# Physics behind Sustainable Fashion & Environmental Art

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# What is sustainable fashion?

- A part of the growing design philosophy and trend of sustainability, the goal of which is to create a system which can be supported indefinitely in terms of environmentalism and social responsibility. -Wikipedia

# How much energy does a T shirt need in its life time?

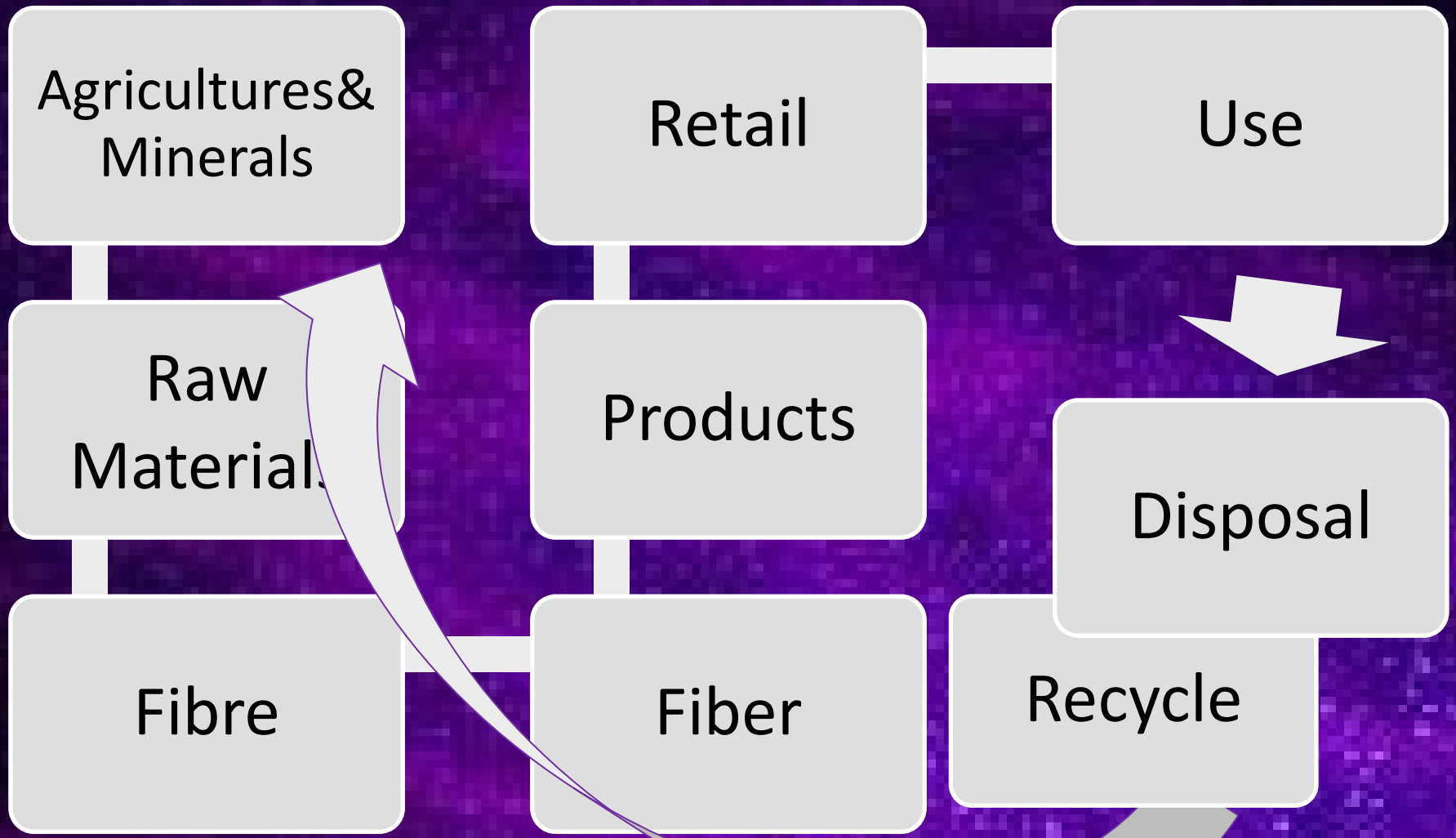
109 MJ!

# Textile Industry

- In 2008,  annual global textile production was estimated at  60 billion kilograms (KG) of fabric. To produce such amount of fabric we need:
- 1,074 TWh of electricity
- 6 – 9 trillion liters of water

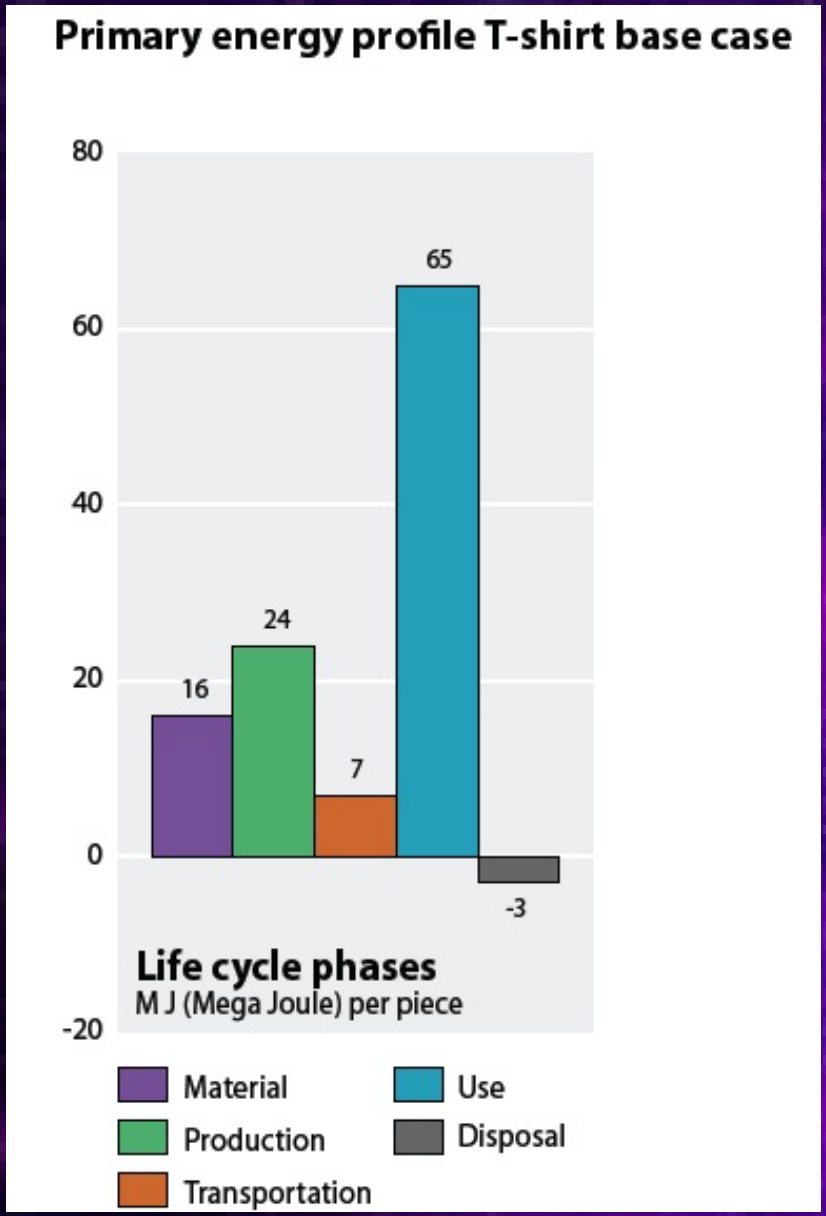
--oecotextiles.wordpress.com

Annual energy consumption for lighting in US ≈ 800 TWh


Agricultures& Minerals
Retail
Use
Raw Materials
Products
Disposal
Fibre
Fiber
Recycle

# Energy Flow Key Points

- Textile manufacture+Production
- Transportation
- Use
- Disposal



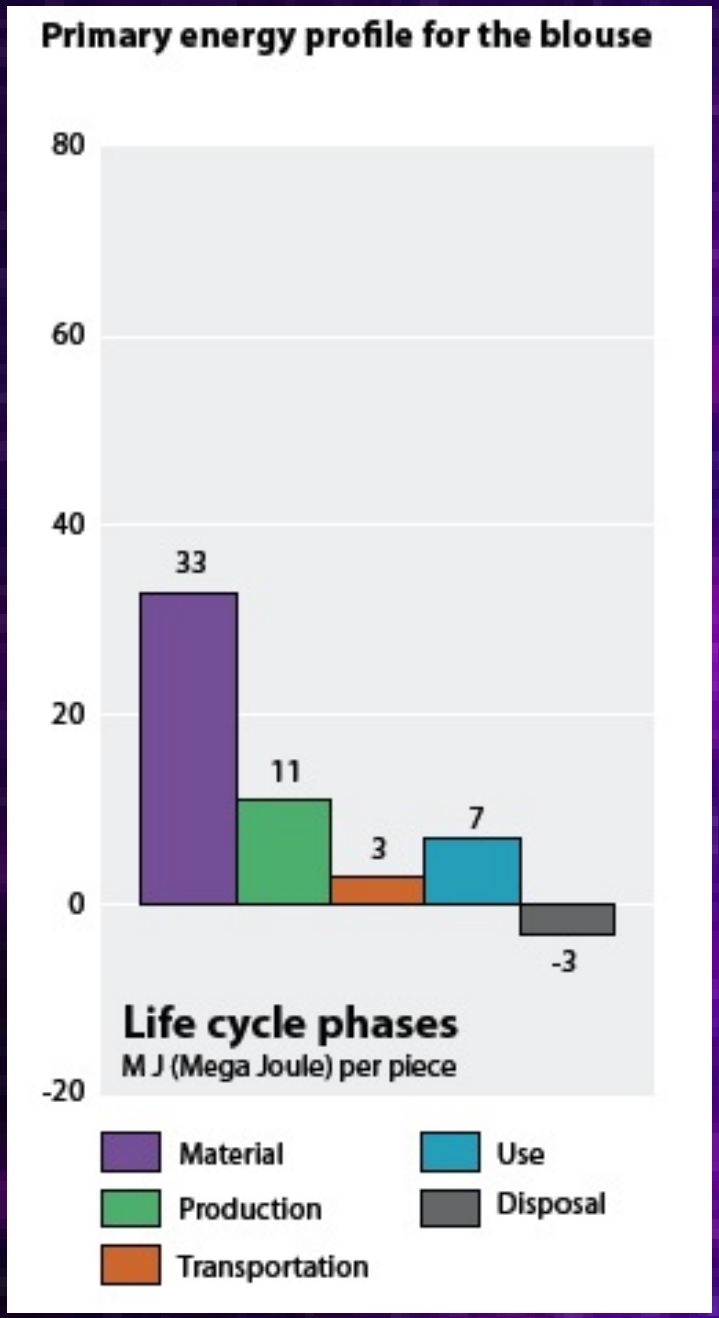

# Energy Consumption Per Tshirt:109MJ

- The use phase includes 25 washes at 60°C, followed by tumble drying and ironing requiring 60% of the total energy.
- The disposal phase includes incineration in which heat is generated and used so the net energy consumption is negative in this phase.

---Institute for Manufacturing
University of Cambridge

# T shirt VS Blouse

- Which one costs more energy?


# Energy Consumption Per Blouse: 51MJ

- The use phase includes 25 washes at 40°C, no tumble dry
- The disposal phase includes incineration in which heat is generated and used so the net energy consumption is negative in this phase.

---Institute for Manufacturing
University of Cambridge

# T shirt (cotton)

- Knitted
- Dyed with reactive dyestuffs
- Washing at 60 degrees Celsius
- Dried in tumble dryer
- Ironing of the T-shirt is assumed
- 25 washes and tumble dry per lifetime
- T-shirt weighs 250g

# Blouse (viscose rayon)

- Woven
- Dyed with reactive dyestuffs
- Washing at 40 degrees Celsius
- Hang-drying
- Ironing not necessary
- 25 washes per lifetime
- The blouse weighs 200g

# Choosing Materials

- Renewability and source of a fiber
- How much energy needed to produce the fiber
- the material's carbon footprint and other possible pollution (e.g. NO2)

# Energy needed to make the fiber

| Fibers | Energy used to make the fiber (MJ/KG) |
|---|---|
| Flax | 10 |
| Cotton | 55 |
| Wool | 63 |
| Viscose | 100 |
| Polypropylene | 115 |
| Polyester | 125 |
| Acrylic | 175 |
| Nylon | 250 |

# CO2 emission (KG/ton of fiber)

| Fiber | Crop cultivation | Fiber production | Total |
|---|---|---|---|
| Polyester USA | 0.00 | 9.52 | 9.52 |
| Cotton, conventional, USA | 4.20 | 1.70 | 5.90 |
| Hemp, conventional | 1.90 | 2.15 | 4.05 |
| Cotton, organic, USA | 0.90 | 1.45 | 2.35 |

Other synthetic fibers emit even more the polyester: acrylic is 30% more energy intensive in its production than polyester and nylon is even higher than that.

--Stockholm Environment Institute

# Production

Amount of energy needed to weave fibers into fabric (not much dependent on the fiber type):

- thermal energy required per meter of cloth is 4,500-5,500 Kcal
- electrical energy required per meter of cloth is 0.45-0.55 kwh.

--Journal for Asia on Textile and Apparel

| Fibers | Energy used to make the fiber (MJ/KG) | Energy used to make the fiber into textile (MJ/KG) | Energy used in total to make the textile (MJ/KG) |
|---|---|---|---|
| Flax | 10 | 92 | 102 |
| Cotton | 55 | 92 | 147 |
| Wool | 63 | 92 | 155 |
| Viscose | 100 | 92 | 192 |
| Polypropylene | 115 | 92 | 207 |
| Polyester | 125 | 92 | 217 |
| Acrylic | 175 | 92 | 267 |
| Nylon | 250 | 92 | 342 |

Energy needed to make a nylon sofa=3886 MJ
Energy needed for driving a Lamborghini from New York to Washington D.C. =2266MJ (Assume 1 gallon of gasoline equals 131 MJ of energy)

-- oecotextiles.wordpress.com

# Use

- Washing times
- Washing temperature
- Tumble dry
- Iron
- Life time

# How much can be improved?

- Washing at a lower temperature has a modest reduction (of around 10%) in global impact.
- Elimination of tumble drying (which uses around 60% of the use phase energy) and ironing, in combination with the lower wash temperature, leads to around 50% reduction in global climate change impact of the product.

---Institute for Manufacturing
University of Cambridge

# Disposal

- According to the most recently released figures from the EPA, in 2010 Americans discarded 13.1 million tons of textiles.
- Only 15% was reclaimed or recycled.
- More than 11 million tons of textiles were dumped in landfills across the country.

# Influence

- Decomposing clothing releases methane, a harmful greenhouse gas and a significant contributor to global warming. There are dyes and chemicals in fabric and other components of clothing and shoes that can leach into the soil, contaminating both surface and groundwater.

# UK


--Textiles Recycling Association

- If everyone in the UK bought one reclaimed woolen garment each year, it would save an average of 371 million gallons of water (the average UK reservoir holds about 300 million gallons) and 480 tonnes of chemical dyestuffs.

--Wasteonline.com

# Recycle

- Recycling textiles can save up to 15 times the energy recoverable by incineration.
- Over 70% of the world's population use second hand clothes
- There are about 6,000 textile banks nationwide, but clothes banks are only operating at about 25% capacity

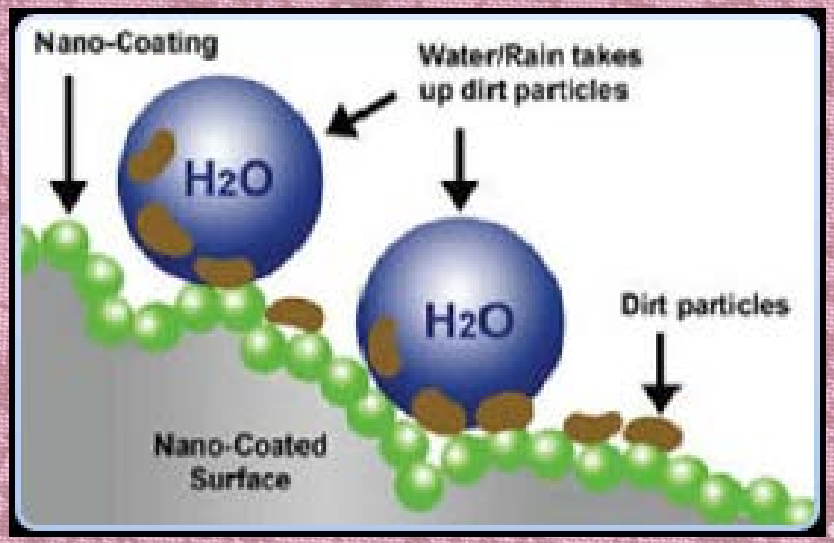
--igcohen.com

What else can be improved?

# New Technology

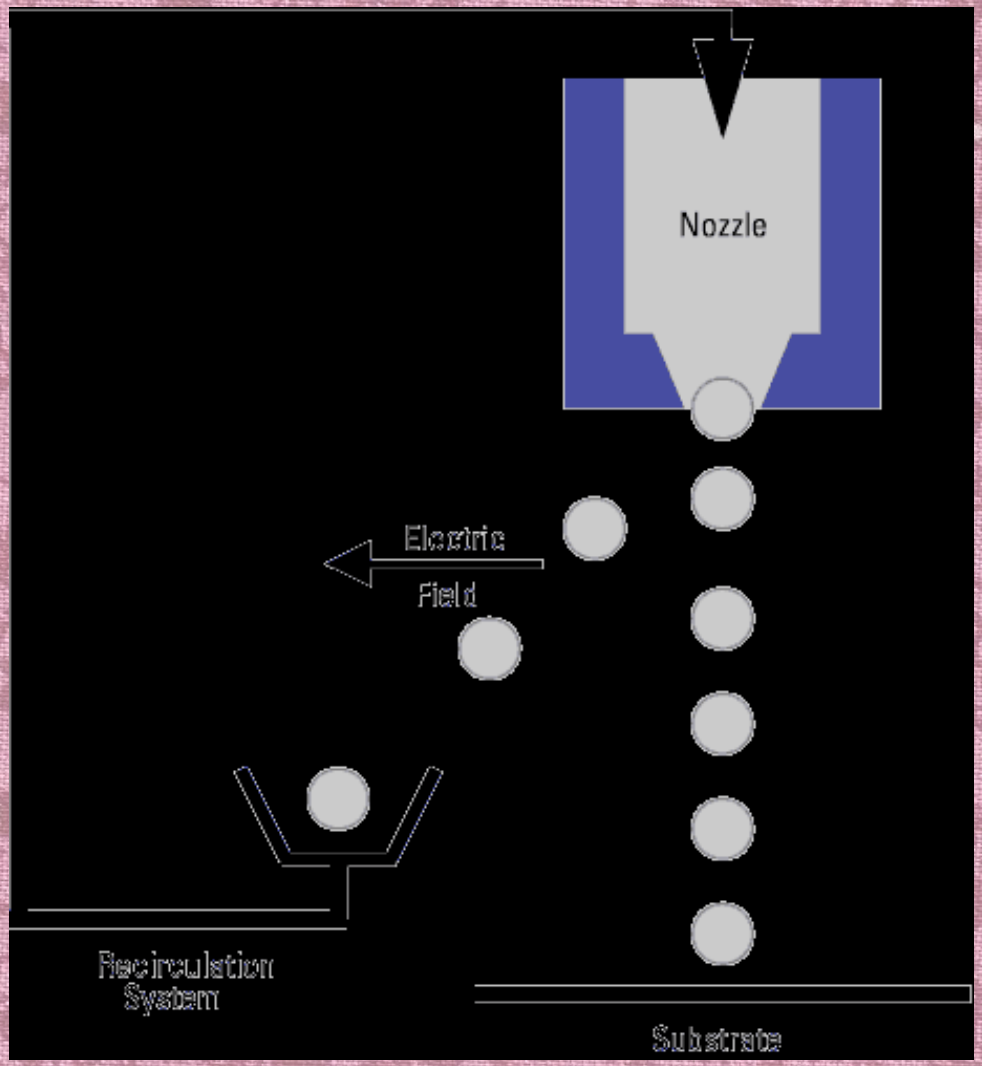
- Nanotechnology
- Digital Printing

# Nanotechnology




- to create stain and water resistance
- increase the ability of textiles, particularly synthetics, to absorb dyes
- using silver nanoparticles for antimicrobial, antibacterial effects, thereby eliminating odors in fabrics

# Digital Printing




- Charged droplets leaving the nozzle are directed either toward a substrate or toward an ink recirculation system, depending upon the imposed electric field.

# Benefit

- **Production space required by 60%**
- **Noise by 60%**
- **Thermal energy usage by 80%**
- **Wastewater by 60%**
- **Electricity consumption by 30%**
- **By-production of waste dyes = eliminated entirely**

--oecotextiles.wordpress.com

# Challenges

- guiding the fabric under digital printer heads
- many types of synthetic and natural fibers, each with its own ink compatibility characteristics
- requirements include light fastness, water fastness (sweat, too) through finishing operations and often outdoor use, heavy wear, abrasion, and cleaning

# Paradox

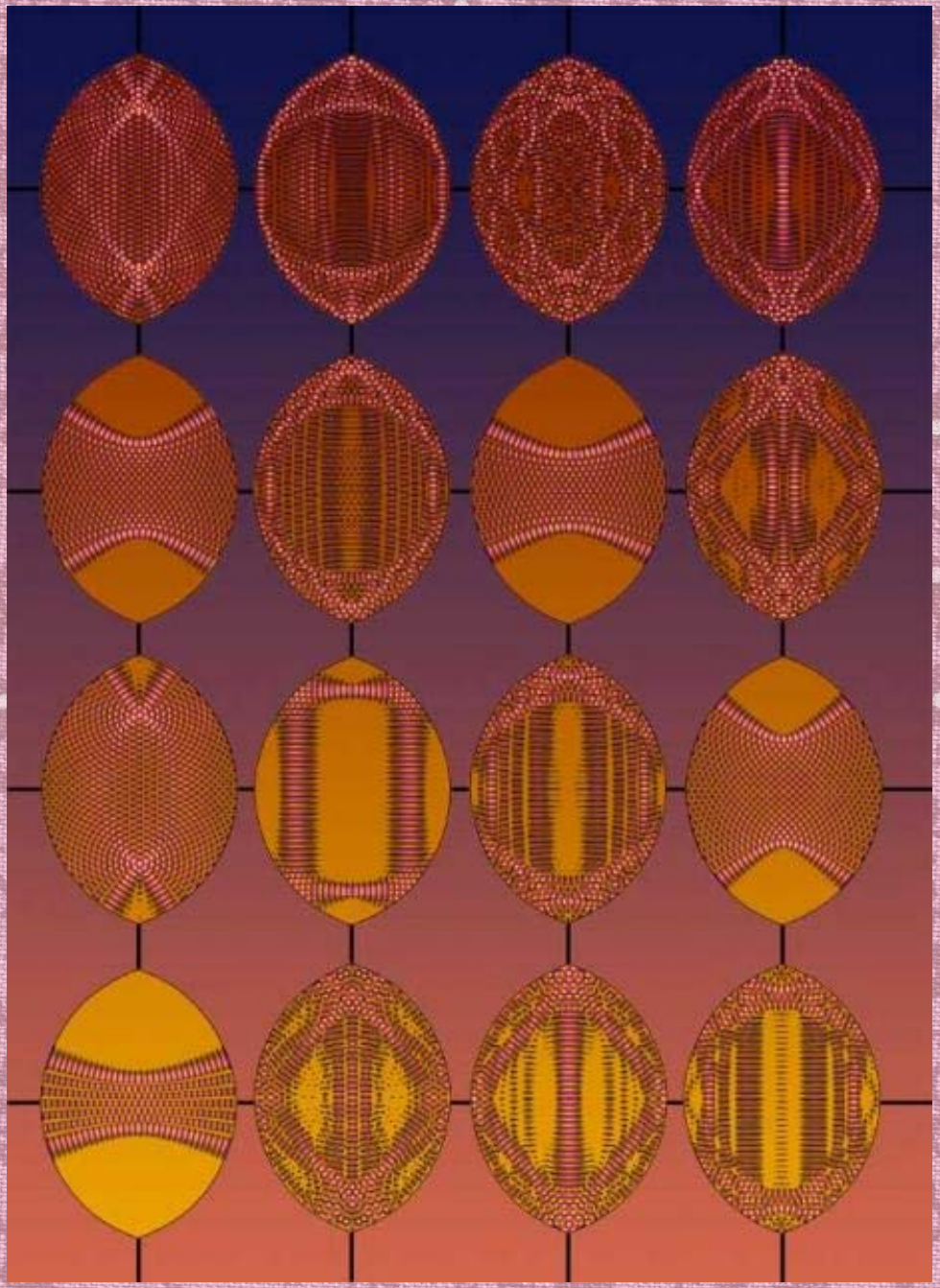
- Fashion does not address ecological issues – its focus is on the market and production.
- People who focus a lot on dressing and fashion typically do not know much about energy&sustainability issues.

# Environmental Art

- Art dealing with ecological issues and/or the natural.

-Wikipedia

- Express fondness toward environment
- Use nonrecyclable waste to do art



- **Standing waves in a lemon-shaped “billiard” cavity**

# Thanks!

http://www.igcohen.com/

http://www.wasteonline.org.uk/

http://oecotextiles.wordpress.com/

http://www.ifm.eng.cam.ac.uk/sustainability/projects/mass/UK_textiles.pdf

http://en.wikipedia.org/wiki/Sustainable_fashion

http://www.youtube.com/watch?v=9WQrkWsSmV4&list=LLAn_1ZjLtZUkF-XfbUxmF4A&index=10&feature=plpp_video