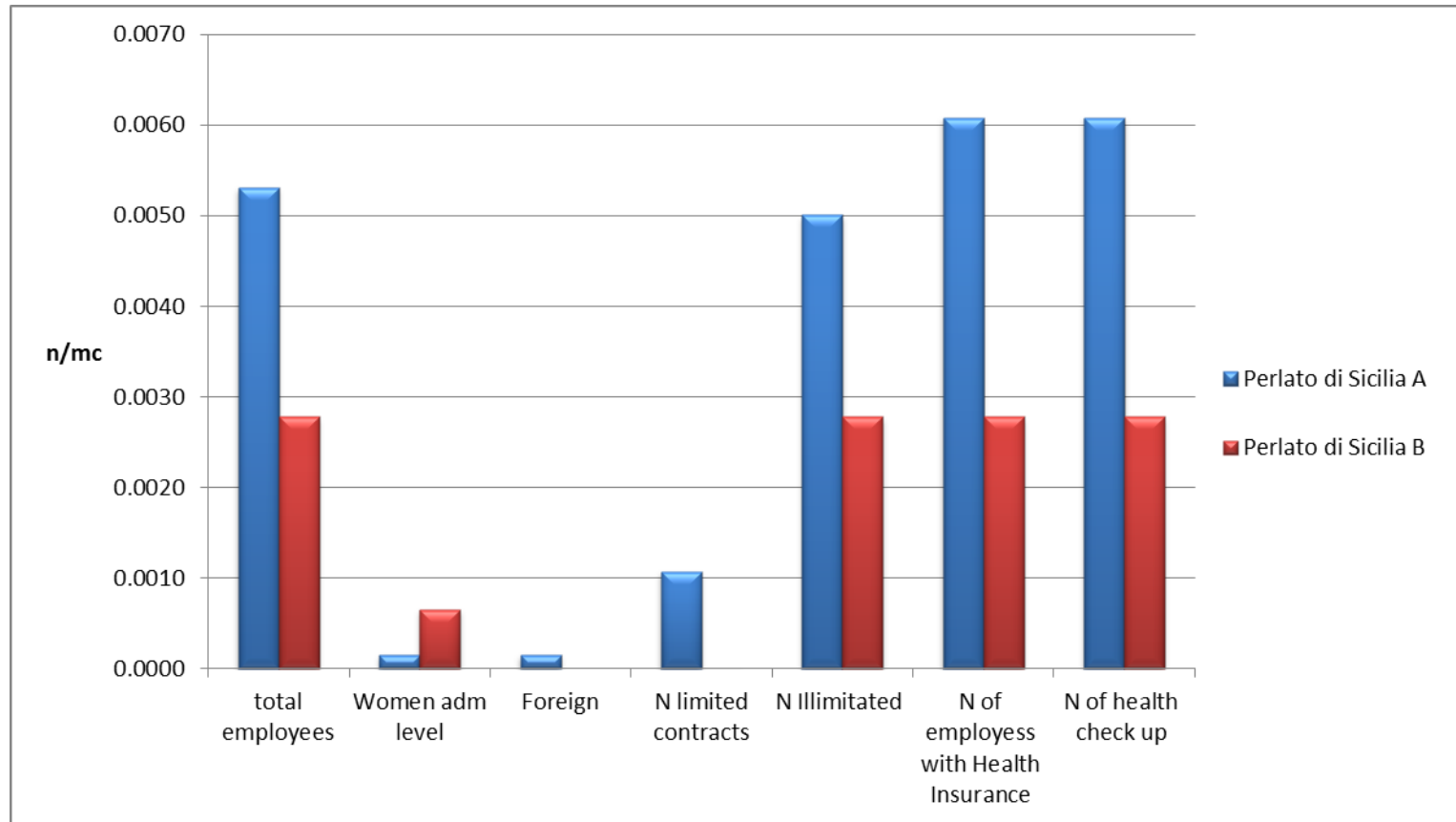




Requested and collected data:

- Number of employees, age, wage, gender, working hours;
- Kinds of the contracts
- % child labor
- % working accidents
-

Data have been collected for all steps of the considered product life cycle





- If you have more products to compare by LCSA
- If one product has better performance for some indicators and worse of others
- If you want to visualize the weak points of each product related to the others
- If you want to show the results to an non-expert audience

By direct LCSA results
it could be not easy

**A possibility is the use of Life Cycle Sustainability
Dashboard**



- According to the framework of LCSA three topics have been selected and their indicators have been considered.

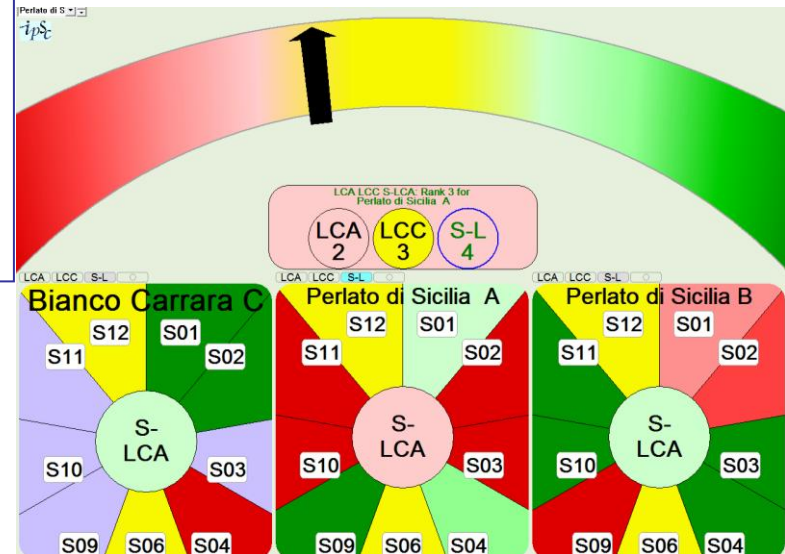
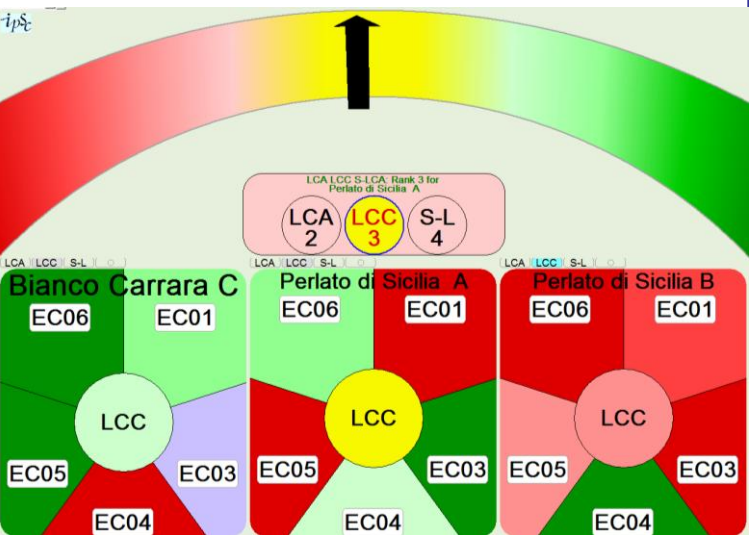
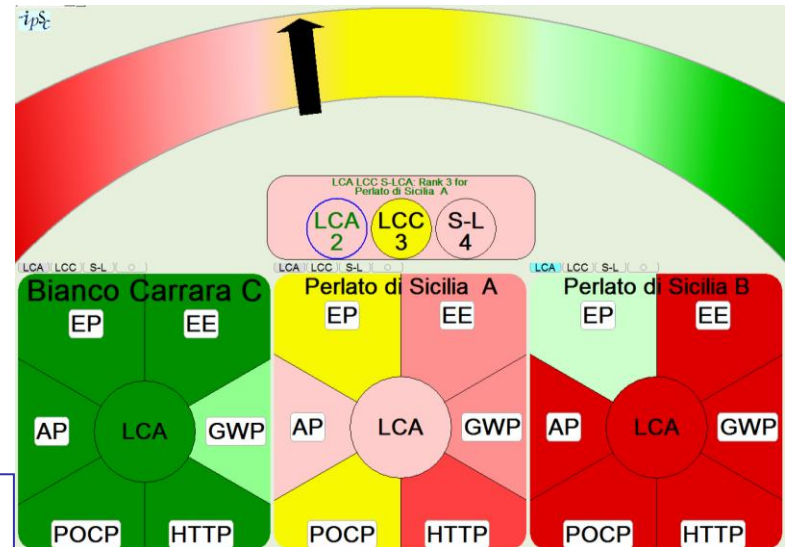
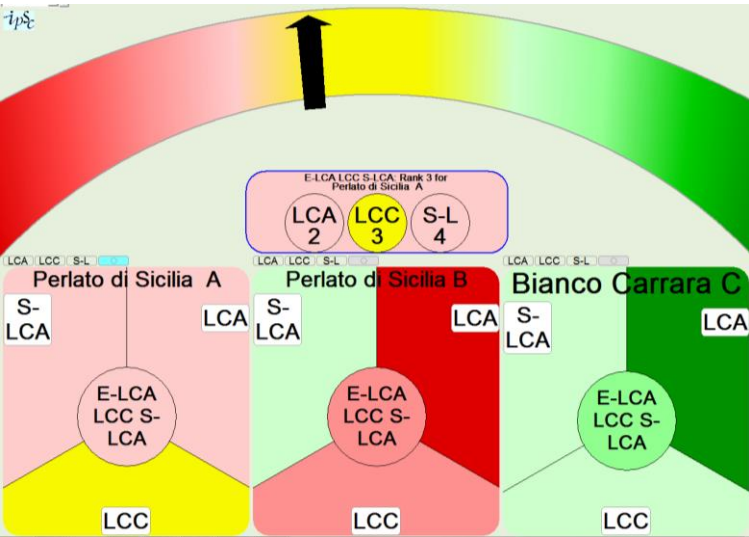
| ELCA | | | | | | | LCC | | | | | | SLCA | | | | | | |
|-----------------|--------------------------|-----------------------|-------------------------------|-------------------------|---------------------------|---------------|------------------|-------------------|------------------|--------------------|-------------------|------------------|-----------------------------------|----------------------|--|--|--------------------|------------------|-------------------|
| E01 | E02 | E03 | E04 | E05 | E06 | E07 | L01 | L02 | L03 | L04 | L05 | L06 | S01 | S02 | S03 | S04 | S05 | S06 | S10 |
| Source | Source | Source | Source | Source | Source | Source | | | | | | | | | | | | | |
| min | min | min | min | min | min | min | min | min | min | min | min | | | | | | | | |
| EE | GWP | ODP | HTPP | POCP | AP | EP | EC01 | EC02 | EC03 | EC04 | EC05 | EC06 | S01 | S02 | S03 | S04 | S05 | S06 | S07 |
| Embodied Energy | Global Warming Potential | Ozone Layer Depletion | Human Toxicity HTP Inf. | Photochemical oxidation | acidification | respirational | radiation eq. | manufacturing eq. | finishing eq. | Waste disposal eq. | Electricity Costs | Resources | Number of employees for materials | Number of franchises | Number of employees with certified control | Number of employees with limited control | Number of residual | Child Labour | Labour hours work |
| MJ/FU | CO ₂ -e/FU | kg CFC-11eq./FU | kg 1,4-dichlorobenzene eq./FU | kg ethylene eq./FU | kg SO ₂ eq./FU | kg PO4---eq. | l/m ³ | l/m ³ | l/m ³ | l/m ³ | l/m ³ | l/m ³ | n/m ³ | n/m ³ | n/m ³ | n/m ³ | n/m ³ | n/m ³ | n/m ³ |
| 1168.85 | 200.11 | | 0.53 | 0.03 | 0.77 | 0.05 | 37 | 86 | 7 | 11 | 3 | 33,198,800.00 | 0.147 | 0.005 | | 0.010 | 0.00 | | |
| 498.68 | 74.48 | | 0.30 | 0.0039 | 0.2948 | 0.0303 | 34 | 25 | 0 | 12 | 2 | 165,000,000.00 | 0.008 | 0.003 | | 0.0002 | 0.0 | | |
| 698.66 | 109.3 | | 0.37 | 0.015 | 0.425 | 0.037 | 49 | 40 | 0 | 1 | 2 | 20,300,000.00 | 0.00796 | 0.00317 | | 0.0002228 | 0.00115747 | | |
| 1414.77 | 37.4 | | 0.96 | 0.025 | 0.789 | 0.098 | 6 | 8 | 0 | n.a | 1 | 45,000,000.00 | 0.00033 | 3.56667E-05 | | 2.333E-05 | 6.1422E-06 | | |

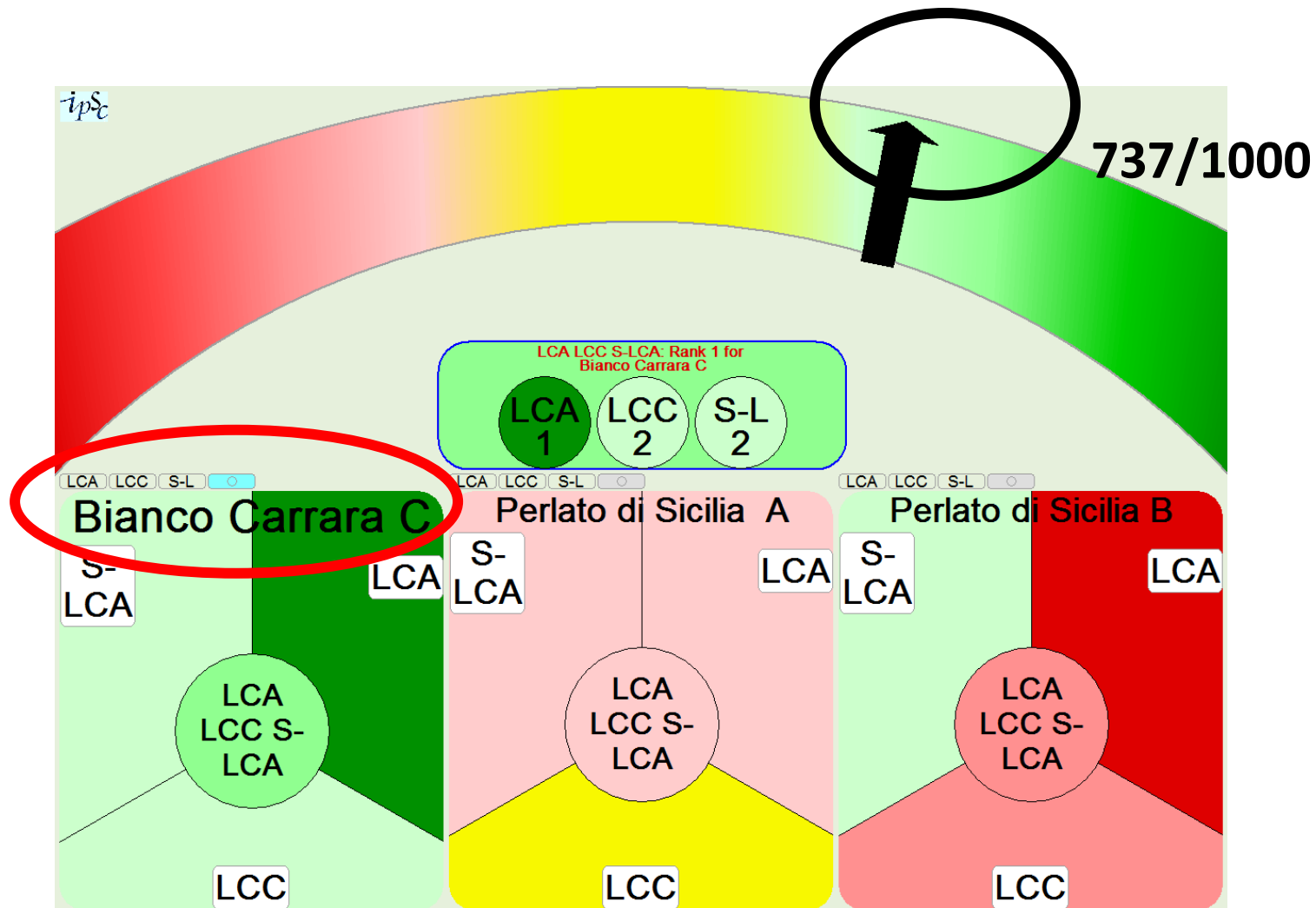


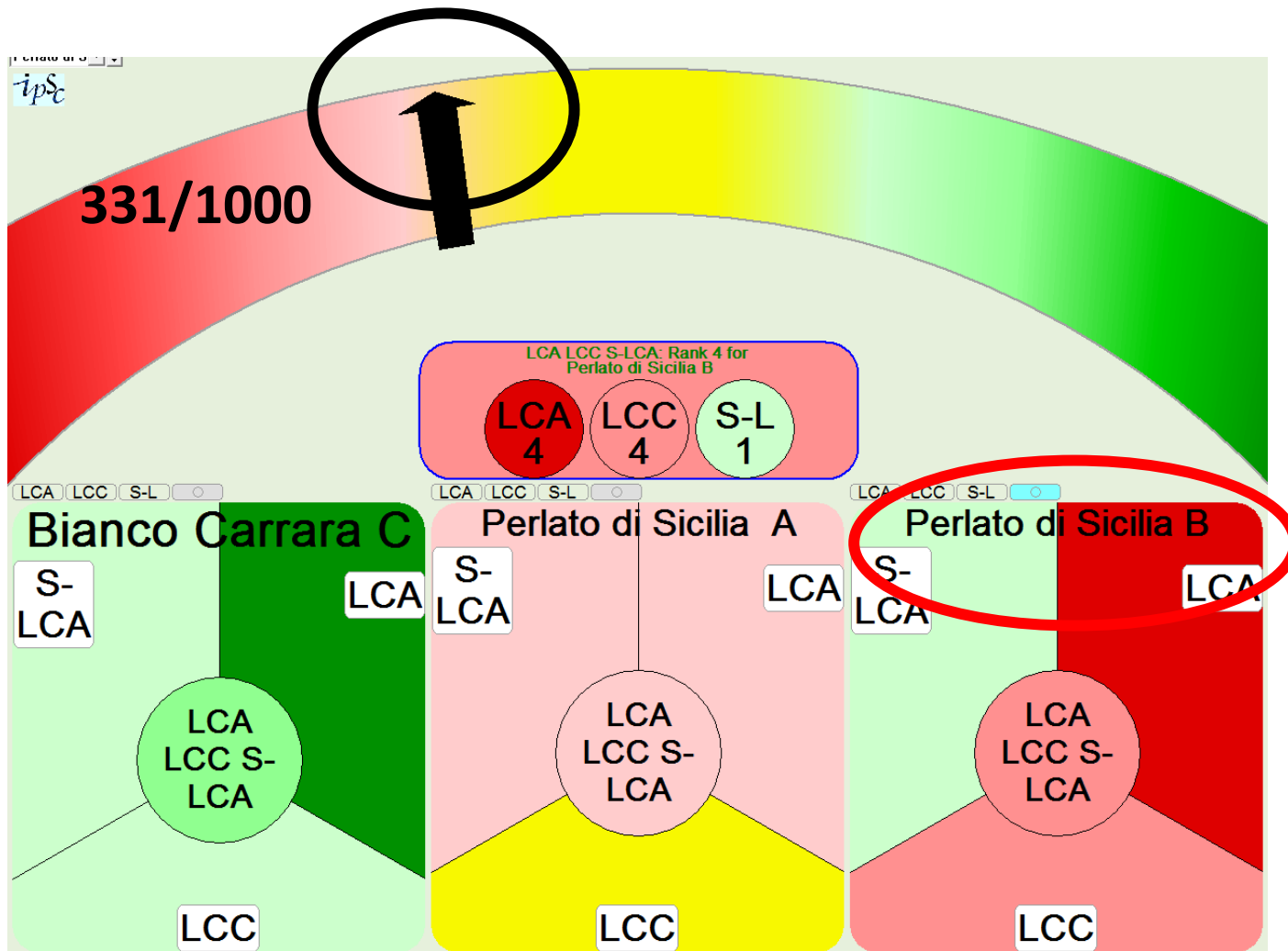
the Life Cycle Sustainability Dashboard to four types of Marble

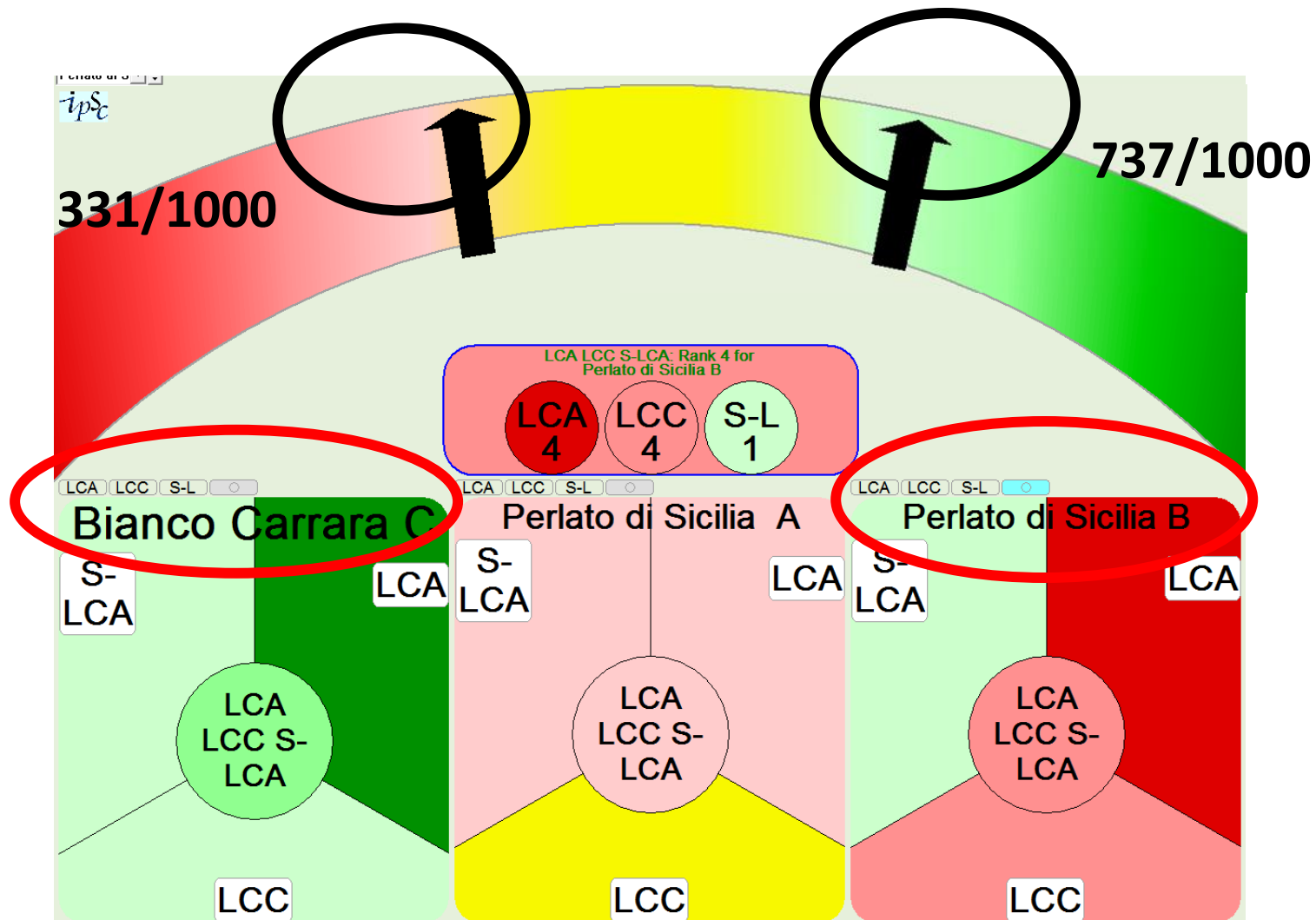
Different level to show the obtained results.

C:\DB_Circo\DB_C_IRCS.EXE











Weakness

- Several difficulties has been met for finding social data directly related to the product chain and consequently to the functional unit.
- After that the LCSD is settled down for a group of products and than supplied to the local administration, the use of the tool should be given to expert staff.
- To evaluate products, the LCSD needs numerical data, but social indicators could be qualitative and quantitative, this could lead to exclude some important indicators from the evaluation process.
- The sustainability evaluation is relative to the other products included in the database



Strengths

- The procedure manages to integrate the different aspects of sustainability for evaluating products and services: environmental, economic and social factors.
- All selected indicators are related to the same system boundary and functional unit.
- The LCSD presents the evaluation results by a graphical representation characterized by a suitable chromatic scale.
- By using graphical and ranking representation the results are more understandable for an expert and a non expert audience when the methodology is used for supporting the decision making process.
- The LCSD allows not to lose the original data that can be shown to the expert in the same time with the graphical representation.
- The ability to present the complex results of Life Cycle Sustainability Dashboard can contribute to spread the use of LCSA as a supporting tool of decision-making process.



Any question is welcome!!!

