التعاون الألماني
DEUTSCHE ZUSAMMENARBEIT

Implemented by
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The Hashemite Kingdom Of Jordan
Ministry of Industry , Trade and Supply

Ministry of Environment

Business Case 3: Mechanical Recycling for Fibre-to-Fibre Yarn Production

Introducing Circularity as a Business Opportunity to Jordan's Ready-Made Garment (RMG) Sector

BACKGROUND

The "Green Action in Enterprises" (GAIN) project, commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) *GmbH,* works in close cooperation with the Ministry of Environment, the Ministry of Industry, Trade and Supply and other stakeholders towards the green industrial transition by introducing sustainable use and management of energy, water, and waste in the sector.

In Jordan, the garment manufacturers at Al-Hassan Industrial Estate (HIE) generate 35 tonnes of solid textile waste per day, which is being disposed of in municipal landfills. This textile waste is being treated as a cost factor harming Jordan´s fragile ecosystem. However, textile waste also does involve numerous opportunities and could be recognised as a valuable resource on regional and international level on the long term. Based on collected quantitative and qualitative data, a list of circularity options was explored. **5 business cases** have been developed which provide marketable solutions for textile and garment waste minimisation, prevention, and revalorisation. The primary purpose of these business case is to identify opportunities to minimise textile waste, including recycling, upcycling, and reuse measures for factories in HIE.

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Business Case 1:	Investing in Material Efficient Technology and Software
Business Case 2:	Mechanical Recycling for Industrial Symbiosis
Business Case 3:	**Mechanical Recycling for Fibre-to-Fibre Yarn Production**
Business Case 4:	Chemical Recycling for Fibre-to-Fibre Yarn Production
Business Case 5:	Upcycling with Social Entrepreneurs

BUSINESS CASE 3 RATIONALE

Mechanical recycling for fibre-to-fibre yarn production requires that the garment manufacturers collect and sort their textile by fibre composition. This will be followed by fluffing similar compositions. Definable compositions can then either be sold directly to yarn mills or recycling platforms. Alternatively, in-house yarning facilities can be established. For processing the fluff into a recycled yarn it must be blended with virgin fibres. Then a sliver is carded which undergoes combing, gilling, drawing and roving before the spinning takes place. After it is winded, twisted and finally steamed the recycled yarn can be used in different applications of the manufacturing process, for instance as a sewing yarn. This business case decreases excessive use of resources, reduces waste generation and costs.

DESCRIPTION OF BUSINESS-AS-USUAL

CURRENT WASTE HANDLING PRACTICE

Garment manufacturers in HIE generate around 35 tonnes of textile waste daily. The waste is collected in containers outside of their premises without separation based on textile type and colour. The waste is collected by a private contractor and transported to Al-Ekeider landfill.

HIE hosts many other industries, including food, chemicals, pharmaceuticals, plastics, furniture, construction, packaging and paper industries. So far, no material exchange routes are formally explored or implemented within HIE.

COSTS OF CURRENT WASTE HANDLING MODEL

- Waste pick-up and landfilling costs: 4 JOD per ton of textile waste

RISKS OF CURRENT WASTE HANDLING MODEL

- Penalties for noncompliance with current waste management regulations
- Increasing costs of waste handling and transport, e.g. closing of Al-Ekeider landfill for textile waste
- Costs of compliance with export market laws (e.g. EU supply chain due diligence)
- Opportunity loss due to high prices of raw materials which is being wasted

DESCRIPTION OF BUSINESS CASE 3

NEW WASTE HANDLING PRACTICE

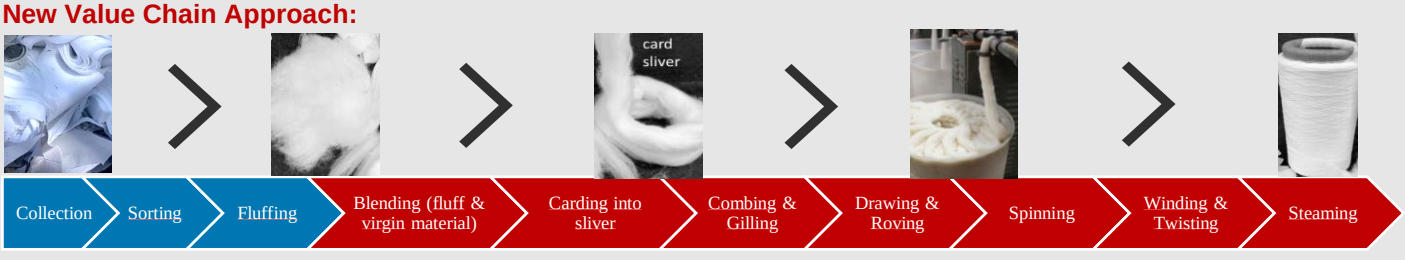
The new waste handling practice converts waste into yarn at an in-house yarning facility. The waste must be collected and separated in similar compositions (e.g., single colour and pattern) beforehand. It is important that the waste has less than 5% elastane content because elastane not only causes problems during mechanical recycling but also lowers down quality of the fibre obtained due to its segmented copolymer structure composed of both soft and hard segments. The throughput capacity of the value chain can be 20 tonnes per day assuming this amount will undergo a high-quality of collection.

For processing the fluff into a recycled yarn, the fluff must be blended with virgin fibres, then a sliver is carded, which undergoes combing, gilling, drawing and roving, before the spinning takes place. Afterwards it is winded, twisted and finally steamed.

Important prerequisites for this new value chain are:

- high degree of sorting according to the fibre composition.
- feeding the fluffing machine using waste with similar fibre composition.
- leaving out textile waste containing more than 5% elastane.

New Value Chain Approach:



Practice Example

Deniz Tekstil receives textile waste from garment producers all over Turkey through companies licensed for waste collection.

- **Waste is sorted manually by colour and type** and then fed into cutting and opening machines to be separated to fibres (mostly cotton).
- **Fabric waste that is mixed** in colour and type is used to produce a lower quality of recycled fibre for **nonwoven (felt) production**, which is sold to felt producers for usage in the automotive, furniture, white goods, and construction sector.

Deniz Tekstil also produces cotton and synthetic shoddy blends in all colours, which is suitable for yarn production between 4 and 20 Nm.

BENEFITS FROM MECHANICAL RECYCLING FOR FIBRE-TO-FIBRE YARN PRODCUTION

- Additional revenue stream from selling recycled yarn which can be as high as €2,500 / tonne (~ 1875 JOD/tonne).
- Using recycled yarn from own production → closed loop recycling and savings on the raw materials.
- Promotion of sustainable product and process innovation at HIE as a lighthouse for Jordan.
- Alignment with the EU Circular Textiles strategy and upcoming regularity requirements if closed loop recycling is applied.
- Alignment with the fashion brands circularity targets (fibre to fibre recycled content) if closed loop recycling is applied.

Financial benefits

	Value per unit	Number of units	Total annual benefit
Cost savings on waste	4 JOD	20 tonnes per day	29,200 JOD
Recycled fibre (colourful)	1,050 JOD	16 tonnes per day[1]	6,132,000 JOD
Sales Tax (16%) for recycled fibre	-	-	- 981,120 JOD
Recycled yarn	1,750 JOD	16 tonnes per day[2]	10,220,000 JOD
Sales Tax (16%) for recycled yarn	-	-	- 1,635,200 JOD
Saved virgin material (polyester/cotton mix) for closed loop production (RMG factories own use)	an estimate of data has to be discussed with companies in HIE	an estimate of data has to be discussed with companies in HIE	an estimate of data has to be discussed with companies in HIE
CO2 emissions avoided	5.19 Kg CO_2/kg mixed fabric[3]	103,800 tonnes CO_2 / 20 tonnes of fabric	30,887,000 tonnes CO_2
Landfill waste avoided	20 tonnes	365 days	7,300 tonnes
Total benefits for recycled yarn	-	-	**8,614,000 JOD**

[1] It is assumed that 80% of the textile waste is processed into fluff, while 20% might get lost as dust or taken out in the final sorting.
[2] It is assumed that 80% of the regenerated fibre (fluff) is processed into fluff, while 20% might get lost as dust.
[3] Source: https://www.researchgate.net/figure/ndustrial-carbon-footprint-of-textile-fabrics-in-this-study-kgCO-2-e-kg_tbl1_303634993

COSTS AND CHALLENGES

Costs:

- Setting up a recycling infrastructure (acquisition of new machines)
- Investments in research and development (R&D) or prototyping exercises that will provide the optimum mixture of recycled fibre and virgin material.
- Value tax added on recycled yarn will pose an extra cost for sales within Jordan.
- Certification of the recycled yarn (compliance with different levels of recycled contents, third-party certification, regular audits, etc.).

Challenges:

- Lack of procedures and experiences for high quality separation.
- Identification of customers (yarn manufacturers) as new buyers and meeting their specific demands.
- For closed loop use, understanding of the right mix of recycled fibre and virgin material, hence specifications for the machinery.
- Lack of enabling policy and investment support for waste recycling and innovative industrial processes.

	Cost per unit	Number of units	Total cost (JOD)
Capital Expenditure (CAPEX)			
Machinery for recycled fibre (fluffing line including cutting and tearing through a series of 6 different rollers)	840,000 JOD	1-time investment	840,000
Machinery for recycled yarn (including carding, combing and steaming spinning machines)	2,590,000 JOD	1-time investment	2,590,000
Factory building for accommodating the recycled yarn production	490,000 JOD	1-time investment	490,000
Operational Expenditure (OPEX)			
Electricity consumption of the machinery for recycled fibre (fluffing machine)	2,336,000 kWh/year	0,11 JOD/kWh	256,960 JOD/year
Electricity consumption of the machinery for recycled yarn (including carding, combing and steaming spinning machines)	13,724,000 kWh/day	0,11 JOD/kWh	1,509.640 JOD/year
Operators (HR)	4,000 JOD per worker per year	50 workers (*)	200,000 JOD/year
Virgin Material	4,381 JOD/year	1/year	4,088,000 JOD/year
Recycled Claim Standard (RCS) certification	3,540 JOD	1/year	3,540 JOD/year
Total cost for high quality recycled yarn			**8,882,640 JOD**

(*) Based on the information on the similar facilities. It is assumed that waste to fibre ratio is 80% and 50/50 blend ratio is applied for recycled and virgin fibres. Virgin polyester fibre price taken as €1,000/tonne

Simple Payback Periods

	Total Cost - initial year (JOD)	Total Benefits - after tax (JOD)	Simple Payback period
End Product of the new value chain			
High Quality recycled Fibre (fluff for sales)	1,296,960.0	5,180,080.0	3 months
High quality recycled yarn (for sales or closed loop)	8,882,640.0	8,614,000.0	12 months

- The payback period is calculated using the payback method, where initial investment is divided by positive cash flow produced per year. The depreciation isn't taken into consideration.
- The prerequisite for both cases is high-quality sorting (according to composition and colour with less than 5% elastane) and R&D support for defining the right mix for recycled fibre (fluff) and virgin material mix. These activities need to be carried out for a feasibility study.

ENABLING FACTORS

1. The new national solid waste management framework requires the implementation of recycling and reuse measures to avoid waste landfilling.
2. There are impact investment funds which may provide financial support in the form of loans and quasi-equity investments (Amam Ventures, EBRD).
3. The EU Circular Economy Action Plan and the EU Textile Strategy will require higher recycled contents in textile products.
4. Demand for recycled fibre and yarn has been rising.
5. Textile waste collection and separation efforts within the project will support the implementation of fibre-to-fibre recycling.

IMPLEMENTATION ROADMAP

SHORT-TERM (1 YEAR)	KPI	Timeline	Cost Incurred
Verify the amount of textile waste available that is suitable for high quality recycled yarn production (<5% elastane)	Amount of collected and separated textile wastes suitable for fibre-to-fibre recycling	Y1 Q1	No
Establish concept for high quality collection and sorting	Number of companies expected to provide collected and separated textile wastes suitable for fibre-to-fibre recycling	Y1 Q1	Yes
Assess which waste composition of the fluff is most suitable for selling or yarning	Assessment in textile recycling laboratory completed	Y1 Q1	No
Define the machinery specifications for the production line and establish links with the providers (e.g. in Turkey and Germany)	List of machine specifications	Y1Q2	No
Carry out a pre-feasibility study to raise interest among investors	Pre-feasibility study based on concrete information and price proposals completed	Y1Q3	No
Build relationships with potential buyers of fluff (yarn mills or recycling platforms)	List of potential buyers	Y1Q4	No

MID-TERM (2-3 YEARS)	KPI	Timeline	Cost Incurred
Engage employees for sorting by composition before fluffing	Daily sorting established	Y2 Q3	Yes
Sell sorted textile fluff to recycling platforms	Regular material stream established	Y3 Q1	No
Sell sorted textile fluff to spinning mills	Regular material stream established	Y3 Q1	No
Develop marketing strategy together with brands	Marketing concept developed	Y3 Q1	Yes
Train and engage Recycling and Yarning staff	Regular Trainings of staff conducted	Y3 Q2	No

LONG-TERM (5 YEARS)	KPI	Timeline	Cost Incurred
Establish spinning factory for manufacturing polyester yarn from pellets	Spinning factory established	Y5 Q1	Yes
Increase visibility of measures	Marketing campaign with brands established	Y5 Q3	Yes
Increasing selling prices of products with recycled yarn		Y5 Q4	No

CONCLUSION

This business case focuses on the development of a value chain for high-quality recycled fibre and ultimately, recycled yarn production. There are several important conditions for the realisation of this business case. The first prerequisite would be excellent collection and sorting processes that can feed the fluffing process with well separated textile according to composition and colour. The second essential factor would be to have the elastane content of the textile waste below 5%. Thirdly, in order to secure high-quality yarn production with good sales value, it would be advised to carry out research and development for finding the optimum mixture between recycled fibre (fluff) and virgin material. If capital is secured for the initial investment, the payback period for recycled fibre and recycled yarn productions can be less than a year.

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