LIFE CYCLE RESEARCH AND MEDICAL TEXTILES

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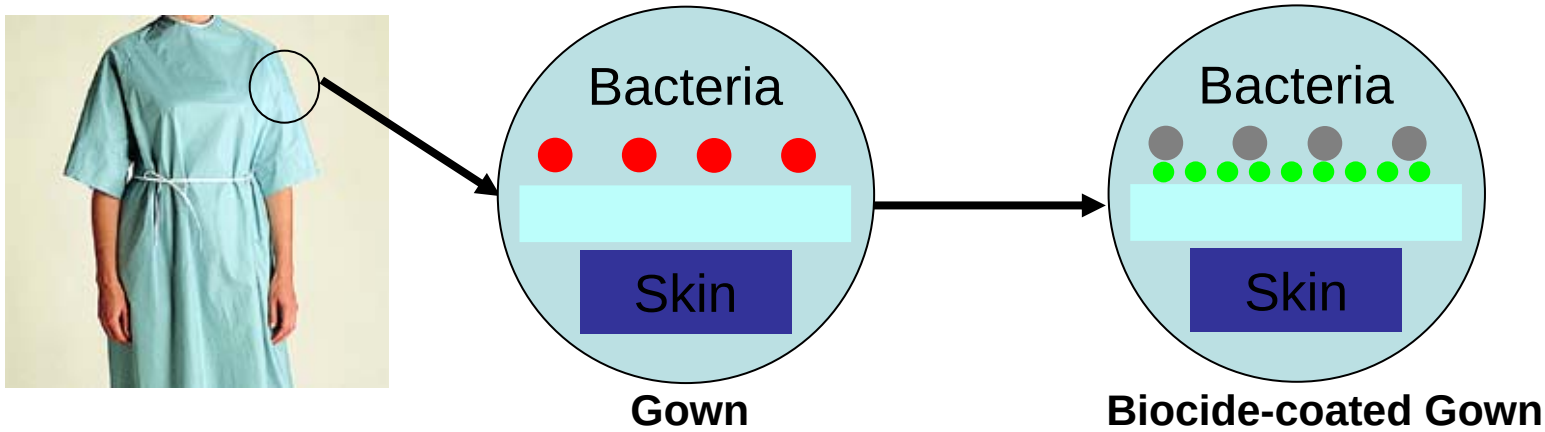
Medical Garment



- Garments used as barriers to prevent infection in hospitals
- In U.S., disposables are dominant, but in Europe, reusables are dominant
- Although each claim superiority, studies show that infection rates for both types are similar (2.2%[1] and 5.1-5.3%[2])
- LCA can be used to compare both cradle-to-grave
- Schmidt (2000) – reusable surgical gowns have less energy, and raw materials consumption and less global warming potential

[1]Garibaldi, R. A. et al. *The American Journal of Surgery* **1986**, *152*, 505-509.
[2]Bellchambers, J. et al. *European Journal of Cardio-Thoracic Surgery* **1999**, *15*, 45-50.
[3]Schmidt, A. European Textile Service Association **2000**.

LIFE CYCLE IS A TOOL

- DEVELOPED TO DEAL WITH COMPLEXITY OF ENVIRONMENT AND PRODUCTS
- HELPS US QUANTIFY, UNDERSTAND, AND SEEK IMPROVEMENT
  - IMPROVE ENVIRONMENT
  - IMPROVE ECONOMICS

LIFE CYCLE TOOLS

LIFE CYCLE STAGE	DECISIONS
IMPROVEMENT ANALYSIS	
IMPACT ASSESSMENT	**•POLICY ISSUES** **•SUSTAINABILITY** **•MACRO IMPROVEMENTS**
INVENTORY ANALYSIS	**•NEW TECHNOLOGY** **•POLLUTION PREVENTION** **•PROCESS ALTERNATIVES**

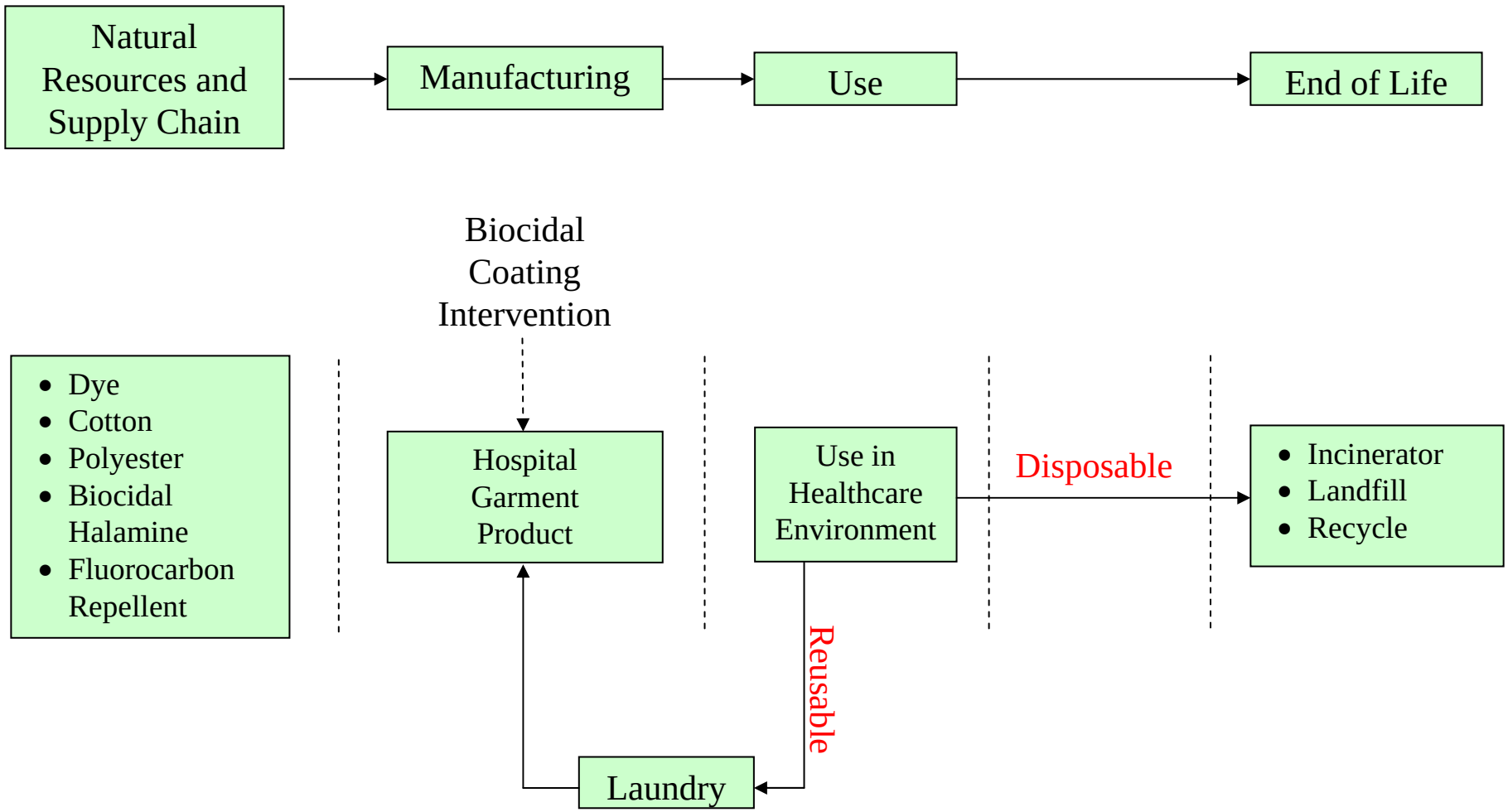
A LIFE CYCLE INVENTORY (LCI) IS A COMPLETE MASS AND ENERGY BALANCE TO DETERMINE

- INPUTS
- CHEMICAL EMISSIONS
- ENERGY NEEDS
- PRODUCTS FORMED
- MAJOR TECHNICAL VARIABLES AFFECTING THE LCI

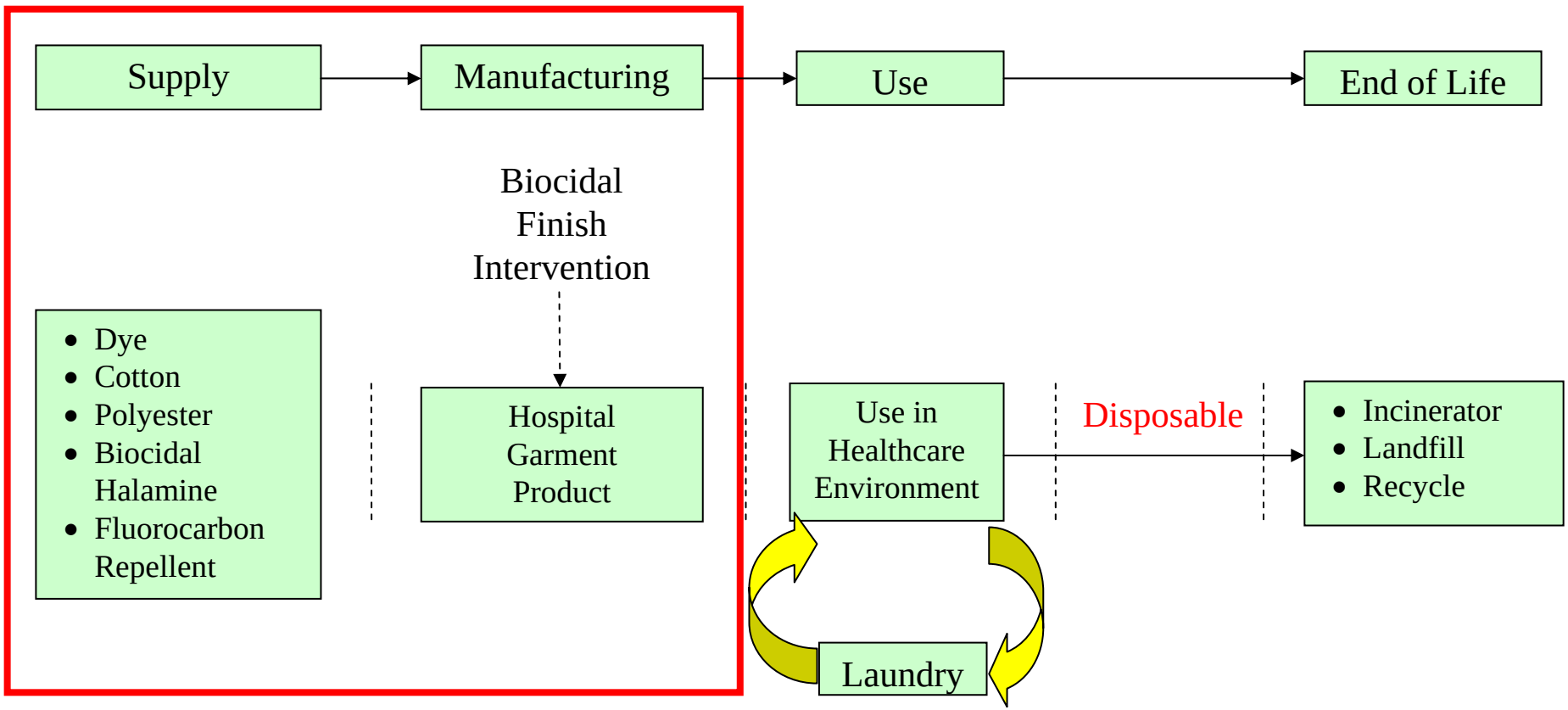
SOME BOUNDARY MUST BE SPECIFIED

LIFE CYCLE INVENTORY QUALITY

- TRANSPARENCY
- ENGINEERING PRINCIPLES OF MASS & ENERGY
- MULTIPLE VIEWS
- LOGICAL MECHANISM TO CHANGE
- EXPECTATIONS OF DECISION-MAKERS
- CRITICAL RELATION OF SYSTEM TO SUSTAINABILITY FACTORS


Natural Resources and Supply Chain
Manufacturing
Use
End of Life
Biocidal Coating Intervention
Dye
Cotton
Polyester
Biocidal Halamine
Fluorocarbon Repellent
Hospital Garment Product
Use in Healthcare Environment
Disposable
Incinerator
Landfill
Recycle
Reusable
Laundry

Project Scope



These LCI data are to be a part of the UC Davis Database on Medical Textiles

Functional Unit

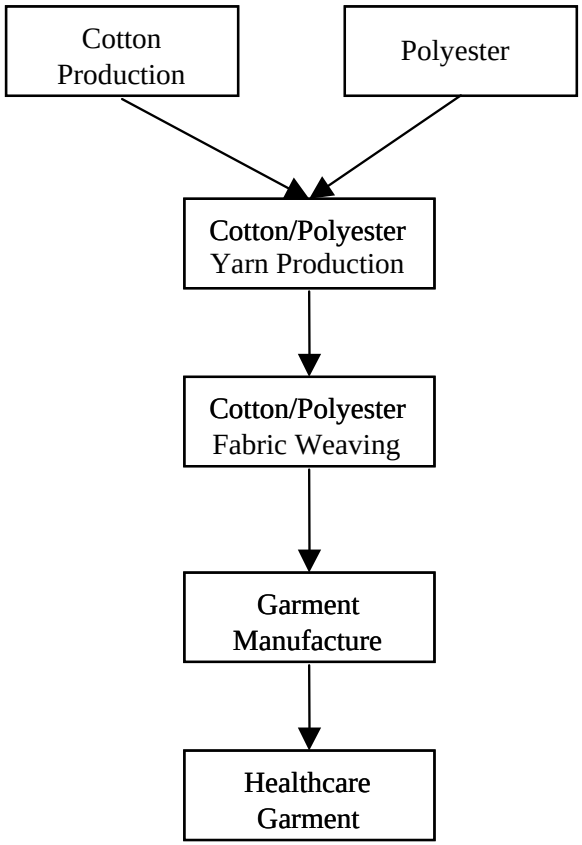
75 Disposable Patient Gowns

Polypropylene Spunlace Fabric

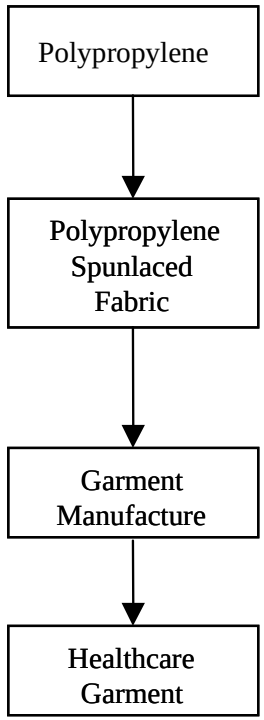
1 Reusable Patient Gown (used 75 times)

55% Cotton, 45% Polyester

Garment Production Diagram



Reusable Garment Production Diagram

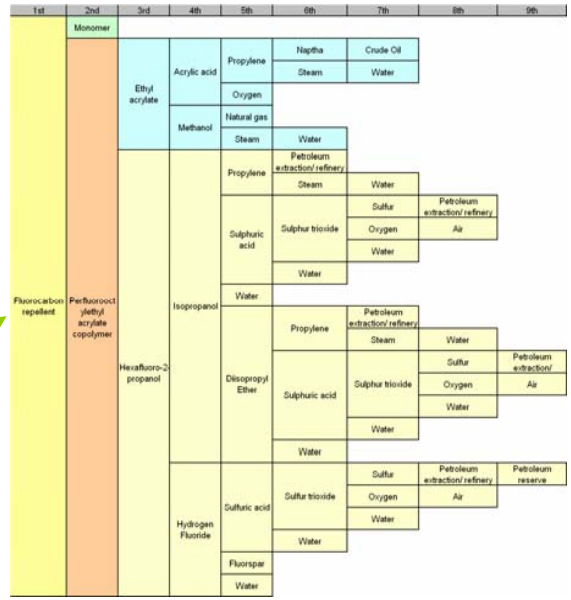


Disposable Garment Production Diagram

Gown Chemistry Tree

Level 1	Level 2	Level 3	Level 4
Polypropylene	Propylene	Naphtha	Crude Oil

Disposable Polypropylene Patient Gown
(A) Polypropylene
(B) Fluorocarbon Finishes
(C) Colorant

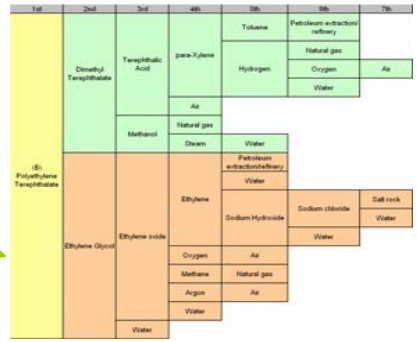


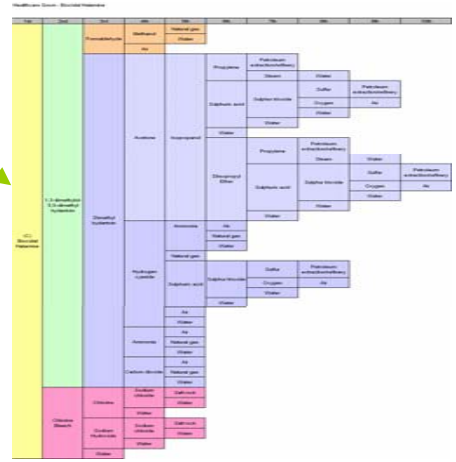
Level 1	Level 2	Level 3	Level 4	Level 5
Copper phthalocyanine	Copper chloride	Chlorine	Sodium chloride	Salt rock
			Water for rxn	Water (untreated)
		Copper	Copper Ore (unprocessed)	
	Phthalic anhydride	o-Xylene	Naphtha	Crude Oil
		Oxygen from air	Air (untreated)	
	Sodium hydroxide	Sodium chloride	Salt rock	
		Water for rxn	Water (untreated)	
	Urea	Ammonia	Natural gas	Natural gas (unprocessed)
			Nitrogen from air	Air (untreated)
			Oxygen from air	Air (untreated)
			Water for rxn	Water (untreated)
		Carbon dioxide	Natural gas	Natural gas (unprocessed)
			Nitrogen from air	Air (untreated)
			Oxygen from air	Air (untreated)
			Water for rxn	Water (untreated)

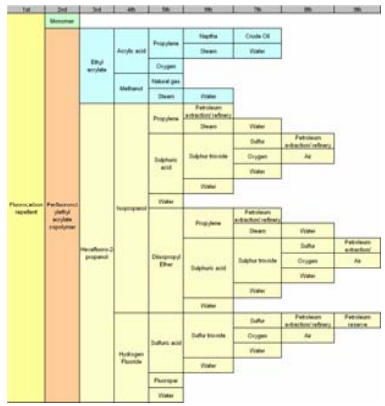
Gown Chemistry Tree

Reusable Cotton/Polyester Patient Gown	
	(A) Cotton
	(B) Polyethylene terepthalate
	(C) Biocidal Finish
	(D) Other Finishes
	(E) Colorant

1st	2nd	3rd
Cotton	Cotton Seed	Cotton Seed (Untreated)
	K fertilizer	Brine
		Sylvanite rock
	N fertilizer	Air (untreated)
		Natural gas (unprocessed)
		Petroleum product
		Phosphate rock (in ground)
		Water (untreated)
	P fertilizer	Air (untreated)
		Natural gas (unprocessed)
		Petroleum product
		Phosphate rock (in ground)
		Water (untreated)







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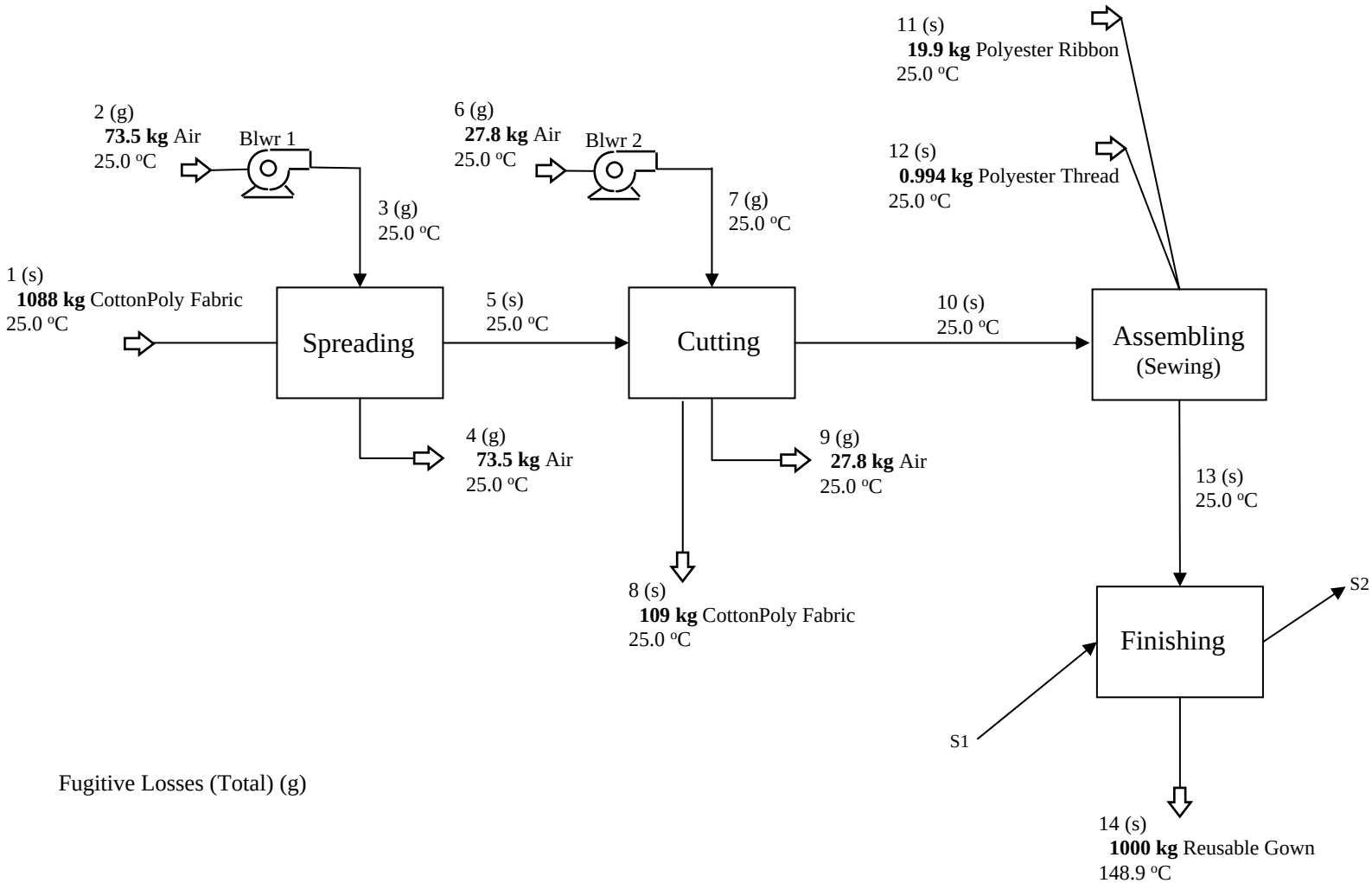
Reusable Gown PFD



Fugitive Losses (Total) (g)

Reusable Gown LCI Summary

Inputs					
Input UID	Input Name	Input Flow	Input purity	Units	Comments
UIDCottonPolyFabric	CottonPoly Fabric	1088		[kg/hr]	
	Total	1088		[kg/hr]	

Non-reacting inputs					
UID	Name	Flow	Purity	Units	Comments
132259-10-0	Air (oxygen)	101		[kg/hr]	
	Total	101		[kg/hr]	

Ancillary inputs					
UID	Name	Flow	Purity	Units	Comments
UIDPolyribbon	Polyester Ribbon	19.9		[kg/hr]	
UIDPolythread	Polyester Thread	0.994		[kg/hr]	
	Total	20.9		[kg/hr]	

Products					
Product UID	Product Name	ProductFlow	Purity	Units	Comments
UIDReusableGown	Reusable Gown	1000		[kg/hr]	
	Total	1000		[kg/hr]	

Benign Outflows					
UID	Name	Flow	Purity	Units	Comments
132259-10-0	Air (oxygen)	101		[kg/hr]	
	Total	101		[kg/hr]	

Chemical Emissions							
Emission UID	Emission Name	Gas Flow	Liquid Flow	Solid Flow	Solvent Flow	Units	Comments
UIDCottonPolyFabric	CottonPoly Fabric	0	0	109	0	[kg/hr]	
Totals		0	0	109	0	[kg/hr]	

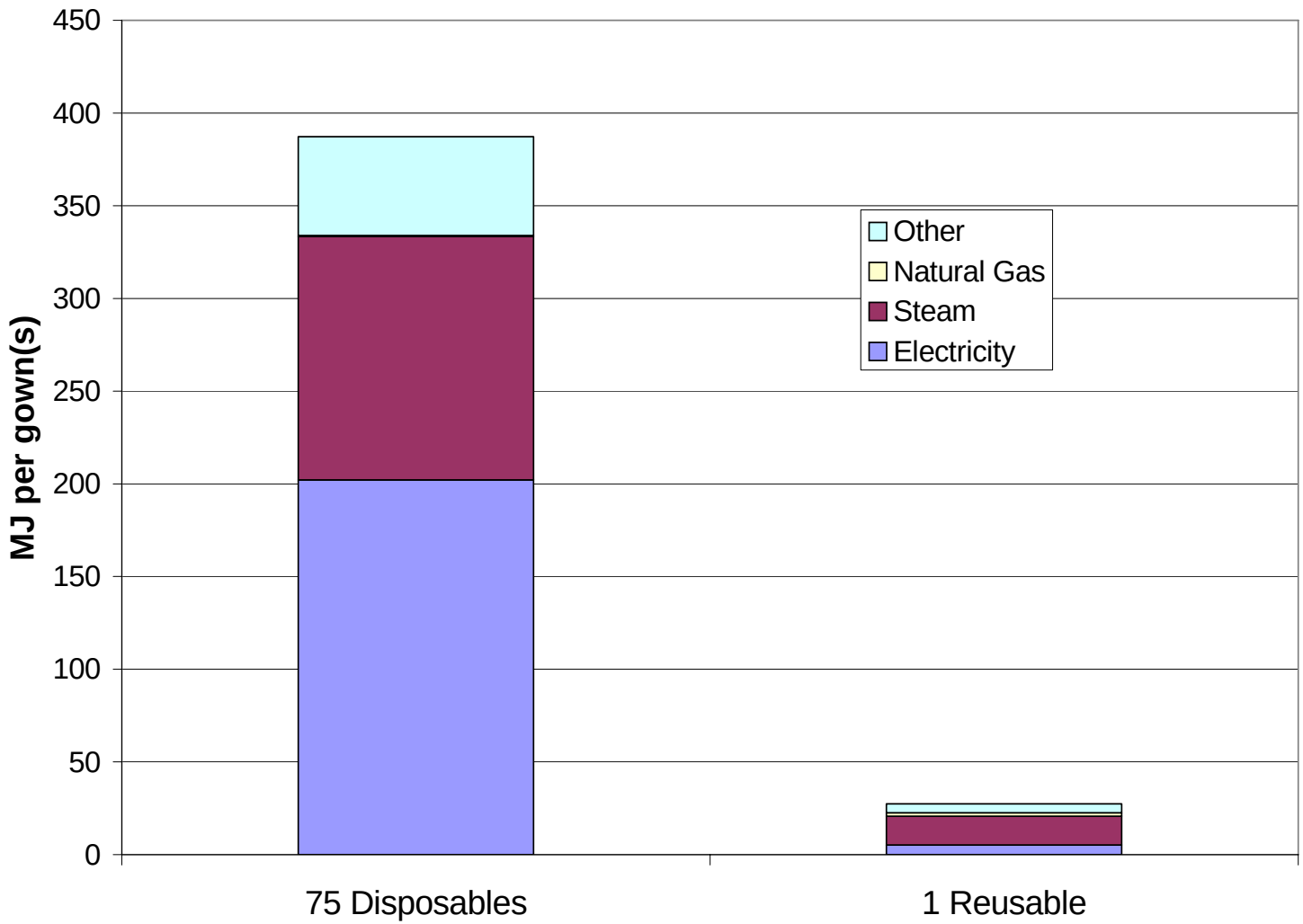
Mass Balance		
Total inputs	1210	
Total outflows	1210	
Net input	1.10e-4	

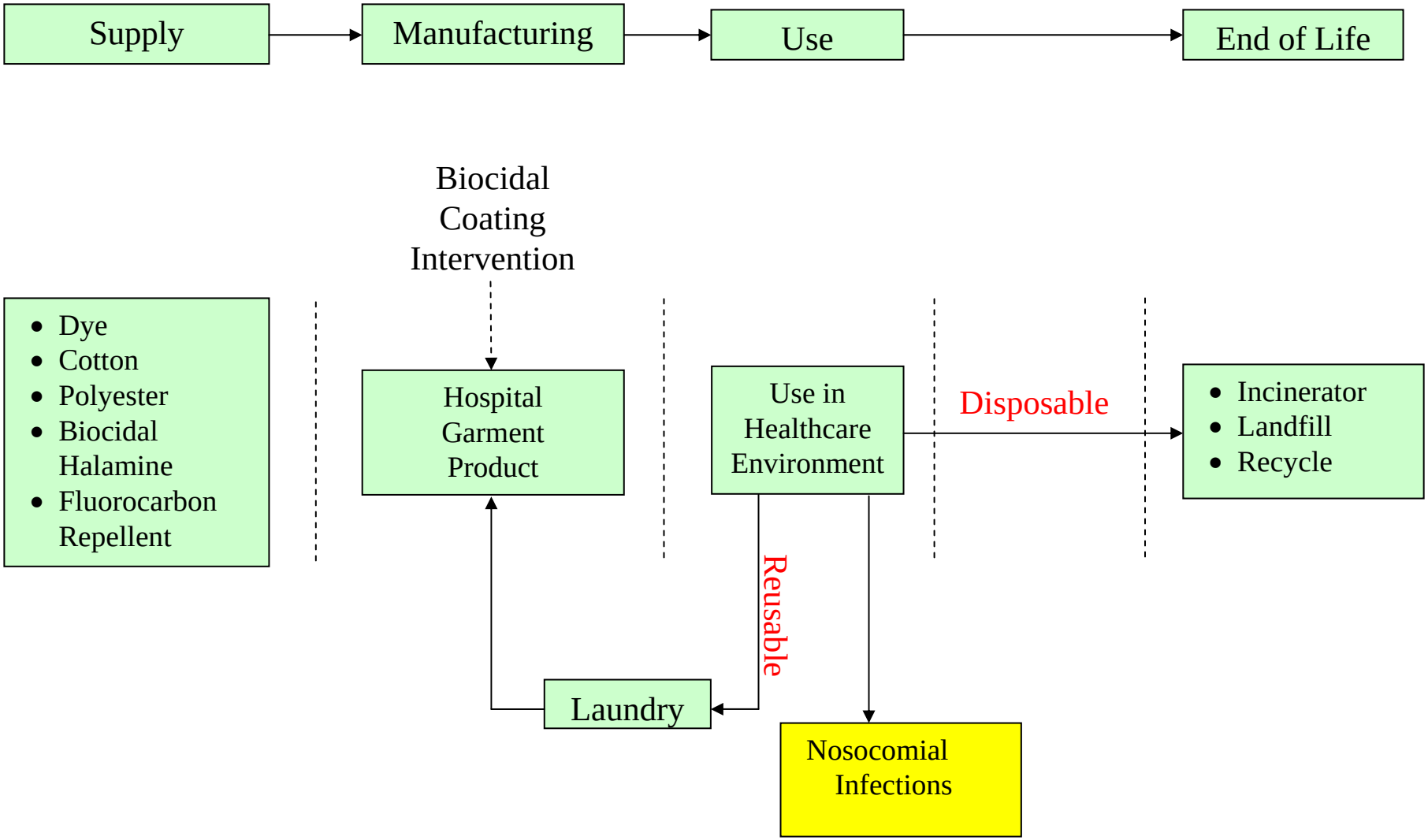
Energy use			
Energy type	Amount	Comments	
electricity	173	[MJ/hr]	
heating steam	324	[MJ/hr]	
Net input requirement	497	[MJ/hr]	Net of energies input to system
Net energy	497	[MJ/hr]	Net input requirement - potential recovery

Energy & Resource Consumption (per 1000 gowns) Cradle-to-gate

	Disposable(0.06 kg)	Reusable(0.23 kg)
Total, Energy, MJ	5162	27 380
Electricity, MJ	2695	5210
Steam, MJ	1750	15550
Natural Gas, MJ	6.83	1820
Other, MJ	711	4790
Natural Resource Energy, MJ	12,000	42,700
Total, Resources, kg	255	1394
Natural Gas, kg	50	308
Crude Oil, kg	48.4	423
Coal, kg	130	252
Other, kg	0	15.8
Mineral rock, kg	19.6	128
Water, kg	531	799 000

Energy for 75 Disposables versus 1 Reuseable




Supply
Manufacturing
Use
End of Life
Biocidal
Coating
Intervention
Dye
Cotton
Polyester
Biocidal
Halamine
Fluorocarbon
Repellent
Hospital
Garment
Product
Use in
Healthcare
Environment
Disposable
Incinerator
Landfill
Recycle
Reusable
Laundry
Nosocomial
Infections

Magnitude of Hospital Infections

Citation	Nosocomial Infection Rate, patients infected per 100 admitted patients
Fox, et. al, 1974	5
CDC, 2005	6
Wenzel, et. al, 1995	5-10
Pittet, et. al, 2004	9-10

- Annual Hospital Admissions in the US, about 32 million persons

- Infections acquired in hospitals (around 6%) or 1.9 million persons. Significant variation among hospitals

- About 33% of these are cited as preventable (Pittet, D., et. al., 1999) or about 640,000 patients per year. Infection Control Offices are established.

- An estimated 4% - 5% of those infected die or 86,000 patients

CURRENT STATUS & FUTURE TASKS

- Life cycle gate-to-gates of supply chain - database
- Laundry versus supply chain of disposable – the first life cycle tradeoff
- Nature of the hospital environmental footprint
- Additive effects of including life cycle for nosocomial infections – the second life cycle tradeoff
- Improvements in location of biocidal interventions to lower health impacts
- These life cycle inventory data can be used in larger numbers of life cycles for other medical textiles and for sustainability standards