# Successful Project Design of Polyester Recycling Investments

## Some Practical Experience, Common Hurdles and Problems

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7th China Int'l Recycled Polyester Fiber Market & Tech Forum
Sept. 21-23, 2011, Shanghai, China


*[Few to the wooden roof of Yu Yuan Temple Shanghai]*

## Content

## 1. Introduction

The rapid growth of polyester recycling industry is generating continuously new projects either as new investments or as substitution of virgin polyester on existing production lines.

These new projects using as raw materials mostly

~ baled bottles,
~ purified bottle flakes or
~ pellets as re-granulate

Recycling projects have different driving forces. The most important are:

~ raw material cost saving
~ shortage of virgin raw material
~ production of environmentally friendly products as marketing advantage
~ request by brand owners like Coca Cola to reduce CO2 foot-print

The first both mentioned are of superior number.

And so the investment or development teams of most of the new projects are looking in the market for raw materials which will fit to the predetermined product or production process like filament, fiber, film, bottle-resin, strapping or others.

At that stage the initial point of hurdles and problems is reached because PET recycling materials in the market represent a very broad range forms of delivery, material properties and quality levels.

Besides kind and level of impurities or sorting accuracy main differences in form of delivery are

- baled bottles
  - ~ baled bottles, loose
  - ~ pre-shredded bottles
  - ~ bottle briquettes
- bottle flakes of different
  - ~ contamination level, kind and concentration
  - ~ level of color sorting
  - ~ bulk density and flake size
  - ~ degree of crystallization (amorphous or wet flakes and crystallized flakes)
  - ~ specific surface area
  - ~ delivery form like big bag, sea-container, silo-truck
- pellets of re-granulates
  - ~ different impurity and color levels

Based on experience of recent recycling projects I would like outline some details of successful project design in polyester recycling.

## 2. Polyester recycling projects - definition of start conditions

First important step is take soundings of the prospective operational window of the new project. Here a classification of the planned production concerning required polymer quality level is required. Dividing the common polyester conversion processes and products in different quality levels we might agree on the following graduation:

Level A – raw material quality comparable to virgin PET, processing to products like POY, FDY, technical yarn, high performance staple fiber, transparent bottle-to-bottle pellets, biaxial oriented packaging film

Level B – strapping, thermoforming A-PET film, bottle-to-bottle pellets nonfood, 3D-staple fiber hollow/tri-lobal, spun-bond, melt-blown, bulked carpet fiber (BCF) dope dyed, mono-filament,

Level C – colored thermoforming film, SF dope dyed - fill type, engineering plastics applications

Other criteria of direct impact to the final product are color (0% , < 5%, <10% blue or green, transparent), mixed colors and transparent and mixed colors non-transparent

After having classified the level of start conditions the next step regarding raw material sourcing is defining a purchasing strategy and with this also the impact to the total investment of the project. From experience projects of level B and C are less critical regarding feed material quality compared to projects defined as level A.

In the following I would like concentrate on level A conversion processes.

## 3. Correlation between product quality level and raw material procurement – what to buy in the market?

The investor should be aware that recycled polyester covers a broad range of quality attributes like:

~ broad variety of bottle flake and re-granulate qualities in the market

~ there is no common quality standard available comparable to virgin polyester pellets

~ parameter are often provided as minimum level only, for instance IV > 0,7 dl/g, moisture< 1%

~ each producer is providing its individual quality specification, only basic data like IV, COOH, color or moisture as ASTM method available

~ the quality is most of the time not consistent for medium and long term (years), small lot sizes common

~ quality parameter evolving unpredictable

~ the input waste bottle quality is floating depending on packaging developments (e.g. weight reduction, new additives, new polymers)

## 4. Practice cases of project design

To demonstrate the correlation between project design, raw material selection and required investment, different raw material purchasing approaches has been considered.

Raw material procurement alternatives are selected between:

A1) Purchasing of bottle flakes in the free market – price oriented

A2) Purchasing of bottle flakes from selected vendors – based on long term contracts

A3) Integration of a flake production plant in the project based on commercial participation or Joint Venture

Different to the processing of virgin polyester the entrance to the application of recycling polyester needs an intensive investigation in the correlations between PET flake / re-PET quality and project design.

Three practical cases are selected to show the narrow correlation between project design, investment and raw material selection.

## 4.1 Price oriented purchasing from global market to produce thermoforming cast film, transparent, colorless

In this project the target was purchasing bottle flakes price oriented in the global market. As a consequence the design of the conversion process included from the first beginning a flake after-finish system and an efficient flake storage and blending unit.

Flake sorting technology has been tremendously improved during the recent years with the result, that meanwhile new flake production lines disclaim the bottle sorting at the entrance of the process . In place of this the final flake stream is sorted in different sorting facilities. As example the company S+S Separation and Sorting Technology GmbH (www.se-so-tec.com) is offering devices for metal separation, separation of foreign polymers and color separation. Mr. Mayer of Se-So-Tec introduced for instance the systems more in detail.

Another powerful flake sorting system is offered by Unisensor Sensorsysteme GmbH (www.unisensor.de). Based on laser spectroscopic recognition the system Powersort 200 is as well useful to improve flake quality remarkably.

Further after-treatment steps are:

~ flake size reduction, de-dusting
~ quality equalization by blending
~ optional hot washing

As a consequence the total investment was increased. Depending on input material flake quality and selected after-treatment facilities the conversion cost will increase by 50 – 150 Euro/ton

## 4.2 Yarn production for non-woven - the stepwise conversion technology

To bring an investment to produce yarns for non-woven products based on an A2-approach smoothly to success it was selected to apply a stepwise conversion approach.

In this case the new PET processing plant needs to have the capability of dual raw material handling and processing.

Basis is that the plant design is made in a way that virgin PET pellets and PET flakes are workable on the same equipment within the specified plant capacity.

This concerns the following equipment:

~ Flake storage and conveying
~ Pellet storage and conveying
~ The extruder feeding zone is designed to operate pellet and flake in ratios from 0:100 till 100 :0
~ Most of the time a special extruder feeding zone design is required
~ To achieve full throughput during flake feeding a forced feeding device for flakes might be useful

Advantage of this approach is the assurance that from first beginning product of high quality is produced. The selection of appropriate flake sources is going step wise and smoothly.

This approach needs specific attention to product quality during conversion phase. Hurdle is the continuous variation of product quality according the flake : virgin ratio and flake quality. Target is to keep product quality within the specification.

## 4.3 Production of special high performance high tenacity staple fiber – Plant conversion from virgin PET pellets to PET bottle flakes

Driving forces of this project has been the shut down of the unprofitable PET resin production at site and reduction of raw material cost in the long run

Raw material procurement alternatives are selected between:

A1) Purchasing of bottle flakes in the free market – price oriented
A2) Purchasing of bottle flakes from selected vendors – based on long term contracts
A3) Integration of a flake production plant in the project based on commercial participation or JV

Out of the discussion about the required resin quality the project planning was concentrated on level A2 or A3 raw material procurement.

Finally it was decided to realize the project in two steps. Step one contains an extensive investigation and trial phase regarding PET flake availability and quality situation.

Based on these results of step one the final project design was established as step two.

To A2: Testing selected PET flake sources of high quality flakes form Europe/World resulted in:

reasonable flake quality
narrow PVC contamination limits
defined color contamination
flake pricing at high level

Result: Test results reasonable, high flake price level, no direct communication to flake production possible

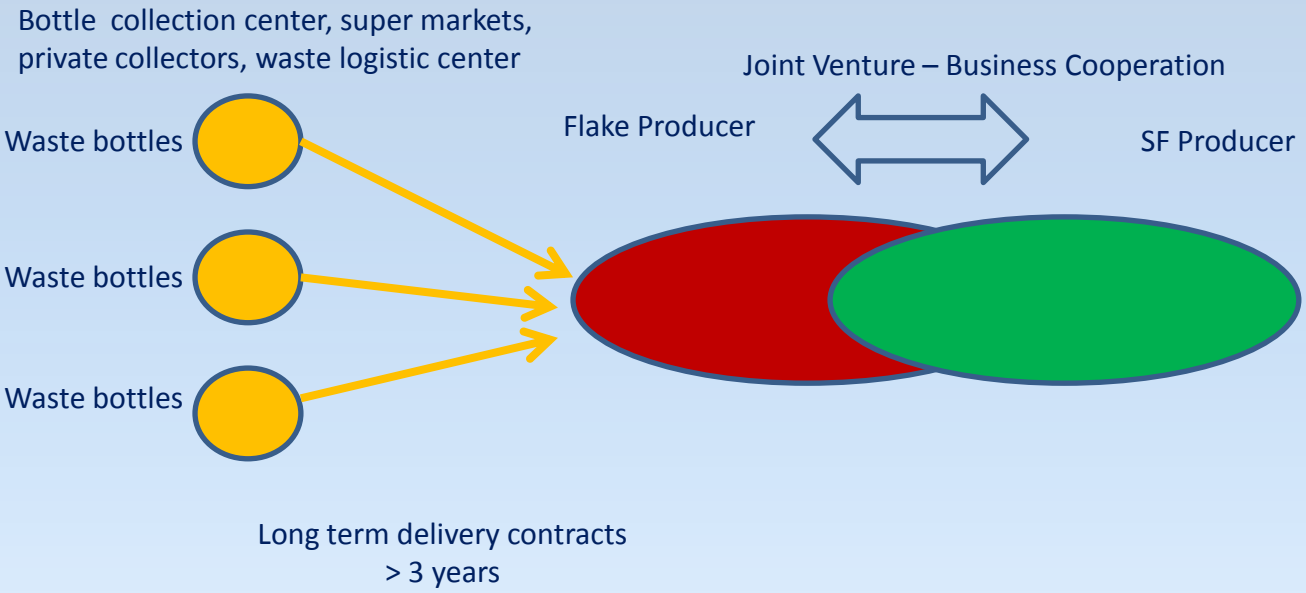
To A3) Integration of a flake production plant in the project based on commercial participation or JV (feasible for projects > 10 000 t/a)

During the trail and preparation phase of the project it becomes clear that the challenging quality of the final product (high tenacity staple fiber) and the respective production process need a tight cooperation between flake producer and flake processor.

Most important is the possibility of backtracking changes in flake quality and process-ability.

The close cooperation and finally the Joint Venture between flake producer and processor was ending up in a step wise optimization of the flake production process including the targeted selection of baled bottle sources.

One important feature of this project design was the establishment of long term purchasing contracts between flake producer and selected waste bottle suppliers.



## 5. Summary

Designing a successful operating polyester recycling project the most important step is the definition of required raw material quality level and the determination of raw material sources

To assure the required raw material input quality different investment strategies are useful:

~ Buying low price flakes and install flake-after treatment facilities

~ Stepwise conversion from virgin to recycled PET, this approach needs dual use of all equipment, additional storage and blending facilities

~Inclusion of flake production unit as vertical integration based on long term cooperation, JV or direct ownership

Different to the processing of virgin polyester, the step to the application of recycling polyester needs an intensive investigation in the impact of PET flake / re-PET quality to the final project design and with this to the total investment.

**THANK YOU FOR YOUR ATTENTION!**


Nothing is as it appears at first sight !
[Few from top of Jing Mao Tower to lobby of Grand Hyatt Shanghai]