Using Life Cycle Analysis to Evaluate the Environmental Benefits of Using Biocidal Medical Garments

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UC Davis

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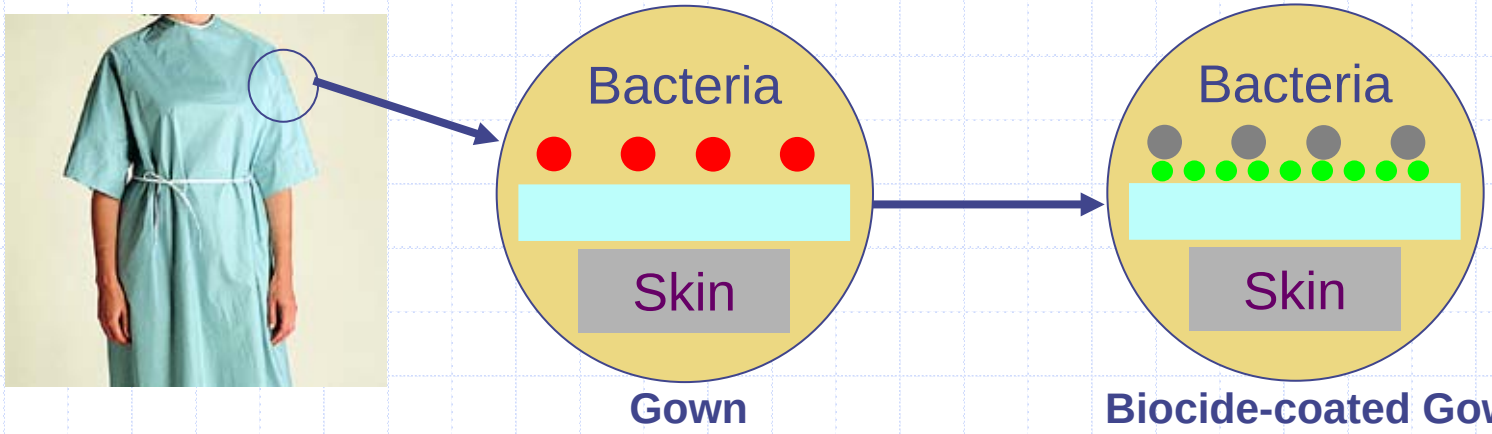
Biocidal Medical Garment

- Part of an interdisciplinary team assessing performance, environmental impact, health risk reduction impact, and social factors regarding material choice of healthcare garments
- NSF-MUSES: Health Protective Textiles: Bridging the Disposable/Reusable Divide

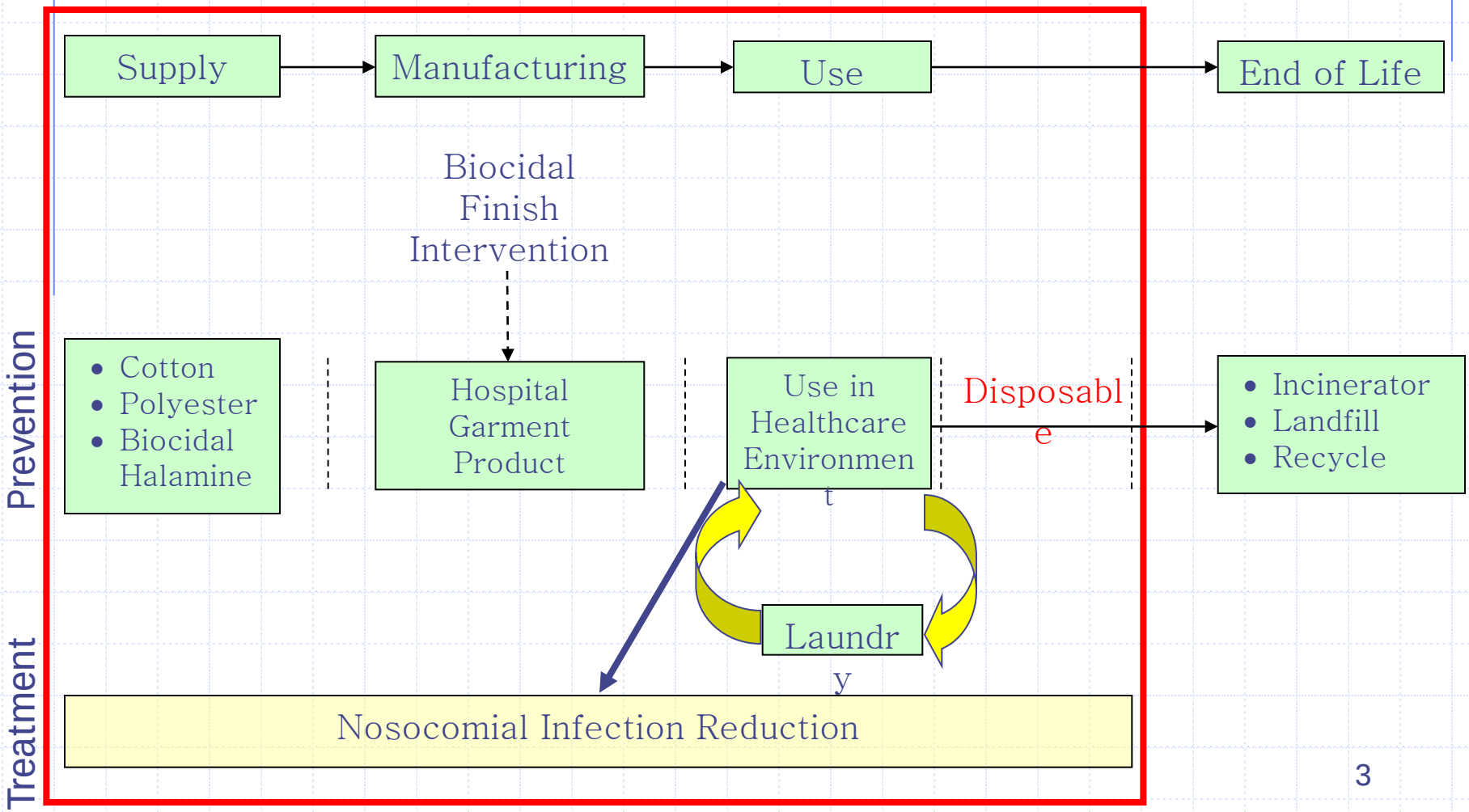
NC STATE UNIVERSITY UCDAVIS UNIVERSITY OF CALIFORNIA Berkeley

- Use life cycle inventories to show the possible environmental benefits of using reusable biocidal healthcare garments



Gown **Biocide-coated Gown**

Project Scope



Life Cycle Inventory

- Backbone of the Life Cycle Assessment
- Quantifies the full range of environmental impacts of a product over its complete life
- Goals are technical clarity and accuracy, transparency, ability to be modified, and streamlining with technical accuracy
- Need
  - Inputs
  - Outputs/products
  - Chemical or material losses
  - Energy requirements

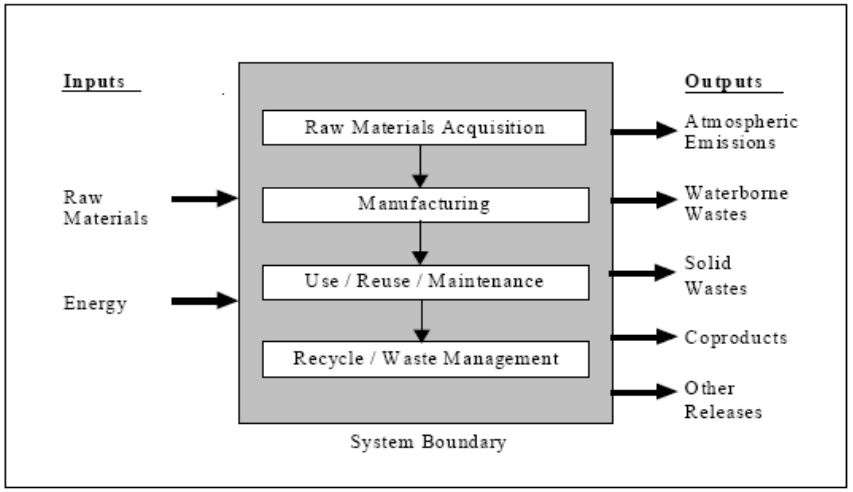


Exhibit 1-1. Life Cycle Stages (Source: EPA,1993)

Methodology

- Research and Collect Data
- Generate Detailed Process Flow Diagram (mass flows and process conditions)
- Calculate Mass & Energy Balances (Excel)
- Generate LCI Report (MS Word)
- Review Process
- Repeat for all Chemicals in Supply Chain

Infection Treatment

- Select General Infection
  - MRSA (Methicillin-resistant Staphylococcus aureus)
- Select Treatment Protocol
  - Vancomycin hydrochloride
- Obtain Infection Treatment Methodology
  - Testing frequency
  - Isolation Procedure
  - Drug Therapy

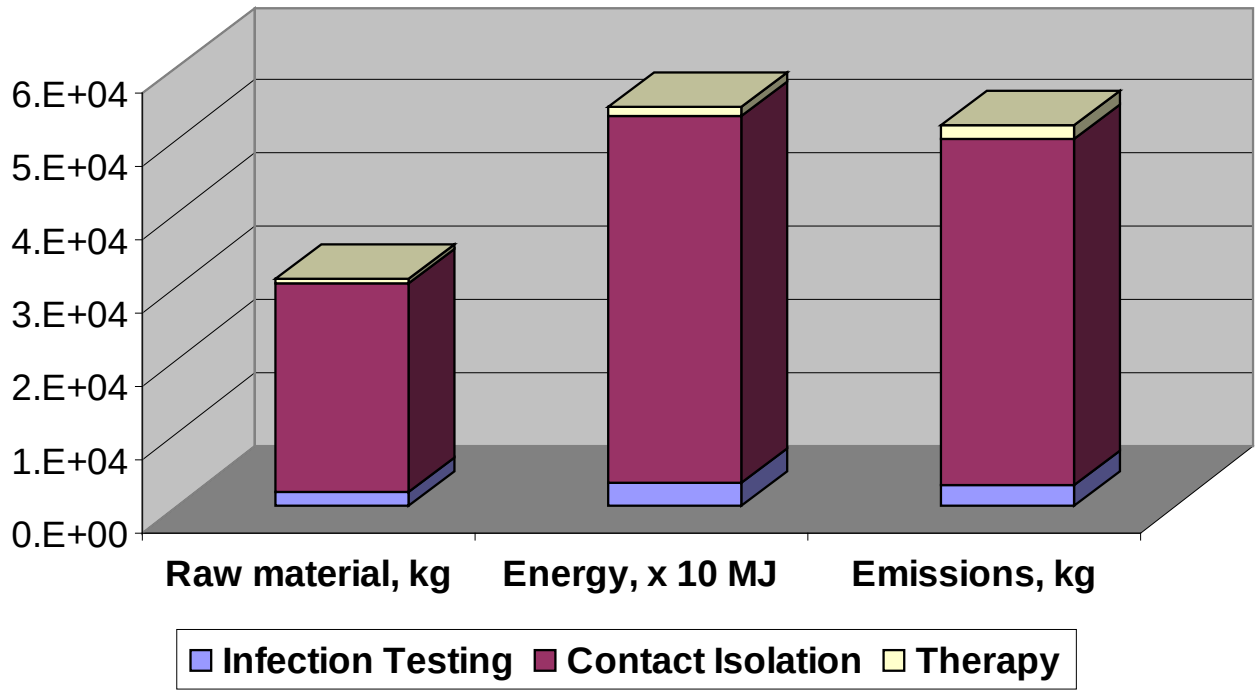
Materials Used to Treat 1 Infection

	Item	Units	Total Mass
Infection Test	MH Agar Plate	3 units	134 g
	Gloves	9 pairs	134 g
	Disposable Gown	9 units	540 g
Treat (Contact Isolation)	Gloves	210 pairs	3129 g
	Disposable Gown	140 units	8400 g
Treat (Therapy)	Vancomycin	20 g	20 g
	Polyvinyl chloride IV Bag	20 units	141 g

Chemical Tree for Treating Infection

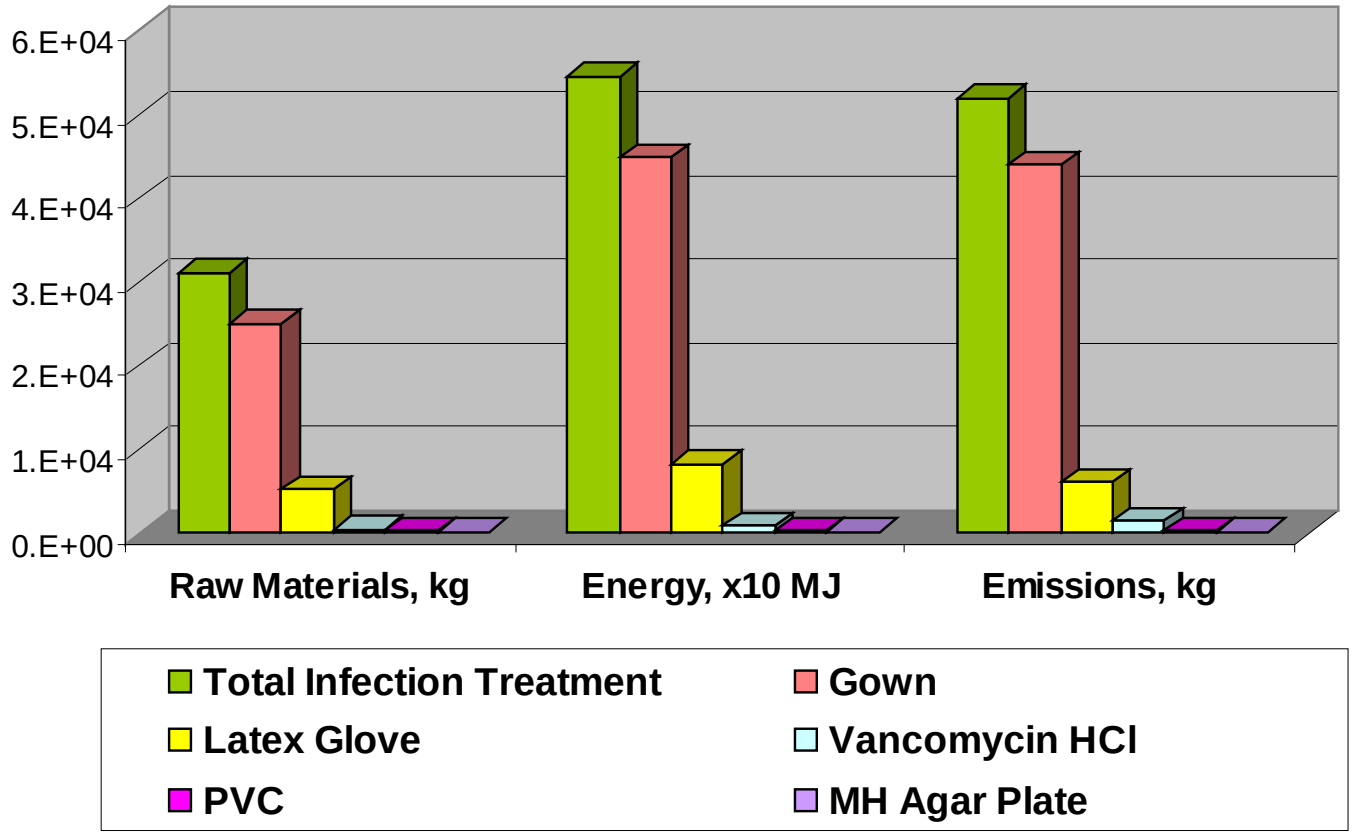
Level 1	Level 2	Level 3		Natural Resources
Infection Treatment	Latex Glove	Corn starch	93 chemicals	Air, Coal, Crude Oil, Gelidium, Natural gas, Phosphate rock, Salt rock, Sand, Soybean seed, Sylvinite ore, Water
		Styrene Butadiene Latex	25 chemicals	
	MH Agar Plate	Agar	25 chemicals	
		Casein hydrolysate	287 chemicals	
		Petri Dish	13 chemicals	
	PVC IV Bag	Vinyl Chloride	15 chemicals	
	SMS Gown	Polypropylene SMS Fabric	4 chemicals	
	Vancomycin HCl	Ammonia	8 chemicals	
		Ammonium chloride	22 chemicals	
		Dextrose	108 chemicals	
		Isopropanol	15 chemicals	
		Soy Flour	99 chemicals	
		Urea	18 chemicals	

Environmental Profile for Infection Treatment (1.7 million infections per year)



Contact isolation step consumes most resources and generate most emissions

Environmental Profile for Infection Treatment



Disposable gown and glove use consume most resources and generate most emissions

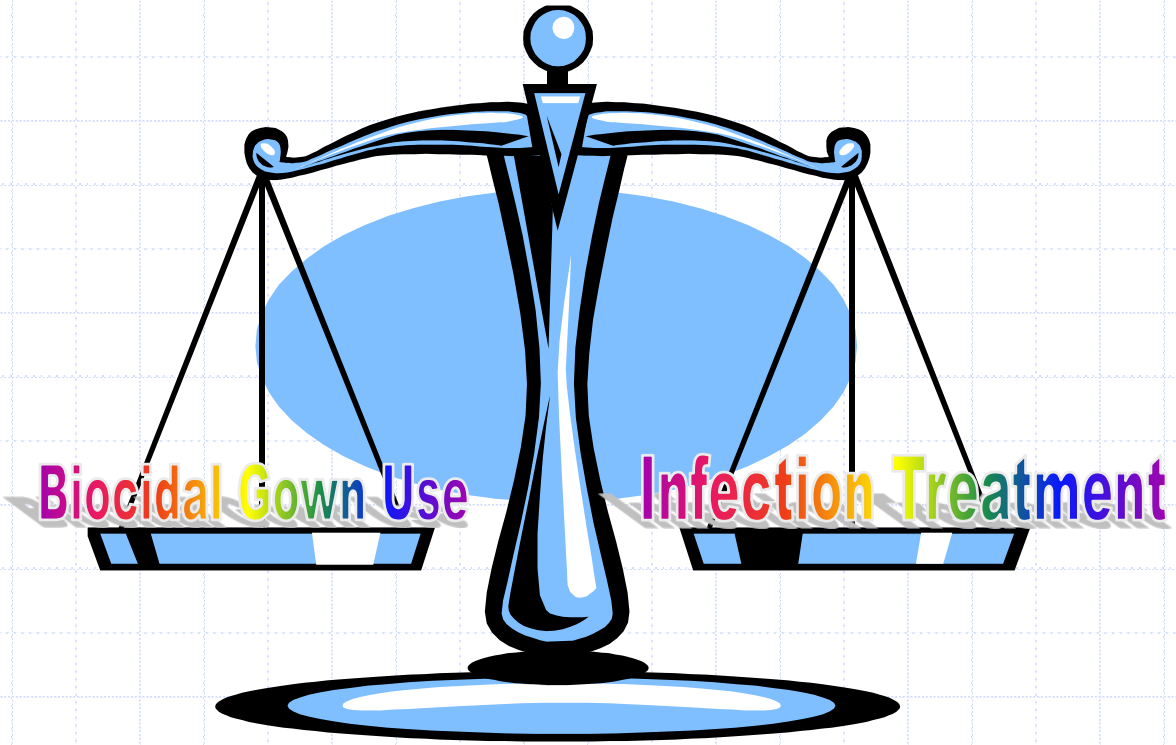
CTG Infection Treatment Energy

		CTG Energy, MJ/1000 Infections Treated							
Chemicals	**Mass, kg**	**Electricity**	**Dowtherm**	**Steam**	**Non-transport**	**Transport**	**Potential recovery**	**Total net energy**	**% of Total**
PP SMS Fabric	9,449	16,532	184,135	490		4,157		205,314	**37.6%**
Propylene	9,885	14,047		23,381	114,427	4,349	-27,969	128,234	**23.5%**
Polypropylene	9,576	80,298		689		4,214	-6,914	78,286	**14.4%**
Naphtha	13,485	3,223		1,510	26,592			31,325	**5.7%**
Styrene	2,110	77		11,044	65,617	929	-60,215	17,452	**3.2%**
C4 stream	1,129	1,604		2,670	13,065	497	-3,194	14,642	**2.7%**
PP SMS Gown	8,940	7,138		2,602		3,934		13,673	**2.5%**
Styrene butadiene latex	3,215	470		13,541		1,415	-4,079	11,347	**2.1%**
Ethylene	642	912		1,518	7,432	282	-1,816	8,328	**1.5%**
pyrolysis gas	455	647		1,077	5,269	200	-1,288	5,904	**1.1%**
1,3-butadiene	1,122	8		5,963		494	-1,387	5,078	**0.9%**
Vancomycin HCl	20	474		4,961		9	-970	4,474	**0.8%**
reformate, from naphtha	1,117	18	926	553	4,209	492	-1,787	4,411	**0.8%**
Benzene	1,568	1		4,085		690	-1,253	3,523	**0.6%**
Latex Glove	3,263	36		1,572	243	1,436		3,286	**0.6%**
Ethylbenzene	2,111	132		3,738		929	-1,915	2,883	**0.5%**
Dextrose	242	11		2,904	17	106	-162	2,877	**0.5%**
Total energy		126,479	185,061	84,372	238,936	24,965	-114,358	545,456	**100.0%**

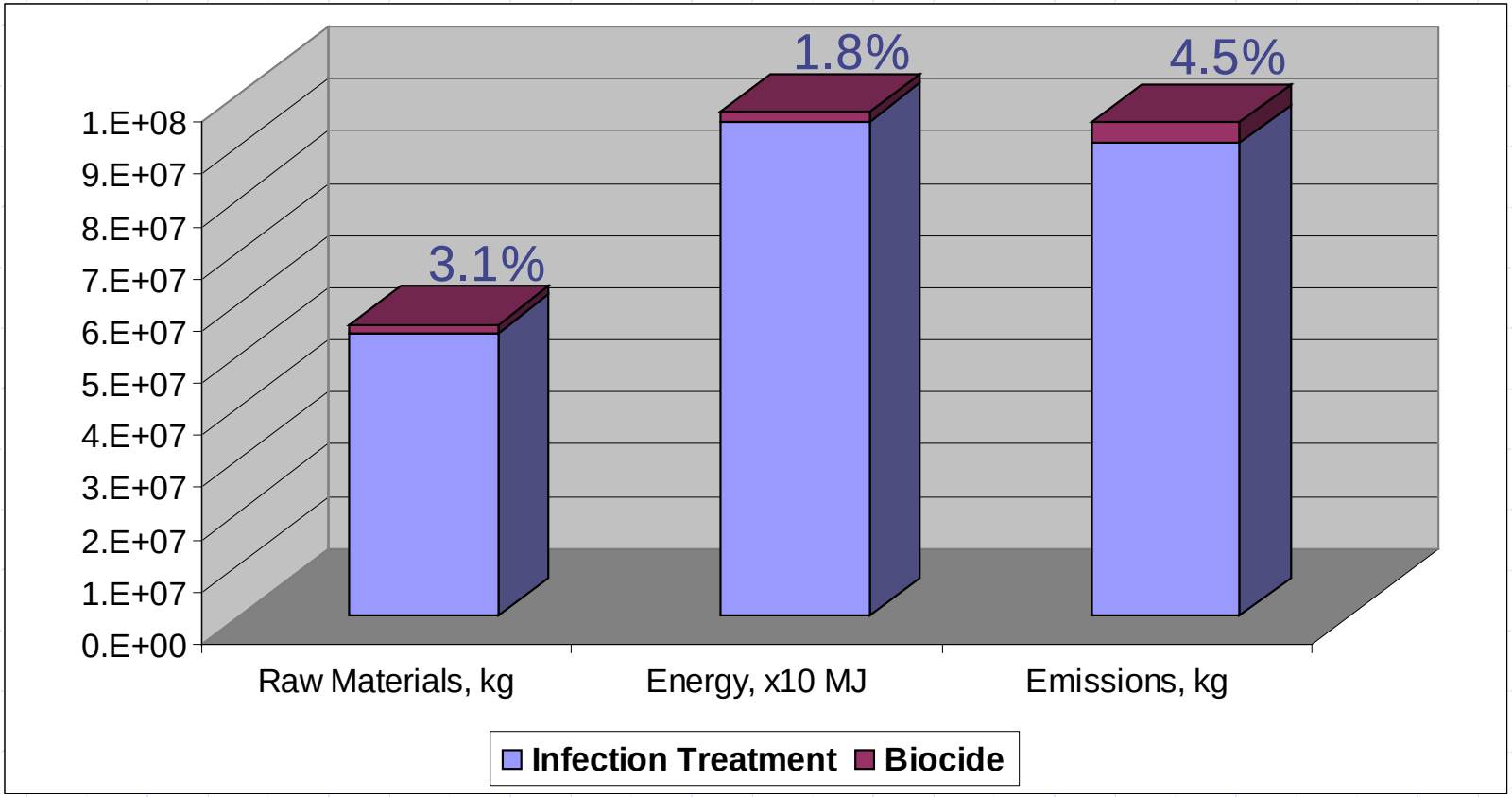
Disposable gowns account for 84% of total CTG energy

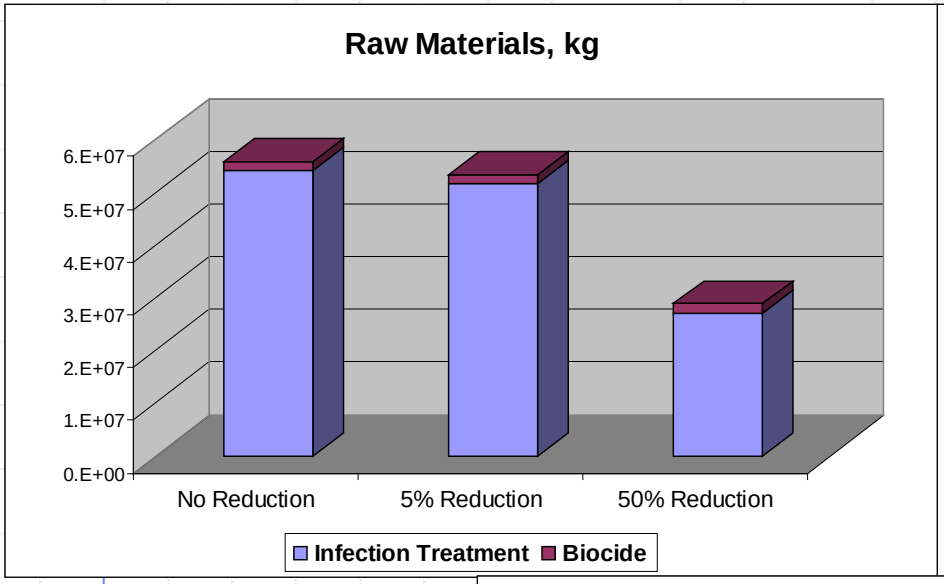
How does applying and using the biocidal finish compare to treating an infection?

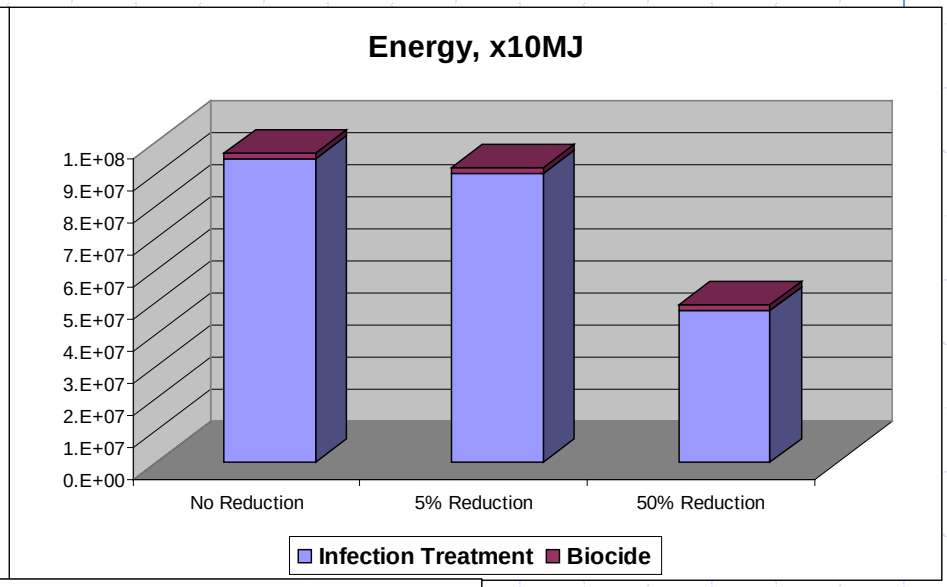
How much of an infection reduction is needed to offset using the biocidal finish?

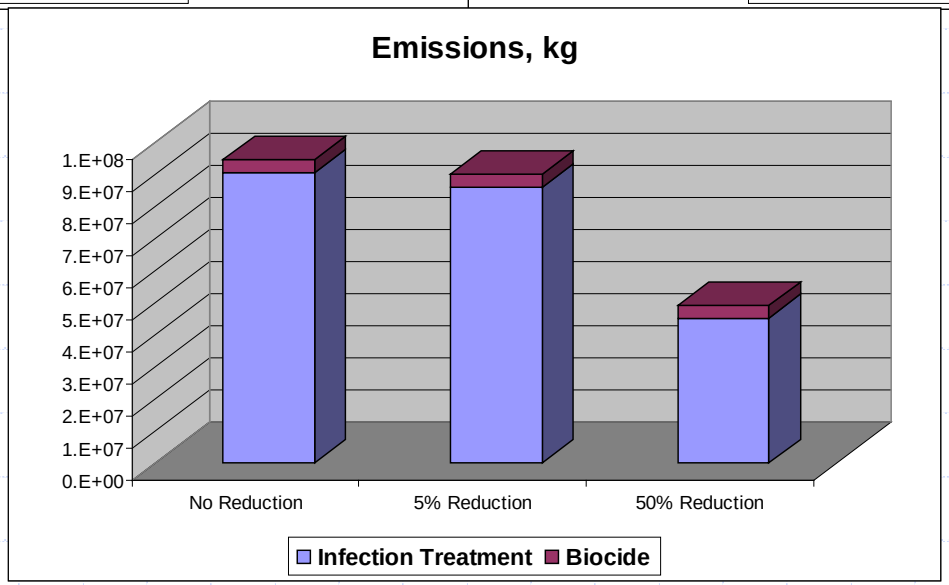


Environmental Comparison









The use of the biocidal gown may significantly impact environmental burden on infection treatment

Conclusions

- Contact isolation step uses the most raw materials and energy
- A 5% nosocomial infection reduction can offset the manufacture and use of the biocidal gown

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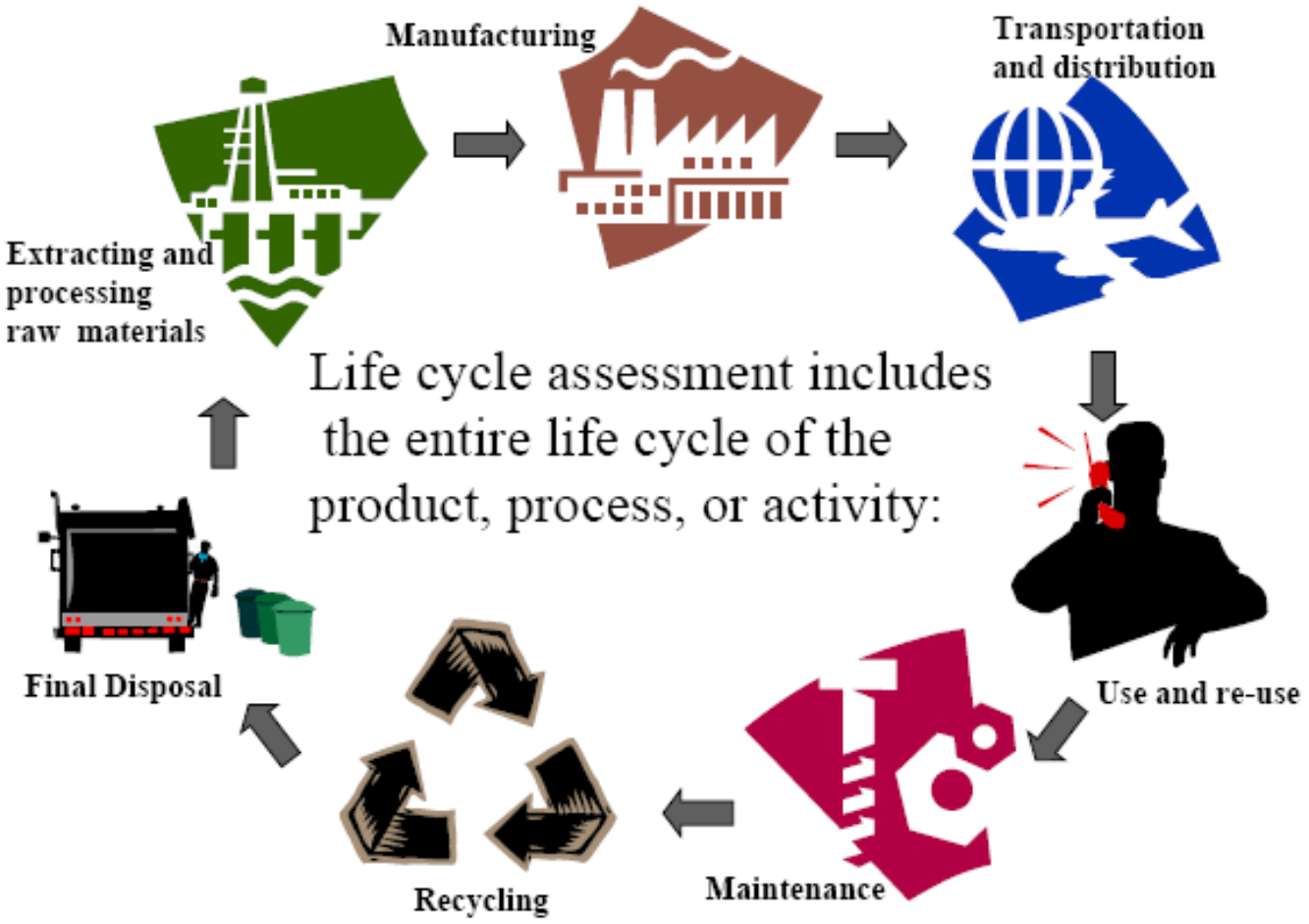
Thank You!

Questions?

What is a Life Cycle Assessment?

Life Cycle Assessment (LCA) is an environmental management tool.

LCA is a tabulation of all water, resource, and energy consumption and emissions generated from a product / process during manufacture, use, and disposal, from cradle to grave.

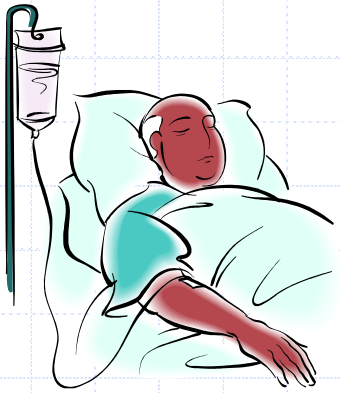


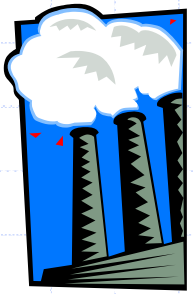
LCA Uses

- Manufacturing improvement
- Corporate sustainability policies
- Beneficial reuse options
- Green purchasing
- International or US labeling – Ecolabel or Energy Star
- CO2 trading credits

Biocidal Hospital Patient Gown

Energy



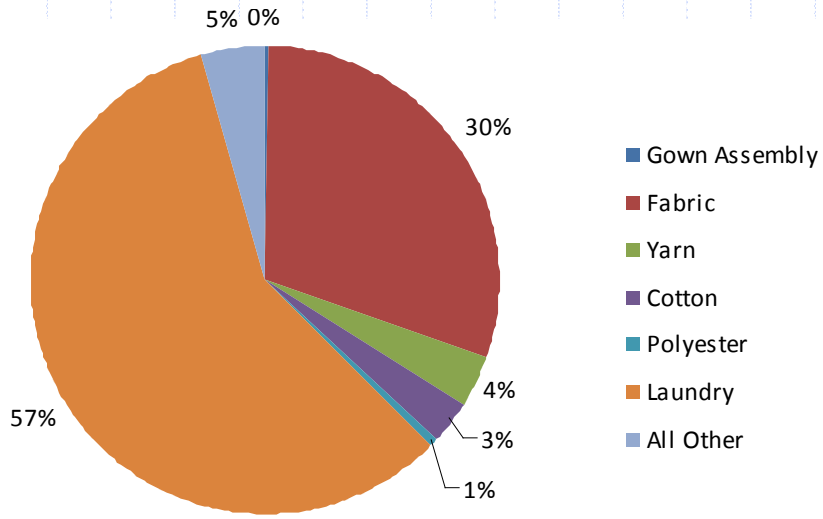


Waste

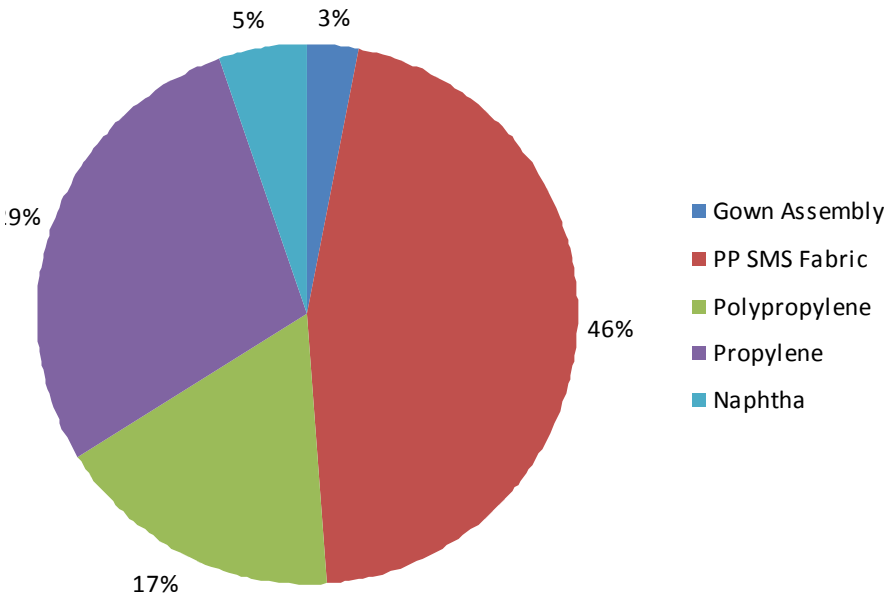
Raw Materials

Energy Comparison - CTU

Reusable Gown



Disposable Gown



Comparison with other Databases

Case Study: Ammonia GTG

Parameter	Process-based	BUWAL 250	Boustead	PEMS	EFMA
Natural gas, kg	446 810	467	760[a]	760[a]	458
Water, kg	1200 12000	920	11176[b]	11000[b]	1500
Ammonia, kg	1000	1000	1000	1000	1000
CO_2, kg	1179	1156	c	c	1150-1300
Total energy, MJ	13300	6000	11600	11600	8000-10000

a. Includes energy input

b. Including cooling water

c. Counted as emission

Life Cycle Assessment History

- Began in 1963, Harold Smith reported cumulative energy requirements for production of chemical intermediates at World Energy Conference
- In 1969, Coca-Cola studied alternative beverage containers.
- Resource and Environmental Profile Analysis (REPA) or Ecobalance (in Europe) done by private consulting firms
- In the 1980s and early 1990s, numerous REPAs with contradicting results and no commonality
- In 1990, REPA by Franklin & Assoc finds disposable diapers preferable.
- In 1991, REPA by Lehrberger & Jones finds cloth diapers preferable
- In 1992, REPA by A.D. Little finds disposable diapers preferable.
- During the 1990s, SETAC (Society of Environmental Toxicology and Chemistry) and ISO (International Organization for Standardization) worked together to develop ISO 14000 standards for the life cycle assessment.
- In 2006, ISO updates Standards 14040 and 14044