

# 2025

RESPECTLIFE

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## **Empowering Sustainable Business: Technical and Environmental Analysis of Polypropylene in Work wear Textiles**

Case Study: Sustainable *work wear* apparel Innovation  
with RFID & AI-Driven Circularity

## Sommario

|                                                                                                   |    |
|---------------------------------------------------------------------------------------------------|----|
| <b>Case Study: Sustainable work wear apparel Innovation with RFID &amp; AI-Driven Circularity</b> | 2  |
| Advantages of Polypropylene in Elis Italia Project                                                | 2  |
| <b>Energy Savings (PP vs. Cotton)</b>                                                             | 3  |
| Summary Table: Environmental & Economic Savings (PP vs. Cotton)                                   | 5  |
| Additional Savings with RFID Tracking                                                             | 5  |
| <b>Combined Benefits (PP + RFID)</b>                                                              | 6  |
| Technical Comparison: Cotton, Polyester, and Polypropylene                                        | 8  |
| 1. WatEr Absorption                                                                               | 8  |
| 2. Specific Weight                                                                                | 8  |
| 3. Thermal Conductivity                                                                           | 8  |
| 4. Thermal Insulation                                                                             | 8  |
| 5. Thermal & Thermodynamic Properties                                                             | 8  |
| 6. Performance in Extreme Cold                                                                    | 9  |
| 7. Flame REACTION                                                                                 | 9  |
| 8. Color Fastness                                                                                 | 9  |
| 9. Hypoallergenicity and Biocompatibility                                                         | 9  |
| 10. Acid and Base Resistance Comparison Table                                                     | 10 |
| Technical Comparison: Cotton vs. Polyester vs. Polypropylene                                      | 11 |
| Environmental Impact                                                                              | 12 |
| CO <sup>2</sup> per kg                                                                            | 12 |
| Water Consumption and Land Use                                                                    | 13 |
| Dyeing process                                                                                    | 14 |
| ENVIRONMENTAL IMPACT OF TRADITIONAL DETERGENT CHEMICAL COMPONENTS                                 | 15 |
| End-of-Life                                                                                       | 17 |
| Environmental cost per 1 kg of traditional fabric                                                 | 18 |
| Recycling environmental cost per 1 kg of polyester (pet)                                          | 18 |
| Respectlife's 100% pure pp recycling methods                                                      | 18 |
| SIMPLIFIED SUMMARY TABLE END OF USE                                                               | 20 |

## ***Case Study: Sustainable work wear apparel Innovation with RFID & AI-Driven Circularity***

Client: Elis Italia – Leading industrial laundry service provider for healthcare textiles

Objective: Replace 1,000 cotton hospital sweatshirts with polypropylene (PP) garments, integrating RFID tracking and AI to enhance hygiene, sustainability, and operational efficiency.

KPIs cover environmental impact reduction, service reliability (via RFID-enabled traceability)

The collaboration between Respectlife and Elis Italia is rooted in a common vision: to revolutionize textile management by integrating sustainability, innovation, and data-driven efficiency.

### **Advantages of Polypropylene in Elis Italia Project**

#### **Sustainability:**

- Reduced water consumption (PP doesn't absorb moisture, requires fewer washes/energy).
- Recyclability integrated with RFID tracking.

#### **Hygiene:**

- Resistance to mold/bacteria (super-hydrophobicity).
- Compatibility with sterilization (autoclave, Sterrad).

#### **Operational Efficiency:**

- RFID tracks lifecycle, optimizes laundering and disposal.
- AI predicts wear and reduces waste.

#### **Comfort & Safety:**

- Lightweight (+69% lighter than cotton).
- Superior thermal insulation and flame resistance.

**Conclusion:** PP offers the best balance of **technical performance, sustainability, and hygiene**, making it ideal for work wear environments.

# Case Study

## Sustainable *work wear* apparel Innovation with RFID & AI-Driven Circularity

### COTTON WORK WEAR SWEATSHIRTS VS POLYPROPYLENE SWEATSHIRTS Projections of Energy and pollution Savings

#### Weight

- Cotton: ~1.54 g/cm<sup>3</sup>; heavier than synthetics.
- Polypropylene: ~0.91 g/cm<sup>3</sup>; extremely lightweight, offering better volume with less weight.

|                      | Specific weight<br>gr/cm <sup>3</sup> | Weight of 1 sweatshirt<br>(Kg) | Weight for 1000<br>sweatshirts (Kg) | Weight |
|----------------------|---------------------------------------|--------------------------------|-------------------------------------|--------|
| <b>Polypropylene</b> | 0.91                                  | 0.320                          | <b>320</b>                          |        |
| <b>Cotton</b>        | 1.54                                  | 0.540                          | 540                                 | +69%   |

#### Water Consumption for Production

|                      | Weight Total (Kg) | Water per 1 kg (liters) | Total Water for Production<br>(Liters) |
|----------------------|-------------------|-------------------------|----------------------------------------|
| <b>Polypropylene</b> | 320               | 0.6                     | <b>106</b>                             |
| <b>Cotton</b>        | 540               | 10,000*                 | 5,408,000                              |

\*Data source: The World Counts, also, global cotton production requires over 250 billion tons of water annually.

#### Dyeing process

The key solution to drastically reducing water and energy use in the **dyeing process** lies within moving from wet processes to dry processes.

| Raw material<br>1 kg | Liters<br>Water |
|----------------------|-----------------|
| <b>Respectlife</b>   | <b>0</b>        |
| <b>Cotton</b>        | 150             |

#### Energy Consumption for Heating Water for Industrial Washing Machines

For industrial washing machines with a 200 kg load capacity, energy consumption varies depending on the temperature:

#### Energy Savings (PP vs. Cotton)

| Energy Type | PP<br>Consumption | Cotton<br>Consumption | Absolute Savings | Percentage<br>Savings |
|-------------|-------------------|-----------------------|------------------|-----------------------|
|-------------|-------------------|-----------------------|------------------|-----------------------|

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|                          |         |             |                            |                    |
|--------------------------|---------|-------------|----------------------------|--------------------|
| <b>Electricity (kWh)</b> | 96–192  | 972–1,350   | <b>780–1,158 kWh less</b>  | <b>80–86% less</b> |
| <b>Thermal (MJ)</b>      | 160–320 | 1,620–2,430 | <b>1,300–2,110 MJ less</b> | <b>80–87% less</b> |

Key Takeaways:

- Electricity savings: Up to 86% less (1,158 kWh saved per 1,000 sweatshirts).
- Thermal energy savings: Up to 87% less (2,110 MJ saved per 1,000 sweatshirts).

PP is more efficient because:

Washes at 30°C (vs. 75°C for cotton).

Lighter weight (320 kg vs. 540 kg).

## End of Use

The environmental and economic cost of disposing of 1000 cotton sweatshirts

### Total weight of cotton sweatshirts:

- Total Weight for 1000 sweatshirts: 540 kg

### Environmental Cost of cotton:

- **Landfill:** If the garments are sent to a landfill, they decompose over time but will release methane (a greenhouse gas). Transporting garments to a landfill also emits CO<sub>2</sub>. On average, it is estimated that textile landfill disposal generates 2-3 kg of CO<sub>2</sub> equivalent per kg of waste.

For 540 kg of sweatshirts, this could mean **1080-1620 kg of CO<sub>2</sub>** released.

- **Incineration:** If the garments are incinerated, the process reduces waste volume but produces CO<sub>2</sub> emissions and other pollutants. On average, incineration can generate about 1-2 kg of CO<sub>2</sub> per kg of fabric.

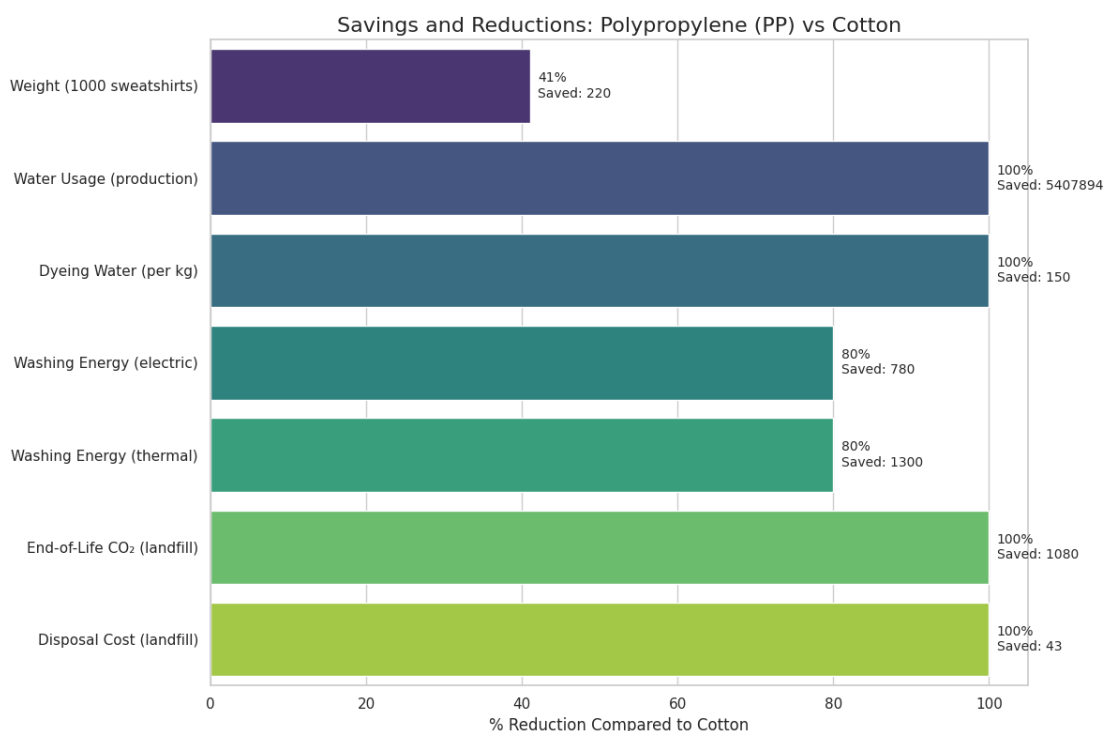
For 540 kg of sweatshirts, incineration would produce about **540-1080 kg of CO<sub>2</sub>**.

### Economic Cost of cotton:

- **Transport and landfill disposal:** Disposal costs vary by country and local policies. In European countries, for example, the average costs for landfill disposal can range between 80 and 150 euros per ton of waste.
- **Incineration:** Incineration can be more expensive, with costs ranging from 100 to 200 euros per ton.

## Summary Table: Environmental & Economic Savings (PP vs. Cotton)

| Category                               | Polypropylene (PP) | Cotton              | Savings (PP vs. Cotton) | % Reduction        |
|----------------------------------------|--------------------|---------------------|-------------------------|--------------------|
| Weight (1000 sweatshirts)              | 320 kg             | 540 kg              | 220 kg less             | <b>41% lighter</b> |
| Water Usage (production)               | 106 liters         | 5,408,000 liters    | 5,407,894 liters less   | <b>~100% less</b>  |
| Dyeing Water (per kg)                  | 0 liters           | 150 liters          | 150 liters less         | <b>100% less</b>   |
| Washing Energy (electric)              | 96–192 kWh         | 972–1,350 kWh       | 780–1,158 kWh less      | <b>80–86% less</b> |
| Washing Energy (thermal)               | 160–320 MJ         | 1,620–2,430 MJ      | 1,300–2,110 MJ less     | <b>80–87% less</b> |
| End-of-Life CO <sub>2</sub> (landfill) | 0 kg (recyclable)  | 1,080–1,620 kg      | 100% reduction          | <b>100% less</b>   |
| Disposal Cost (landfill)               | €0 (reusable)      | €43–81 (for 540 kg) | 100% cost saved         | <b>100% less</b>   |



## Additional Savings with RFID Tracking

Implementing **RFID (Radio-Frequency Identification)** for tracking hospital sweatshirts further improves efficiency:

## 1. Operational Savings

- **Reduced Losses:** Prevents garment loss (typical loss rates in hospitals: **10–20%**).
  - **Savings:** Avoid repurchasing **100–200 sweatshirts/year** (€2,000–€4,000 saved).
- **Optimized Laundry Cycles:**
  - Tracks wash counts, extending garment lifespan by **15–30%**.
  - Reduces replacement costs by **~€3,000/year** (for 1,000 sweatshirts).

## 2. Energy & Labor Savings

- **Automated Inventory:** Saves **5–10 hours/week** in manual tracking.
- **Smart Washing:** RFID triggers:
  - **Cold wash only** for PP (avoiding accidental hot washes).
  - **Reduced rewashing** (saving **5–10% water/energy**).

## 3. Environmental Impact

- **Less Waste:** Fewer lost/discarded garments = **lower CO<sub>2</sub> from production/disposal**.
- **Data-Driven Sustainability:** Monitors real-time usage to optimize stock (reducing overproduction).

## Combined Benefits (PP + RFID)

| Metric                    | PP Alone               | PP + RFID       | Additional Savings    |
|---------------------------|------------------------|-----------------|-----------------------|
| Lifespan Extension        | 20% longer             | 30–50% longer   | <b>+10–30%</b>        |
| Annual Cost Savings       | ~€5,000 (energy/water) | ~€8,000–€10,000 | <b>+€3,000–€5,000</b> |
| CO <sub>2</sub> Reduction | ~3,000 kg/year         | ~4,500 kg/year  | <b>+1,500 kg/year</b> |

**Conclusion:** Switching to **PP sweatshirts + RFID tracking** maximizes savings:

- **Up to 87% less energy/water.**
- **~€10,000/year cost reduction.**
- **Near-zero textile waste.**

### Operational Savings

- Reduced Losses: Prevents 100–200 sweatshirt losses/year (€2,000–€4,000 saved)
- Optimized Laundry: Extends lifespan by 15–30%, saves ~€3,000/year

### Energy & Labor Savings

- Automated Inventory: Saves 5–10 hours/week
- Smart Washing: Cold wash for PP, 5–10% water/energy savings

### Environmental Impact

- Less Waste: Fewer lost/discarded garments
- Data-Driven Sustainability: Optimized stock reduces overproduction



### Combined Benefits (PP + RFID)

- Lifespan Extension: +10–30% over PP alone
- Annual Cost Savings: +€3,000–€5,000
- CO<sub>2</sub> Reduction: +1,500 kg/year

### Conclusion

- Up to 87% less energy/water
- ~€10,000/year cost reduction
- Near-zero textile waste

## Technical Comparison: Cotton, Polyester, and Polypropylene

### 1. Water Absorption

| Fiber Type    | Absorption Rate (%) | Notes                 |
|---------------|---------------------|-----------------------|
| Polypropylene | <b>&lt;0.03</b>     | Negligible absorption |
| Polyester     | <0.9                | Low absorption        |
| Cotton        | 25–30               | High absorption       |

### 2. Specific Weight

| Fiber Type    | Density (g/cm³) | Relative Weight Increase Compared to PP |
|---------------|-----------------|-----------------------------------------|
| Polypropylene | <b>0.91</b>     | –                                       |
| Polyester     | 1.38            | +51%                                    |
| Cotton        | 1.54            | +69%                                    |

**Observation:** PP offers more bulk and coverage per unit weight.

### 3. Thermal Conductivity

| Fiber Type    | Thermal Conductivity (W/mK) | Performance                             |
|---------------|-----------------------------|-----------------------------------------|
| Polypropylene | <b>0.22</b>                 | Excellent insulation, low heat transfer |
| Polyester     | 0.05                        | Moderate insulation                     |
| Cotton        | 0.04                        | Loses insulation when wet               |

### 4. Thermal Insulation

| Fiber Type    | Heat Transmission Coefficient | Insulation Quality      |
|---------------|-------------------------------|-------------------------|
| Polypropylene | <b>6.0</b>                    | High (best performance) |
| Polyester     | 7.0                           | Good                    |
| Cotton        | 17.5                          | Poor when humid         |

Lower coefficient indicates better heat retention.

### 5. Thermal & Thermodynamic Properties

- **Polypropylene:** Melts at ~160°C, resistant to heat but less durable under high-temperature stress. **Autoclavable:** steam at 120°C, Sterrad (all cycles), gamma rays.
- **Polyester:** Handles up to ~250°C but melts under intense heat.

- **Cotton:** High-temperature tolerance, degrades above 150°C.

## 6. Performance in Extreme Cold

- **Polypropylene:** Excellent performance in cold environments.
- **Polyester:** Flexible, reliable insulation.
- **Cotton:** Becomes rigid, less comfortable.

## 7. Flame REACTION

| Fiber Type    | Flame Reaction                              |
|---------------|---------------------------------------------|
| Polypropylene | Self-extinguishing when removed from flame* |
| Polyester     | Flame-retardant, melts rather than burns    |
| Cotton        | Highly flammable                            |

\*UNI 846 Fire Test (Respectlife): Category 1

## 8. Color Fastness

| Fiber Type    | Resistance to Fading                             |
|---------------|--------------------------------------------------|
| Polypropylene | High resistance; pigments integrated in polymer* |
| Polyester     | Excellent; intrinsic pigmentation                |
| Cotton        | Fades over time with sunlight and washing        |

\*Xenotest ISO 105B02 (Respectlife): Score ≥ 5/6 on blue scale

## 9. Hypoallergenicity and Biocompatibility

### **Skin Irritation and Allergies**

#### Polypropylene (PP)

- Inert and hypoallergenic; FDA-approved for medical use (e.g., masks, sutures) (source: FDA CFR Title 21).
- Moisture-repellent, reducing bacterial growth (source: \*Journal of Biomedical Materials Research\*, 2018).

#### Polyester

- Synthetic and less breathable; may cause skin irritation in sensitive individuals.
- Can release microfibers and may contain finishing chemicals unless Oeko-Tex® certified.

#### Cotton

- Natural and breathable, but can retain allergens (dust mites, pollen) if untreated.
- Non-certified fabrics may contain chemical residues (e.g., formaldehyde, heavy metals) from farming or dyeing (source: ECHA).

### **Biocompatibility**

Polypropylene (PP) • Used in surgical implants for resistance to foreign body reactions (source: ISO 10993-1:2018).

Polyester • Biocompatibility varies by formulation; generally not used in implants due to lower tolerance by the immune system.

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Cotton • Prone to mold growth in humid environments—a risk for immunocompromised patients (source: CDC Guidelines).

### 10. Acid and Base Resistance Comparison Table

| Property                     | Polypropylene                                                                                                                                                                    | Polyester                                                                                                                                 | Cotton                                                                                       |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| <b>Acid Resistance</b>       | <i>Excellent</i> – Resists most mineral acids (HCl, H <sub>2</sub> SO <sub>4</sub> , HNO <sub>3</sub> ). <i>Weak</i> against strong oxidizers (oleum, fuming HNO <sub>3</sub> ). | <i>Good</i> – Resists dilute acids (acetic, citric). <i>Poor</i> against concentrated H <sub>2</sub> SO <sub>4</sub> , HNO <sub>3</sub> . | <i>Moderate to Poor</i> – Degrades in strong acids unless treated (e.g., aldehyde finishes). |
| <b>Base Resistance</b>       | <i>Excellent</i> – Highly resistant to NaOH, KOH, and other strong bases.                                                                                                        | <i>Poor</i> – Degrades in strong alkalis (NaOH, KOH) due to hydrolysis.                                                                   | <i>Poor</i> – Cellulose breaks down in strong bases (e.g., mercerization in NaOH).           |
| <b>Moisture Absorption</b>   | <b>Very low</b> (hydrophobic).                                                                                                                                                   | <b>Low</b> (but absorbs slightly more than PP).                                                                                           | <b>High</b> (prone to hydrolysis).                                                           |
| <b>Scientific References</b> | HMC Polymers Chemical Guide, Engineering Toolbox, Calpac Lab Charts                                                                                                              | Rubber & Seal Guide, Allbro GRP Chemical Chart                                                                                            | Wiley Polymer Science, BMC Plant Biology, Frontiers in Plant Science                         |

- **Polypropylene** is the most chemically resistant of the three, especially in both acidic and basic environments.
- **Polyester** performs well in acidic and neutral conditions but breaks down in alkaline environments due to ester bond hydrolysis.
- **Cotton**, being a natural cellulose fiber, is sensitive to both strong acids and bases unless chemically treated.

## Technical Comparison: Cotton vs. Polyester vs. Polypropylene

| Property                  | Polypropylene                               | Polyester                                     | Cotton                                  |
|---------------------------|---------------------------------------------|-----------------------------------------------|-----------------------------------------|
| Water Absorption (%)      | <0.03 (negligible)                          | <0.9 (low)                                    | 25–30 (high)                            |
| Specific Weight (g/cm³)   | 0.91 (lightweight)                          | 1.38 (+51% vs. PP)                            | 1.54 (+69% vs. PP)                      |
| Thermal Conductivity      | 0.22 W/mK<br>(excellent insulation)         | 0.05 W/mK (moderate)                          | 0.04 W/mK<br>(poor when wet)            |
| Thermal Insulation        | Coefficient: 6.0<br>(best)                  | Coefficient: 7.0 (good)                       | Coefficient: 17.5<br>(poor when damp)   |
| Heat Resistance           | Melts at ~160°C;<br>autoclavable (120°C)    | Melts at ~250°C                               | Degrades above<br>150°C                 |
| Cold Weather Performance  | Excellent (flexible)                        | Good                                          | Stiff/uncomfortable                     |
| Flame Reaction            | Self-extinguishing<br>(UNI 846 Category 1)  | Flame-retardant (melts)                       | Highly flammable                        |
| Color Fastness            | High<br>(pigments integrated<br>in polymer) | Excellent                                     | Fades<br>with washing/light<br>exposure |
| Hypoallergenic Properties | Hypoallergenic<br>(FDA-approved)            | Potential irritation<br>(microfiber shedding) | Traps allergens<br>(dust mites, pollen) |
| Bacteria growth           | NO                                          | High                                          | YES                                     |
| Chemical Resistance       | Acids: Excellent<br>Bases: Excellent        | Acids: Good<br>Bases: Poor                    | Acids/Bases: Poor<br>(unless treated)   |

## Environmental Impact

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### CO<sup>2</sup> per kg

#### CONVENTIONAL COTTON

##### Global average value:

- ~8.1 kg CO<sub>2</sub>eq/kg – Quantis (2018)
- 5–10 kg CO<sub>2</sub>eq/kg average value, but it can exceed 20 kg – Textile Exchange (2021)

##### Why this variability?

- Irrigation: Cotton grown in arid regions (e.g., India, Pakistan) requires more energy for water, increasing emissions.
- Fertilizers: The production of nitrogen-based fertilizers is highly CO<sub>2</sub>-intensive.
- Transport and processing.

##### Full sources

**Textile Exchange** (2021). *Preferred Fiber & Materials Market Report*.

**Quantis** (2018). *Measuring Fashion Report*.

**Water Footprint Network** (2015). *Water Footprint Assessment of Cotton*.

**Journal of Cleaner Production** (2017). *LCA of Cotton Production Systems*.

#### VIRGIN POLYESTER

##### Global average value:

- ~6.4 kg CO<sub>2</sub>eq/kg – CO<sub>2</sub> Everything (2025)
- 5–10 kg CO<sub>2</sub>eq/kg – Carbonfact (2025)\*

\* depending on the process and energy source

##### Why this variability?

- Energy-intensive processes: Production requires heat and pressure, often powered by non-renewable sources.
- Limited recycling: Virgin polyester has a higher footprint than recycled polyester, which can reduce emissions by up to 30–50%.

##### Full sources

**Carbonfact** (2025). *The Carbon Footprint of Polyester*

**CO<sub>2</sub> Everything** (2025). *Polyester Carbon Footprint*

**LUT University** (2024). *Polyester Production: Transitioning from Fossil Fuels to Sustainable Alternatives*

**MDPI Sustainability Journal** (2024). *Carbon Footprint Analysis in Textile Industry*

#### VIRGIN POLYPROPYLENE

##### Global average value:

- ~1.7–2.0 kg CO<sub>2</sub>eq/kg – LUT University (2024), MDPI (2024)
- May range from 1.5 to 2.5 kg CO<sub>2</sub>eq/kg – Basell Poliolefine Italia (2005)\*

\*depending on energy efficiency and the energy mix used

##### Why this variability?

Spheripol process: One of the most efficient methods for producing PP, with loop reactors and Ziegler-Natta catalysts that reduce energy consumption.

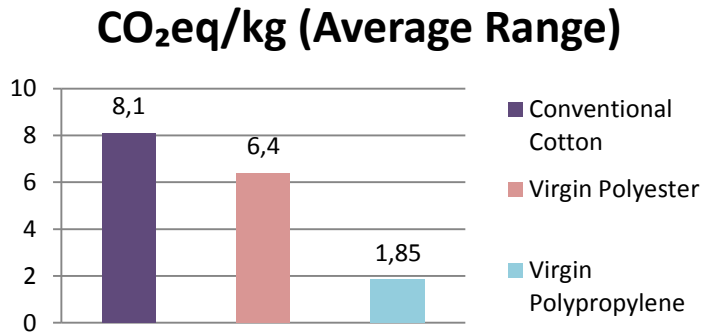
Energy sources: The CO<sub>2</sub> footprint depends on the type of energy used (e.g. natural gas vs. renewables).

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## Full sources

Basell Poliolefine Italia (2005). Technical report on polypropylene production – Italian Ministry of Environment  
LUT University (2024). Polypropylene Production: Transitioning from Fossil Fuels to Sustainable Alternatives  
MDPI Sustainability Journal (2024). Carbon Footprint Analysis in Textile Industry

| Material             | CO <sub>2</sub> eq/kg (Average Range) |
|----------------------|---------------------------------------|
| Conventional Cotton  | 8,1                                   |
| Virgin Polyester     | 6,4                                   |
| Virgin Polypropylene | 1,85                                  |



## Water Consumption and Land Use

### CONVENTIONAL COTTON

#### Global average value:

- o 10,000–20,000 litres of water per 1 kg (source: Water Footprint Network).
- o Requires 5.3 m<sup>2</sup> of land per 1 kg (source: FAO, 2020).
- o Pesticides and fertilizers: Conventional cotton uses 16% of the world's insecticides and 7% of its pesticides (source: PAN Europe).

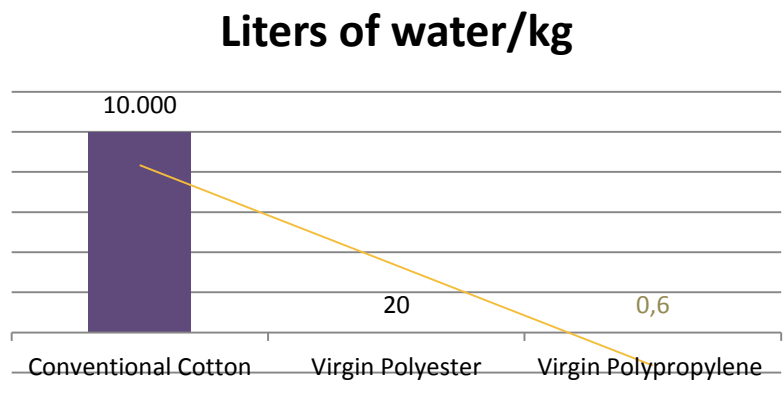
### POLYESTER

- o 20 litres of water per 1 kg (source: Textile Exchange).
- o No agricultural land use (derived from petroleum/gas).

### POLYPROPYLENE

- o 0.6 litres of water per 1 kg (source: Plastics Europe).
- o No agricultural land use (derived from petroleum/gas).

| Material             | Liters of water/kg |
|----------------------|--------------------|
| Conventional Cotton  | 10.000             |
| Virgin Polyester     | 20                 |
| Virgin Polypropylene | 0,6                |



## Full sources

Textile Exchange / Water Footprint Network (2017): Water Footprint Assessment of Polyester and Viscose.  
ICAC – International Cotton Advisory Committee (2025): Water Footprint in Cotton 2020–2024: A Global Analysis.  
FAO (2020): Land Use Statistics and Indicators

## Dyeing process

### COTTON

- ~150 L/kg of water required for reactive dyeing—the most common dyeing method for cotton.
- This process uses approximately 0.6–0.8 kg of salt (NaCl) and ~40 g of reactive dye per kilogram of fabric. *Source: Environment & Ecology, 2017*

### POLYESTER

- Modern dyeing methods (low-liquor ratio machines): 40–80 L/kg
- Traditional dyeing processes: 100–150 L/kg. *Source: European Commission, 2021*

### Chemical Use – Reactive Dyeing *traditional* fabrics

| Category  | Parameter                                  | Range               | Unit  |
|-----------|--------------------------------------------|---------------------|-------|
| CHEMICALS | Salt (NaCl o $\text{Na}_2\text{SO}_4$ )    | 0.5-1               | kg/kg |
|           | Alkalies (NaOH, $\text{Na}_2\text{CO}_3$ ) | 5-20                | g/kg  |
|           | Dye                                        | 30-60 (20-50% lost) | g/kg  |
| POLLUTION | COD (Chemical Oxygen Demand)               | 50-200              | g/kg  |
|           | Dissolved Salt (TDS)                       | 2-10                | kg/kg |
|           | Heavy Metals (Cr, Cu)                      | Traces              | -     |

Fonts: EU BAT (2021), OECD (2017), Textile Exchange (2020)

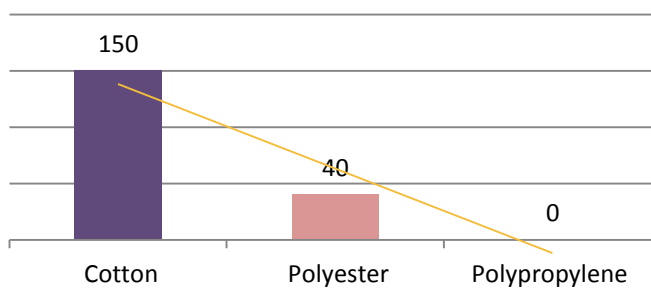
### POLYPROPYLENE

- 0 liter of water consumption and no dye release in wastewater.
- Pigments are directly added to the molten polymer prior to spinning (extrusion), fully eliminating the need for post-production dyeing.

| Parameter  | Mass Pigmentation        |
|------------|--------------------------|
| Water      | 0 L/kg                   |
| Energy     | Reduced (extrusion only) |
| Chemical   | NO                       |
| Free dye   | NO                       |
| Efficiency | 100% pigment fixation    |

| Material      | Liters of water/kg |
|---------------|--------------------|
| Cotton        | 150                |
| Polyester     | 40                 |
| Polypropylene | 0                  |

### Liters of water/kg dyeing



**Full sources** OECD (2017), *Environmental Impact of the Textile and Clothing Industry*.  
 Environment & Ecology (2017), *Impact of Textile Dyes on Water Bodies*.  
 Textile Exchange (2020), *Preferred Fiber & Materials Market Report*.  
 EU BAT Reference Document for the Textile Industry (2021)  
 Textile World (2020) – "Mass Pigmentation: A Dry Solution for Synthetic Fibers"

## ENVIRONMENTAL IMPACT OF TRADITIONAL DETERGENT CHEMICAL COMPONENTS

### RESOURCE CONSUMPTION FOR WASHING

| Parameter     | Range                   | Fonts               |
|---------------|-------------------------|---------------------|
| Water         | 40-80 L                 | EU Ecolabel (2022)  |
| Surfactants   | 15-30 g (fosfati <0.5g) | ICEA (2023)         |
| CO2 Emissions | 0.3–1.2 kg per wash     | Carbon Trust (2023) |

(Ranking of 8 impact categories in Europe – Source: JRC European Commission, 2021)

1. Freshwater Eutrophication
  - → **+50%** Phosphates and phosphonates impact (even at low concentrations)  
 Source: *EPA Detergent Impacts Report (2020)*
2. Human Toxicity / Carcinogenicity
  - → **12%** of tested detergents exceed WHO limits Source: *EWG (2023)*
  - **1,4** dioxane (residue from SLES/SLS)
3. Aquatic Toxicity
  - → **1 µg/L** Nonylphenol ethoxylate (NPE) is enough to harm aquatic organisms  
 Source: *Regulation (EU) 2019/1021*

### COMPARISON OF WASHING TEMPERATURES

| Temperature | Electricity Consumption (kWh/kg) | Thermal Energy Consumption (MJ/kg) |
|-------------|----------------------------------|------------------------------------|
| 30°C        | 0.3–0.6                          | 0.5–1.0                            |
| 60°C        | 1.2–1.8                          | 2.0–3.0                            |
| 75°C        | 1.8–2.5                          | 3.0–4.5                            |

#### Environmental Impact

- **0.8–1.2 kg CO<sub>2</sub>/kg** CO<sub>2</sub> equivalent (at 75°C, EU energy mix) Source: JRC, 2023
- Micro-plastics released: At 75°C, polyester **releases 2–3×** more fibers compared to 30°C Source: Nature Sustainability, 2020

#### ENVIRONMENTAL IMPACT OF NANO-WASH

##### **NanoWash detergent**

is a concentrated nano-technology detergent designed for washing Respectlife fabrics. Thanks to its advanced formula, it effectively removes tough stains (oil, ink, wine) even at low temperatures (20-30°C), reducing energy consumption by 25-40% compared to conventional detergents.

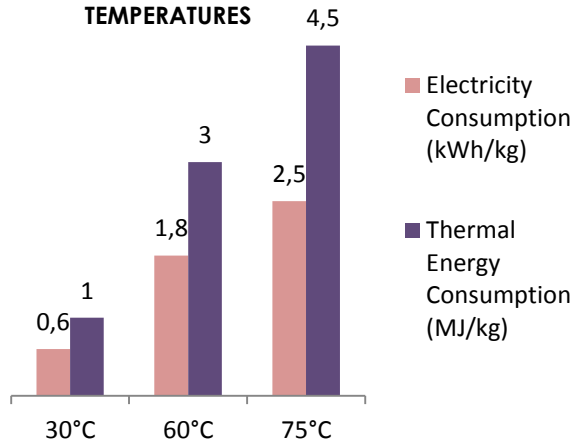
NanoWash's ability to work effectively at low temperatures (cold wash) is a key factor in limiting microfiber release from synthetic fabrics.

Studies show that washing at 30°C vs. 60°C reduces micro-plastic shedding by 50% (Nature Sustainability, 2020).

Additionally, its non-corrosive components preserve fiber integrity, minimizing the wear that contributes to particle dispersion.

| Parameter             | Value                |
|-----------------------|----------------------|
| Type                  | Nano-tech detergent  |
| Density               | 1 kg/m <sup>3</sup>  |
| Nanoparticle size     | 60 nm                |
| Washing temperature   | Cold wash compatible |
| Ph.                   | 7 to 10              |
| Surfactants           | ≥15%                 |
| Phosphates/corrosives | NO                   |
| Biodegradable         | YES                  |

COMPARISON OF WASHING  
TEMPERATURES



**Full sources:**

**European Commission** (2021), *Best Available Techniques for Textile Washing*

**IUCN** (2017), *Primary Micro-plastics in the Oceans*

**Nature Sustainability** (2019), *Microfiber Release vs. Washing Parameters*

**Plastic Soup Foundation** (2023), *Annual Report on Micro-plastic Filters*

## IMPATTI AMBIENTALI DEI DETERGENTI TRADIZIONALI vs NANOWASH



### DETERGENTI TRADIZIONALI



Freshwater  
Eutrophication  
+50% impatto  
da fosfati  
(EPA, 2020)



12% superano  
i limiti OMS;  
presenza di  
1,4-diossano  
(EWG, 2023)



1 µg/L di NPE può  
danneggiare  
flora e fauna  
(EU 2019/1021)



Lavaggi ad alte  
temperature  
aumentano  
la dispersione



### NanoWash (Eco-friendly)



Nessun fosfato:  
riduzione del  
rischio di  
eutrofizzazione  
(EWG, 2023)



Nessun composto  
cancerogeno:  
sicuro su pelle  
e tessuti  
(EU 2019/1021)



Formula  
biodegradabile:  
nessun NPE  
né interferenti  
(Nature Sustainability,  
2020)



Non corrosivo:  
mantiene l'integrità  
delle fibre

## Recycling and disposal rates

Summary of data on cotton and polyester textile recycling within the European waste management system: General context (EU-27, year 2020)

The European Union generated about **6.95 million tons of textile waste** (around **16 kg per person**). Only a tiny fraction (**less than 1%**) of textile waste is turned back into new clothing.

## End-of-Life

### Cotton

Recycled cotton fibers are shorter and less strong, so they are often blended (for example, with virgin cotton or polyester) to improve yarn quality.

### Polyester

Polyester recycling is mostly done through mechanical or thermo-mechanical processes, with some emerging chemical or enzymatic innovations (e.g., Circloo, Reo Eco) ([sciencedirect.com], [voguebusiness.com]).

## Environmental cost per 1 kg of traditional fabric

### Landfill

When a cotton garment ends up in a landfill, it decomposes slowly, releasing methane (CH<sub>4</sub>), a powerful greenhouse gas.

For cotton textiles, landfill disposal is estimated to produce on average:

- **2 to 3 kg of CO<sub>2</sub> equivalent per kg** (including transport and decomposition).

Economic Cost per 1 kg of Cotton Waste in Europe

- **~ €80–150 per ton ⇒ €0.08–0.15 per kg**

### Incineration

Incineration reduces waste volume but produces CO<sub>2</sub> and other pollutants.

For cotton textiles, incineration is estimated to produce on average:

- **1–2 kg of CO<sub>2</sub> per kg.**

Economic Cost per 1 kg of Cotton Waste in Europe

- **~ €100–200 per ton ⇒ €0.10–0.20 per kg**

## Recycling environmental cost per 1 kg of cotton

Mechanical recycling (especially pre-consumer) has a much lower footprint than landfill or incineration.

For cotton textiles, textile-to-textile recycling is estimated to produce on average:

- **0.5–1.1 kg of CO<sub>2</sub>e per kg of mechanically recycled cotton.\***  
This value depends on material contamination and transport distance.  
\*Source: McKinsey (2022), Resortecs (2024).

## Recycling environmental cost per 1 kg of polyester (pet)

Recycled polyester from bottles (rPET) has a lower impact than virgin polyester.

However, textile-to-textile polyester recycling (not from bottles) is still developing and has higher costs and impacts. McKinsey estimate (2023):

For polyester textiles, textile-to-textile recycling is estimated to produce on average:

- **1.5–2.5 kg of CO<sub>2</sub> e per kg.**  
This value is higher than cotton due to more energy-intensive thermochemical processes.

## *Respectlife's 100% pure pp recycling methods*

- **New raw material:** The regenerated granules can be used to produce new yarn, pellet and a variety of plastic items, such as containers, packaging, toys, ecc..

"The damage caused by plastic recycling operations is two orders of magnitude lower than that caused by the production of virgin polymer."

Respectlife srl Via della Torretta, 7 Pavia Italy mail: [info@respectlife.it](mailto:info@respectlife.it)

- **Energy recovery:** programs divert plastics from landfills and result in using those materials to generate an added source of energy. The overall sustainability profile of energy recovery is positive.

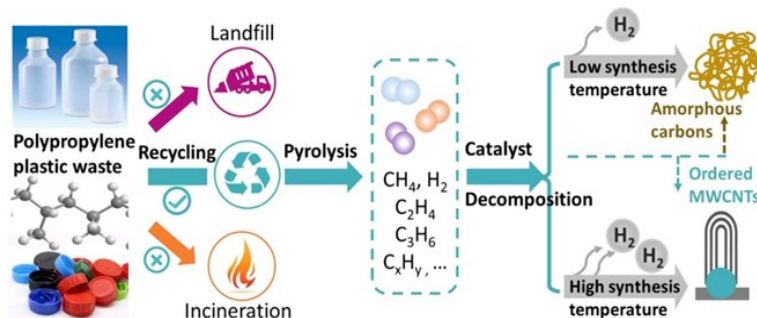
The U.S. Environmental Protection Agency (EPA) recognizes energy recovery as an advantageous end-of-life approach, stating that it is a "clean, reliable, renewable source of energy" with a lower total environmental impact than most other energy sources.

**Hydrogen from plastics** waste, European Program IPCEI Hy2Use (Important Project of Common European Interest – Hydrogen Technologies and Systems) these program involves 35 projects in 13 EU countries will receive up to €5.2 billion in public funding, which is expected to attract an additional €7 billion in private investments.

Hydrogen Production Sites – **IPCEI Hy2Use** (EU Project)

1. **Rome, Italy** – NextChem / Maire Tecnimont
  - o Development of a waste-to-hydrogen plant at the core of the Hydrogen Valley of Rome.
  - o Initial capacity: 1.5 kt H<sub>2</sub>/year, scalable up to 20 kt H<sub>2</sub>/year, processing 200 kt of non-recyclable waste annually.
2. **Sarroch, Sardinia** (Italy) – SardHy Green Hydrogen
  - o A 20 MW electrolyzer powered by renewable energy, developed by Enel Green Power and Saras.

Located at an existing industrial site, producing green hydrogen.



## SIMPLIFIED SUMMARY TABLE END OF USE

of the key data on textile recycling and disposal rates in Europe (EU-27, 2020)

### Textile Waste & Recycling Overview (EU, 2020)

| Metric                        | Value                            |
|-------------------------------|----------------------------------|
| Total textile waste generated | 6.95 million tons (16 kg/person) |
| % recycled into new clothing  | <1%                              |

### Recycling Methods & Challenges

| Material  | Recycling Process                                                                     | Key Issues                                                       |
|-----------|---------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Cotton    | Mechanical recycling (often blended with virgin cotton/polyester)                     | Shorter, weaker fibers; requires mixing                          |
| Polyester | Mostly mechanical/thermo-mechanical; some chemical/enzymatic (e.g., Circloo, Reo Eco) | Higher energy use; textile-to-textile recycling still developing |

### Environmental Cost (CO<sub>2</sub>e per 1 kg) (Textile-to-Textile)

| Disposal Method | Cotton                       | Polyester                    |
|-----------------|------------------------------|------------------------------|
| Landfill        | 2–3 kg CO <sub>2</sub> e     |                              |
| Incineration    | 1–2 kg CO <sub>2</sub> e     |                              |
| Recycling       | 0.5–1.1 kg CO <sub>2</sub> e | 1.5–2.5 kg CO <sub>2</sub> e |

### Economic Cost (Europe, per 1 kg)

| Disposal Method | €         |
|-----------------|-----------|
| Landfill        | 0.08–0.15 |
| Incineration    | 0.10–0.20 |

### Plastic (PP) Recycling & Hydrogen Projects

- 100% Pure PP Recycling**
  - Recycled into pellets for yarn, containers, toys, etc.
  - EPA-approved: Energy recovery from plastic is cleaner than virgin production.
- EU Hydrogen from Waste (IPCEI Hy2Use)**
  - Rome, Italy:** 1.5–20 kt H<sub>2</sub>/year from non-recyclable waste (NextChem).
  - Sardinia, Italy:** 20 MW green hydrogen plant (Enel/Saras).
  - Total funding: €5.2 billion (public) + €7 billion (private).

### Key Takeaways

- <1% of EU textile waste becomes new clothes.
- Cotton recycling** has the lowest CO<sub>2</sub> impact (0.5–1.1 kg/kg vs. 2–3 kg/kg for landfill).
- Polyester recycling** is energy-intensive (1.5–2.5 kg CO<sub>2</sub>e/kg).
- Waste-to-hydrogen** projects in Italy aim to turn non-recyclable waste into clean energy.

# RESPECTLIFE'S

## 100% PURE PP RECYCLING METHODS

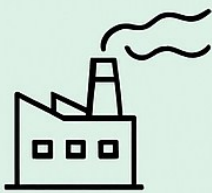


### New raw material

The regenerated granules can be used to produce new yarn, pellets and a variety of plastic items, such as containers, packaging, toys, etc.

*"The damage caused by plastic recycling operations is two orders of magnitude lower than that caused by the production of virgin polymer."*

*Life Cycle Analysis of Possible Plastic Disposal Scenarios (Luca Ferrari)*



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Programs divert plastics from landfills and result in using those materials to generate a added source of energy

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*Hydrogen from plastics waste, European Program IPCEI*

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A 20 MW electrolyzer powered by renewable energy.

## **Empowering Sustainable Business: Circular Innovation in Professional Textiles**

*Respectlife Srl & Elis Italia S.p.A.*

### **Achieved Objectives**

- **Environmental sustainability:**

Up to 99% reduction in water consumption and CO<sub>2</sub> impact via polypropylene (PP) garments.

- **Operational efficiency:**

RFID tracking and smart washing reduced waste, losses, and costs.

- **Technical innovation:**

PP excels in lightness, durability, hygiene, and comfort.

- **Circular economy:**

PP is fully recyclable and supports energy recovery and hydrogen production.

### **Strategic Partnership**

This synergy between technological innovation and industrial service shows how sustainability can be integrated into daily processes, generating economic, environmental, and social value.

**Respectlife and Elis Italia share a common vision:**

*"To make professional textiles a model of circular economy, traceable, efficient, and zero-impact."*

### **Future Prospects**

- Extending the model to other garments and sectors (industry, catering, logistics).
- Integration with AI for predictive lifecycle management.
- Collaborations with public and healthcare entities to promote sustainable textiles.