



# Presentation 12: Analytic Decisions on Durable or Disposable Plastic Caging systems

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- New Multi Species facility (mice and rats)
- Design and Planning in Early Phase then making all options available (Disposable, Durable caging systems, with or without washing are, with or without flexible warehouse spaces, and so on).
- Objective:
  - Select the best Balance between:
    - Animal Welfare
    - Cost
    - Operational Efficiency
    - Environmental Impact
- Evaluated the suitability of both systems over the long term: 6 years
- 100% of occupancy

- New Multi Species facility
- Comparison of the following Key Performance indicators:
  - Economic Sustainability
  - Operational Functionality and Efficiency
  - Environmental Impact conducting an Environmental Assessment of each scenario using a LCA process conforming to ISO 14040 and ISO 14044.
- The Facility has a capacity of 2000 mouse cages and a minimum amount of cages to support other species (600 rat cages and metabolic cages)
- Integral cage change
- Water Bottles
- Bedding added to cages onsite

- Inflation free analysis
- A Life Cycle Analysis was conducted to evaluate the environmental impact of both systems using a specific LCA software (SimaPro or PReNL)
  - The LCA Study was conducted according to PAS 2050 and Study Results were reviewed by an independent LCA Specialist
  - The LCA included the analysis of 5 phases:
    - Materials
    - Manufacturing
    - Transport
    - Use
    - Final Disposal

# Modelling Assumption

- Complete Cage Change
- Disposable cage supplied without Bedding
- Similar cost of labor
- Similar cost of Consumables (feed, Bedding, and other supplies) with the exception of the capital and operating costs associated with repeated washing and sterilizing Durable Cages
- Additional Waste Generation and disposal, associated the use of Disposable Cages was also identified as a system specific issue (local regulation requires the handling of caging as hazardous waste)
- Final Disposal



	Durable Cages	Disposable (Single use)
<b>1: IVC CAGE &amp; RACK PURCHASE &amp; OPERATING COSTS</b>		
<b>Rack Capacity (number of cages)</b>	80	88
<b>Cost of Racks with Cages and AHU /€</b>	348,500,00	Leasing cost of €278 Euro per rack month for 3 years plus an initial payment of €1000 and a termination fee of €2,000 per rack
<b>Cost x Replacement Cages /€</b>	€100,48	€3,00
<b>Buffer Supply of cage to support Washing cycles</b>	50%	----
<b>Average Cage lifetime (year)</b>	6	----
<b>Annual Cage Breakage</b>	2%	4%
<b>Average Cage Change Interval in days</b>	11	11
<b>Complete Cage Changed x person x day</b>	240	240
<b>Labor: Number of Vivarium Technicians</b>	2.7	2.7
<b>Labor: Fully loaded cost x technician/ €/Year</b>	40.000	40.000
<b>2: WASHROOM AND OTHER COSTS/€</b>		
<b>Building Washroom Area</b>	250,000	190,000
<b>Capital Equipment – Washer</b>	€250,000	142,000
<b>Capital Equipment – Sterilizer</b>	€250,000	120,000
<b>Capital Equipment – Bedding</b>	-----	----
<b>Recurring Operating Costs</b>		
<b>Annual Maintenance/Supplies</b>	5,000	3,500
<b>Labor: Number of Washroom Staff</b>	2	1
<b>Labor: full loaded cost x technician/€/Year</b>	40,000	€40,000

DURABLE CAGING	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
<b>1.EQUIPMENT COSTS/€</b>						
Cost of Racks	348.500					
Cost of Cages	200.960					
Cost of Additional cages /€	100.480					
Annual cage breakage cost /€	0	4.000	4.000	4.000	4.000	4.000
Annual Freight Cost/€	30.000	2.000	2.000	2.000	2.000	2.000
<b>TOTAL RACK &amp; CAGE COSTS/€</b>	<b>679.890</b>	<b>6.000</b>	<b>6.000</b>	<b>6.000</b>	<b>6.000</b>	<b>6.000</b>
<b>2. WASHROOM COSTS/€</b>						
Washroom building & equip.	750.000					
Annual Washroom Operating Costs	15.000	15.000	15.000	15.000	15.000	15.000
Annual Maintenance/Supplies x Year	5.000	5.000	5.000	5.000	5.000	5.000
Annual Washroom Utilities Costs	30.000	30.000	30.000	30.000	30.000	30000
<b>TOTAL ANNUAL WASHROOM COSTS/€</b>	<b>800.000</b>	<b>50.000</b>	<b>50.000</b>	<b>50.000</b>	<b>50.000</b>	<b>50.000</b>
<b>3. LABOR &amp; COSTS/€</b>						
Vivarium technicians	2.7	2.7	2.7	2.7	2.7	2.7
Washroom technicians	2	2	2	2	2	2
<b>TOTAL LABOR COST/YEAR</b>	<b>188.000</b>	<b>188.000</b>	<b>188.000</b>	<b>188.000</b>	<b>188.000</b>	<b>188.000</b>
<b>YEARLY OPERATING COSTS/ € (1 + 2 + 3)</b>	<b>1.667.940</b>	<b>244.000</b>	<b>244.000</b>	<b>244.000</b>	<b>244.000</b>	<b>244.000</b>



<b>1. EQUIPMENT COSTS/€</b>						
Capital Cost of Racks	108.400	76.728	133.400			
Annual cage costs	207.000	207.000	207.000	207.000	207.000	207.000
Annual cage breakage cost	8.000	8.000	8.000	8.000	8.000	8.000
Cost of Waste Disposal	12.500	12.500	12.500	12.500	12.500	12.500
Cost of Packaging Waste	5.000	5.000	5.000	5.000	5.000	5.000
Freight Costs	60.000	30.000	30.000	30.000	30.000	30.000
<b>TOTAL RACK &amp; CAGE COSTS/ €</b>	<b>400.900</b>	<b>339.228</b>	<b>395.900</b>	<b>262.500</b>	<b>262.500</b>	<b>262.500</b>
<b>2. WASHROOM COSTS</b>						
<i>Washroom Building &amp; Equipment (Decon lock with generator + Autoclave)</i>	452.000					
<i>Annual Washroom Operations</i>	5.000	5.000	5.000	5.000	5.000	5.000
<i>Annual Maintenance/Supplies x Year</i>	3.500	3.500	3.500	3.500	3.500	3.500
<i>Annual Washroom Utilities</i>	7.500	7.500	7.500	7.500	7.500	7.500
<b>TOTAL ANNUAL WASHROOM COSTS/€</b>	<b>468.000</b>	<b>16.000</b>	<b>16.000</b>	<b>16.000</b>	<b>16.000</b>	<b>16.000</b>
<b>3: LABOR COSTS</b>						
Vivarium technicians	2.7	2.7	2.7	2.7	2.7	2.7
Washroom technicians	1	1	1	1	1	1
<b>TOTAL LABOR COST/€</b>	<b>148.000</b>	<b>148.000</b>	<b>148.000</b>	<b>148.000</b>	<b>148.000</b>	<b>148.000</b>
<b>TOTAL ANNUAL OPERATING COSTS/€ (1 + 2 + 3)</b>	<b>1.016.900</b>	<b>503.228</b>	<b>559.900</b>	<b>426.500</b>	<b>426.500</b>	<b>426.500</b>

# Durable vs Disposable Caging Systems

## 6 Years Cash Flow Statement Comparison

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6
<b>ANNUAL DISPOSABLE SAVING/LOSS</b>	<i>651.040</i>	<i>- 259.228</i>	<i>-315.900</i>	<i>-182.500</i>	<i>-182.500</i>	<i>-182.500</i>
<b>CUMULATIVE DISPOSABLE SAVING/LOSS</b>	<i>651.040</i>	<i>391.812</i>	<i>75.912</i>	<i>-106.588</i>	<i>-289.088</i>	<i>-471.588</i>

# Discussion of comparative Capital & Operating Cost Analysis I

## Washing and

- It is not possible to wash and sterilize the cage required
  - In Addition to the new facility operation support a cage wash facility would be required
  - This means that the cage wash facility would be cost effective at Year 4.
- Results:
- Use of Disposable caging system delivers marginal savings in both capital and operating costs associated with washing and sterilizing operations.
  - Use of Durable caging system begins to be cost effective at Year 4.
- Using a Disposable system would not entirely eliminate the construction and equipment costs associated with a cage wash facility

# Discussion of comparative Capital & Operating Cost Analysis II

## Storage Space

- Disposable Cages require **additional separate storage space** to hold stocks

### Results:

- At best the facility footprint and equipment requirements would be similar for either system, though the **need to provide additional storage space** to hold stock of clean storage weather
- Disposable Cages (**60m<sup>2</sup>**) plus space for storage of soiled extra 20 cages (**20m<sup>2</sup>/day**) before disposal could potentially increase the total space required.

- Labor:

- Disposable Cages **do reduce labor** input in the washing area but **increase labor** for

### Results:

- Disposable cage system **reduce the staffing level** (from 2 to 1 in the washing area) and associated labor costs; however, **additional labor costs** associated with repeated reception, storage and handling of new and soiled cages **reduces** the overall savings in labor of only about 40.000 Euro/Year



- Washroom operating Costs: Utilities

## Results:

The Disposable System **reduce but do not eliminate**:

- the operating costs
- Capital costs (Washroom construction and equipment

Financial Modeling and operational analysis of the facility operations showed that Disposable Cages produced marginal reductions in the cost of utilities associated with washing and sterilizing equipment and materials

there remain the need to decontaminate the exterior of the packaging prior to introduction into the barrier

- Cage Management and Transportation
  - Single use cages **increase both the amount of waste generated** at the reception (packaging) and the amount of waste at exit level, doubling the amount of material entering and exiting.
  - This is not balanced by the reduction in time associated with washing and autoclaving durable cages.
  - Gains of the elimination of internal transport of racks and cages to and from the cage washer are offset by increased inventory management and clean/dirty disposable handling.
- Cage Change Interval
  - The cage change interval is a variable with a major impact on the comparative operating costs between Durable (number of washing cycles) and Disposable caging system (number of cages used).
- Operating Costs: maintenance costs
  - As it would be necessary to retain a washing/Sterilizing area these costs would only be marginally reduced with the use of Disposable caging.

## Discussion on Operating Costs III

Italian Waste Disposal Regulations **require that soiled bedding must be treated as clinical waste** and must be packaged, sealed and incinerated at a cost of Euro 1,00/Kg. Disposable cage tend to have bedding with higher humidity which will likely increase the weight of waste bedding further increasing disposal costs.

On the other hand **Durable cages do not generate** significant plastic waste with a life span of 6 years and a low breakage rate. Moreover at the end of their useful life, Durable cages can be decontaminated and sold on through **local recycling** programs to be reprocessed into granules.

One Kg of recycled plastic represents about 19 Kg of avoided CO<sub>2</sub> in the atmosphere

Recycled plastic is valued between 1 euro and 1.5 euro per Kg

# Environmental Impact of Durable & Disposable cages

## LCA Results:

LCA analysis showed that both energy and material consumption of

LCA Modelling of the facility showed that Disposable Caging would have produced more than 9 tons/year of CO<sub>2</sub> compared with only 0.4 Tons with the Durable caging System (a reduction of 96% in CO<sub>2</sub> emissions)

Cage Type	ENERGY (MJ)
DURABLE	983
DISPOSABLE	2245

# Carbon foot Print of Durable & Disposable cages

LCA and Carbon foot Print analysis data show that the Durable cages scored significantly lower in all environmental impact categories than the Disposable cages, even where Durable Cages are repeatedly washed and sterilized.

	Durable Cages		Disposable Cages	
	# Cage Units	Quantity of CO <sub>2</sub>	# Cage Units	Added Units
CO <sub>2</sub> Footprint	2.200	797.4 tons	396.000	55.476 tons
CO <sub>2</sub> Saved with Recycling 2	2.160	( - 42 tons)	-----	-----
Net CO <sub>2</sub> Footprint		<b>755.00 Tons/CO<sub>2</sub></b>		<b>53,064.00 Tons/CO<sub>2</sub></b>



# Conclusions

## Durable vs Disposable cages

- The decision regarding the which is the most suitable caging system for this specific facility is **influenced by a number of factors**. This will include: research demands, economic/operational efficiency and sustainability options. At the end

Objective comparisons between different products for similar uses in research facilities can be complex and errors can be potentially costly. Different animal care system models and alternative scenarios will generate different outcomes. This case study **show the importance of developing and using a combination of Key Performance Indicators (KPI), Financial modeling and Life Cycle Assessment**, during the planning of the facility to identify and analyze options and support objective decisions that otherwise would be subjective in nature

- **ENVIRONMENTAL IMPACT:** the most interesting data. We wanted to identify the system that not only provides efficient performance and effective return of investment but also safeguards the environment. **LCA showed that Disposable cages would have a greater environmental impact due to energy and CO<sub>2</sub> production.**

«Conditio sine qua non»: we think Single Use Cage are important and essential for safety, effectiveness, quality and first choice and we have adopted in the following applications:



Disposable  
Retrofittable on GM500 racks  
Recyclable in case

Contingency  
Housing

Transport

Quarantine as  
IVC retrofittable  
on existing Racks

Satellite  
Facilities or  
Biotech StartUp

Hazardous  
Researches  
- Irradiation  
- Infective Disease



# Conclusions Durable vs Disposable cages



*Decisions on Durable  
or Disposable Plastic Caging Systems*

**Abstract**  
The following case study describes a decision making process to evaluate the impact of utilizing either a reusable (Durable) or single use (Disposable) ventilated caging system in a new multi-species facility being constructed for the Mario Negri Institute for Pharmacological Research, located in Bergamo, Italy. The basis of the decision making process was the development and comparison of the following key performance indicators; economic sustainability, operational functionality and efficiency, and environmental impact. It was assumed there was no obvious difference in animal welfare between the two systems and so this was not considered in the evaluation. The facility has a capacity of 2000 mouse cages, which were the focus of the study. Facility operating protocols dictated the need for changing the complete cage with each cage change, the use of water bottles, and that bedding is added to cages onsite. It was determined a minimum amount of cage processing would be required to support other species and that all materials entering the facility would require chemical decontamination. The location of the facility limited the availability of options for recycling Disposable caging and local regulations requires the handling of caging as hazardous waste. Equipment, space, and operating costs for each system were developed into cash flow statements and an incremental cash flow comparison developed. A review of the operational impacts related to material handling flows, cage change operations, and biosecurity were conducted. An environmental assessment of each scenario was conducted using a Life Cycle Assessment (LCA) process conforming to ISO14040 and ISO14044. Economic indicators demonstrated short-term gains with the use of Disposable caging due to reductions in initial capital costs. Higher long-term operational costs associated with Disposable caging reduced initial capital savings and in Year 4, the two systems were at a breakeven point with further cumulative losses in subsequent years. Operational impact analysis demonstrated no significant space savings or labor savings and additional operational complexities were associated with the frequent delivery and entry of materials to the facility. Results of the environmental impact analysis demonstrated Durable cages produced 50% of the carbon footprint over its entire useful life when compared with Disposable caging. With Durable caging scoring higher on all three key performance indicators it was concluded that Durable caging provided the best solution to the specific functional and operational characteristics of the new facility.

**1. Background**  
New developments in technology and equipment are major considerations when planning new facilities. During the design and planning phases for an additional multi-species research animal facility in Bergamo, Italy, we aimed to evaluate rodent caging options currently available on the market with the goal of selecting the best balance between animal welfare, cost, operational efficiency and environmental impact. The new multi-species facility would have a capacity of approximately 2000 mouse cages and 600 rat cages. The project was in early design making all options available including Disposable or Durable caging systems, used with or without washing facilities, with or without

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In case of interest:

A complete White Paper has been published

Do not hesitate to contact us!

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## VOEN Analytics Conference 2018

### Impact Summary



**Title:** Analytic Decisions on Durable or Disposable Plastic Caging Systems

**Problem and analysis method:** a decision making process to evaluate the impact of utilizing either a reusable (Durable) or single use (Disposable) ventilated caging system in a new multi-species facility. The basis of the decision making process was the development and comparison of the following key performance indicators; economic sustainability, operational functionality and efficiency, and environmental impact

**Summary:** A review of the operational impacts related to material handling flows, cage change operations, and biosecurity were conducted. An environmental assessment of each scenario was conducted using a Life Cycle Assessment (LCA) process conforming to ISO14040 and ISO14044.

#### Impact of the analytics study

**Decisions made/Actions Taken:** A Durable caging System was selected

#### Calculated or actual Improvements:

**Economic Reasons:** *Financial modeling over a 6 year life cycle showed a decreasing cost/ benefit from in the use of Disposable versus Durable caging. The reduction in savings occur from the second year forward, even when the cost of replacement of Durable cages is factored in and inflationary factors are excluded from the costs of Disposable cages. Transport was responsible for 7-8% of the cost. Initial savings from Disposable cages are eroded by year 4. After 6 years there is a recurring annual loss of approximately € 500.000*

**Operational Efficiency and Functionality:** *operations and flexibility are better supported where facilities for cage washing and sterilization/autoclaving are available. Potential capital and operating cost savings in cage wash processes from using Disposable cages were reduced by the necessity to retain cage wash and autoclaving facilities. Regular receiving of Disposable cages, increased waste disposal, additional storage facilities, materials handling and increased labor add to the operational complexity of the facility.*

**Environmental Impact:** *Life Cycle Assessment of both systems showed that Disposable cages would have a greater environmental impact due to energy and CO2 production during manufacture, transport, disposal/recycling and volume of waste generated. Durable cages have a lower environmental impact and CO2 footprint, even though they need to be washed and autoclaved regularly*

**Cost avoidance:** *Cumulative loss of 471.000 Euro of Disposable Caging System after 6 year operations*





# THANK YOU!

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Leopoldo ZAUNER

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