HANDOUT · 1st Argentine Congress of Sustainability (SAPROCEA)

Recovery and Recycling of Polypropylene Big Bags (FIBC)

Reverse logistics network design and evidence from a life cycle assessment

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THE SHORT VERSION

- **Big bags are made of polypropylene, a plastic that can be reused and recycled.** Most still end up in landfill or are incinerated.
- **The problem is not the material.** The problem is getting empty bags back, clean and with a known history.
- **In our life cycle assessment, the circular system cut climate impact by 91.5%** compared with the linear one. The other three impacts we measured also fell by 44.7% to 87.0%.
- **In our scenario, a bag must be reused about 4 to 6 times** to pay off for the environment. This is an assumption to test, not a proven limit.
- **Argentina already has a take-back system** for empty farm chemical containers (Law 27,279 and Campo Limpio). The same idea could be tested for big bags.

1. WHERE THIS WORK COMES FROM

This handout is based on a master's thesis written at Rosenheim and submitted in January 2026. Its title is "Evaluating and Transitioning the Supply Chain of Flexible Intermediate Bulk Containers (FIBC): Closed-Loop and Open-Loop Recycling, Environmental Impact, and Reverse Logistics through Life Cycle Assessment." It does three things:

- It maps the whole big bag supply chain, from raw material to end of life.
- It compares **open-loop recycling** (the plastic is turned into lower-value products and leaves the big bag market) with **closed-loop recycling** (the plastic is turned back into bags or similar products and stays in the market).
- It runs a life cycle assessment (LCA) that links environmental impact to how the return system is designed.

An LCA adds up the environmental effects of a product over its whole life: making the material, producing the product, using it and disposing of it. If two systems are calculated in the same way, their results can be compared fairly. That is what we did for the linear and the circular big bag system.

2. THE PROBLEM: A MATERIAL WE THROW AWAY BY DESIGN



A FIBC (flexible intermediate bulk container), or "big bag"

A FIBC is a large woven polypropylene sack with lifting loops. It often carries 1,000 kg of product and weighs only about 2 kg itself. It is very useful, but the bag alone has very little material value. That is exactly why it is often used just once.

Big bags are among the highest-volume industrial packaging formats in the world. They carry grain, seed, fertilizer, minerals and chemicals. The vast majority end up in landfill or incineration, although polypropylene itself is well suited to reuse and to mechanical recycling (shredding, washing and melting the plastic into new granules).
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> The problem is not the material: polypropylene is recyclable. The problem is reverse logistics. Reverse logistics means moving a product backwards, from the user back to a point where it can be reused or recycled.

2.1. Not all big bags are the same:

The standard ISO 21898 sets the **safety factor (SF)**. This is how many times stronger the bag is than the load it is rated for. A higher factor means a bag that is built and tested to stay safe under more demanding conditions:

- **5:1, single trip.** Built and tested for one use only. Reuse is not allowed under the standard, even if the bag looks fine.
- **6:1, multi-trip.** Designed for repeated cycles. Standard in closed-loop systems, food and pharma.
- **8:1, dangerous goods.** UN-certified designs.

There is no fixed number of reuse cycles. At every cycle, the loops, seams, UV damage and contamination must be checked. A multi-trip bag is therefore not "good for N uses"; it is good for as long as each inspection says it is safe.

2.2. How bags are used in practice in Argentina:

- **Agriculture (grain, seed, feed):** seasonal peaks, long rural distances, outdoor storage, and often no return infrastructure at the farm.
- **Fertilizers and chemicals:** large volumes and contents that can contaminate. What is left inside decides if reuse or recycling is even possible.
- **Mining and minerals:** abrasive contents and rough handling wear the bag out, whatever its safety factor.
- **Construction:** one delivery, one use, and the bag is often left on site. Throwing it away is cheaper than organizing a return.

> A big bag is rarely retired because it is worn out. It is retired because nobody knows where to send it or what it contained.

2.3. A network problem, not a technology problem:



Three reasons used big bags do not come back

Once a bag is delivered, ownership passes to the receiver, who has no business reason to care what happens to it. Sending an empty bag back is not worth it on its own, because the bag has little value for the space it takes. And without a record of where a bag has been, it cannot be certified for another trip. So, this is a question of network design and who is responsible for what.

3. THE EVIDENCE: WHAT THE LIFE CYCLE ASSESSMENT SHOWS

3.1. How we measured:

We followed ISO 14040 and ISO 14044 and used GaBi software with the CML 2001 method. We looked at four impacts: global warming, acidification, eutrophication (nutrient pollution of water), and fossil resource depletion. **Global warming:** greenhouse gas emissions, expressed in kg CO_2e (kilograms of CO_2 equivalent):

- **Acidification:** emissions that acidify soil and water.
- **Eutrophication:** nutrient pollution of water.
- **Fossil resource depletion:** use of oil, gas, and coal as energy sources

The main settings of the calculation were:

- **Unit compared:** 1,000 kg of FIBC. Both systems are calculated for this same amount.
- **Data:** literature and industry data, supported by GaBi and ecoinvent 3.8 datasets.

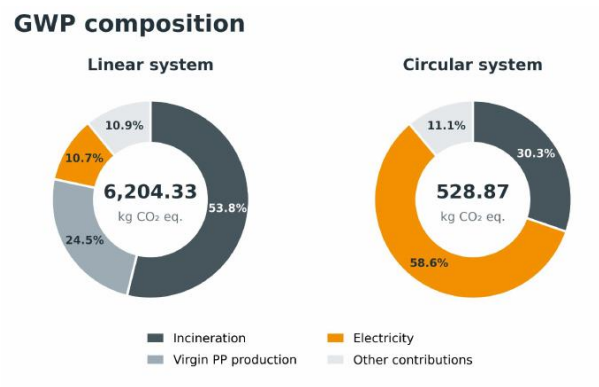
- **Setting:** European recycling plants with German/EU electricity. The results therefore describe a European case, not yet an Argentine one (see “How sure are we?”).
- **Fair split of burdens:** the circular model carries the collection and recycling burdens. Making the first virgin plastic belongs to the first life cycle, so reused material does not carry it again.

3.2. How the two systems work:

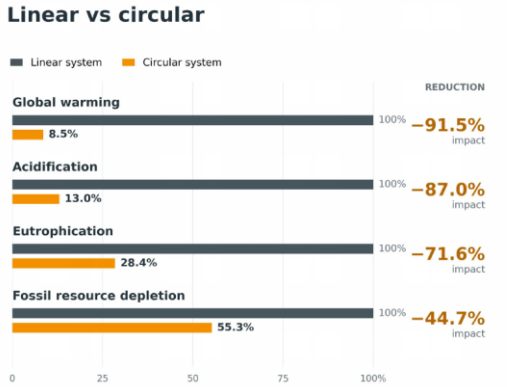
- **Linear:** virgin polypropylene production, bag manufacturing, use, then incineration with energy recovery.
- **Circular:** collection, inspection, cleaning, mechanical recycling, then recycled polypropylene granules. Rejected bags and process residues are treated separately.

3.3. The hotspot moves, and so does what you need to manage:

- **In the linear system, disposal dominates.** Incineration gives 3,340 kg CO_2e (54%) and virgin plastic production gives 1,520 kg (24.5%), out of a total of 6,204.33 kg CO_2e.
- **In the circular system, process energy dominates.** Electricity gives 310 kg CO_2e (58.6%) and burning the rejects gives 160 kg (30%), out of a total of 528.87 kg CO_2e.
- **Electricity use falls from 665 to 310 kg CO_2e,** but it becomes the biggest remaining source. Cleaner electricity and more efficient processes are the next lever, along with fewer contaminated bags and fuller return loads.



Where the climate impact comes from



Circular impact as a share of linear (100%)

Result: the circular system came out lower in all four categories. Climate impact fell by 91.5%, acidification by 87.0%, eutrophication by 71.6%, and fossil resource depletion by 44.7%. In fossil energy terms, that is 8,335 MJ down to 4,605 MJ.

4. THE MODEL: YIELDS, INDICATORS AND THE BREAK-EVEN POINT

Not every collected bag becomes new material. Some bags fail inspection, some material is lost in washing and some in the recycling step itself. In our model, 1,000 kg of collected bags give 785 kg of recycled granules, an overall recovery of 78.5%.



Yield at each step of the circular model

4.1. The reverse logistics model: three pillars:

- **Collection hubs close to heavy users.** A hub is a place where users drop off empty bags. It brings together small, frequent batches, allows early quality checks, and can be shared by several firms.
- **Smart routing on the empty return leg.** This drives the economics, because an empty big bag has so little value for its volume. Big bags fold flat, so they can ride back on trucks that would otherwise return empty.

- **Sorting at the point of generation.** Good bags are separated from contaminated ones where they become empty, and are logged at the hub with RFID or QR codes. The code gives every bag a history that can be checked later.

4.2. What to track:

- **Return rate:** the share of supplied bags that come back (% of bags supplied).
- **Reuse cycles per bag:** how many trips each bag makes before it is retired.
- **Recycled content by mass:** how much of a new bag is made from recycled material.
- **Reverse logistics cost:** the cost of collecting, in € per ton collected.
- **Greenhouse gas emissions per use:** the climate impact of one trip of one bag.

> **BREAK-EVEN: ABOUT 4 TO 6 REUSE CYCLES**
> In our scenario, a reusable bag has to go around about four to six times before it beats single-use for the environment. This is a scenario assumption, not a confirmed threshold. It depends on four things: transport distance, cleaning energy, return rate, and how durable the bag is.

5. TRANSFER TO ARGENTINA: DEMANDING CONDITIONS, SO A USEFUL TEST

Argentina combines several demanding conditions, which makes it a useful test case for a return system. These are the main features of the local situation:

- **Long distances and spread-out rural users.** Collection is expensive. Picking up bags on a truck's return trip can cut transport cost.
- **Strong harvest seasonality.** Material does not flow evenly, which makes planning and plant use harder. This is also a problem in Europe, but a stronger one here.
- **A recycling industry with capacity, but it depends on clean input.** That puts cleaning at the source at the center of the question.
- **Greater Rosario.** It is described as the largest soy product shipping complex in the world. Many agricultural firms and transport services sit close together, so shared collection points could work well.

5.1. The institution already exists, for a different container:

Law 27,279 and the Campo Limpio program require take-back of empty crop-protection containers. The industry pays and farmers return them for free. The program reports about 95 storage centers in 22 provinces and more than 25 million kg recovered, third in the world after Brazil and China.

It also shows the weak spot. In 2025, around 1.3 million kg could not be recycled because the required triple rinse had not been done, which was 33% of what came in. Organizing the return is one half of the job. Organizing a clean return is the other half. That is what our model's 97% washing yield stands for.

5.2. Can four conditions be met here?

- **Shared bag formats.** Technically possible, but an industry association has to lead. The market could do it, but will not on its own.
- **Binding return rules.** Law 27,279 is a precedent. Extending it to big bags would fit the existing system.
- **Steady two-way transport.** Present in the Rosario corridor, missing in thinly populated regions.
- **Professional pooling.** Barely present today. It needs an operator that keeps ownership of the bags. This is the biggest gap, and also an open business opportunity.

> Which of these four can the market create, and which need regulation?



Four conditions for a return loop

6. WHAT WORKS, AND WHAT THE MARKET WILL NOT DELIVER ALONE

Five tools tackle the barriers described above:

- **Deposit-and-return:** the user pays a deposit with the bag and gets it back on return.
- **Shared formats:** common sizes and specifications, so bags can be used by all partners.
- **Pooling:** an operator keeps ownership of the bags, collects them, cleans them and supplies them again.
- **Digital tracking:** each bag has a record of its trips and contents.
- **Extended producer responsibility (EPR):** the companies that put packaging on the market are made responsible for its collection and recovery.

Other industries show that this can work. The automotive industry uses common KLT containers, and CHEP pools and cleans pallets and crates. In both cases, somebody owns the containers and organizes the return. A big bag is worth much less than these, so the cost of the return has to be shared fairly between the companies involved.

When voluntary returns are not enough, regulation can decide who must organize collection and who pays for it.

For Argentine exporters, the European rules are also relevant. Under the EU Packaging and Packaging Waste Regulation (PPWR), recycled content is likely to become a market access question over time.

7. WHAT YOU CAN TAKE HOME

- **Choose the right route.** Check each bag's condition and previous contents before deciding on reuse or recycling.
- **Make returns practical.** Combine local hubs, enough volume and available return trips.
- **Measure the benefits.** Use life cycle data to compare emissions, resource use and material recovery.
- **Make responsibilities clear.** Say who collects the bags, who pays, and how returns are organized.

> **HOW SURE ARE WE?**
> The model uses a European electricity mix and 120 km of return transport. Virgin polypropylene data comes from industry data for 2015–2016, while the circular system was modelled for 2024–2025. With another electricity mix and longer distances, the advantage will change, and we expect it to be smaller. Argentine data is needed to say by how much. We prefer to state this openly rather than defend one number.

The model has parameters that can be changed, and it can be transferred to other settings. You know the Argentine parameters better than we do, and we would be glad to hear them.

Sources used for the Argentine facts

argentina.gob.ar/normativa/nacional/norma-266332 (Law 27,279)
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lagaceta.com.ar, article 1139912 (Campo Limpio and triple rinse)