



Grün Book

CLOSING THE WASTE LOOP THROUGH INNOVATIVE PLASTIC RECYCLING



Singaporean-German Chamber
of Industry and Commerce
Deutsch-Singapurische
Industrie- und Handelskammer



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Grün Book – CLOSING THE WASTE LOOP THROUGH INNOVATIVE PLASTIC RECYCLING

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Foreword by Ms Grace Fu, Minister for Sustainability and the Environment



Ms Grace FU

Minister for Sustainability and the Environment

Sustainability has been a cornerstone of Singapore's development since our independence. However, megatrends such as rapid urbanisation, excessive consumption of resources, as well as the intensifying effects of climate change are leading us to an increasingly resource- and carbon-constrained world. This has added impetus to our drive for green growth. To ensure that our future generations can continue to enjoy a vibrant and liveable city, we are working to build up our climate, resource and economic resilience.

Following the success of our Year of Climate Action in 2018, the Ministry of the Environment and Water Resources designated 2019 as Singapore's Year Towards Zero Waste. This reflected our ambition to design waste and wastefulness out of our economy. We recognise that everything we produce, consume, and dispose of has an impact on our environment and climate. We are taking steps to transit towards a low-carbon economy, by making a paradigm shift from the 'take-make-throw' linear model to the circular economy model where resources are used over and over again. Just as we have done for our Water Story through NEWater, we are working to close our resource loops. In fact, we already recycle 99 per cent of our ferrous metal waste, and construction and demolition waste. But we are looking to do even more.

Singapore's inaugural Zero Waste Masterplan charts our strategies towards this future. We have set ourselves an ambitious target, to reduce the amount of waste sent to landfill per capita by 30 per cent by 2030. All stakeholders must work

together to achieve this — individuals, schools, businesses, civil society, and the government. This includes the co-creation of innovative environmental solutions between the public and private sectors, and tapping into ground-up initiatives to drive sustainability.

Sustainability will be a competitive advantage for companies in the future economy, and the circular economy approach will create new economic growth opportunities and good jobs for Singaporeans. We already have a vibrant waste management and recycling industry in Singapore. Plans are underway to further strengthen our local recycling capabilities to close our food waste, e-waste, and plastic waste loops. These initiatives will create new jobs in emerging areas, such as engineering, robotics and automation. They will also put Singaporean companies in a position to export these solutions to the region and the rest of the world. I am heartened that the Singaporean-German Chamber of Industry and Commerce (SGC) has contributed this insightful publication to advance the discussion. Both Singapore and Germany place high importance on sustainable development, and the Grün Book covers important areas of waste management and recycling which will be of great relevance to us.

Singapore and Germany enjoy strong cooperation in a broad range of areas, and bilateral trade between our countries stood at SGD\$21 billion in 2019. Notably, Germany is Singapore's largest trading partner in the European Union (EU), and Singapore is Germany's largest trading partner in the South-East Asia region. Our trade links will continue to be enhanced under the EU-Singapore Free Trade Agreement which came into force last year and commits the EU and Singapore to protecting environmental standards. German environment and water companies have also played a key role in Singapore's sustainability infrastructure and value-chain over the years.

The Grün Book is a continuation of this long-standing partnership. The issues addressed in this book, such as the implementation of the Extended Producer Responsibility and turning waste into valuables through resource recovery or even upcycling, are among the areas of cooperation between Singapore and Germany. In particular, I encourage greater research and exchanges in the area of recycling.

Singapore and Germany are well-positioned to help address the waste challenges facing the South-East Asia region through the use of cutting-edge

technologies and solutions. There is immense potential to generate economic opportunities and green jobs in doing so.

I congratulate the Singaporean-German Chamber of Industry and Commerce on this initiative and look forward to new opportunities for collaboration with Germany and the SGC to address common challenges, and realise our joint vision of ensuring a sustainable future for our people.

Grace Fu
Minister for Sustainability and the Environment

Foreword by Dr Ulrich A. Sante, Ambassador of the Federal Republic of Germany



Dr Ulrich SANTE
German Ambassador to Singapore

These last weeks, Covid-19 and the efforts undertaken worldwide to contain and push back the pandemic have claimed our attention almost exclusively, and the absence of meetings and events may have led us to pay less attention to other challenges. This is understandable but wrong, and the SGC Grün Book on Closing the Waste Loop Through Innovative Plastic Recycling is an effort to remedy that.

The protection of the environment and the prevention of its further degradation is a subject close to the heart of the governments of both Singapore and Germany (and many other States). It is a long-term effort that is needed, in order to make this globe a more liveable place for us and to leave to our children and their children a world which is still worth living in. One of the scourges of our age is the ever-increasing mountain of waste, combined with the depletion of valuable resources and raw materials.

“Plastic” is a wonderful material, which helps us, for instance, to bring to the market or to our home healthy and unspoilt food and beverages, and whose physical properties allow for uses which older materials closer to nature have never had. But there is a price to pay for that, for plastic once used and then discarded on the garbage-heap is having more and more serious negative effects on our environment, while allowing a valuable resource to go to waste. It is therefore not surprising that efforts are made both to reduce the amount of plastic waste and to put that which cannot be avoided to use again (and again).

This is what this book describes: moving on from a linear scheme extending from raw material via use to waste, to a circular system in which plastic that has been used is either re-used directly or transformed in order to give it a second life in some other shape.

We are all far too much aware of the finity of available resources and the life-threatening character of a polluted environment not to look intensely at all possible ways to achieve exactly that. Chapter 2 of the present publication describes in some detail what Singapore has been doing in this field, both from a technical and a regulatory point of view (and the international framework in which all such efforts insert themselves). Chapter 3 is describing the German experience. Chapter 4 is a case study on one particular aspect of plastic recycling: PET bottles, that omnipresent (and extremely convenient) drinks container which we find in every supermarket, every restaurant, every beverage selling machine. This chapter brings to the fore an important consideration: recycling plastic is not just an important and necessary activity in which States – or more largely societies – should be prepared to invest large amounts of money in order to safeguard our future. It is also a commercial activity worthy of the attention of Singaporean and German companies, including niche SMEs and start-ups (hence the list of German companies active in this field which you will find in Chapter 6 of this book). The importance of this can hardly be overestimated: protection of the environment is not just a necessity for which we have to bring sacrifices, but also an opportunity.

This is an effort which we have to make together. It needs the cooperation of different actors: the companies, the citizens, and the regulators who have to create a playing-field conducive to what companies and citizens are doing.

Covid-19 has been, and still is on all our minds. But one day, we will have got past it, and our other challenges will still be there. This book is a contribution by SGC to make sure we continue to pay attention to them. Singaporean-German cooperation is nothing new, but I hope this book will act as an encouragement to carry it to new heights. I wish the Grün Book wide circulation and many attentive readers!

Dr Ulrich A Sante
Ambassador of the Federal Republic of Germany

Foreword by Mr Jens Rübbert, President and Dr Tim Philippi, Executive Director of the Singaporean-German Chamber of Industry and Commerce



Mr Jens RÜBBERT

President Singaporean-German Chamber of Industry and Commerce



Dr Tim PHILIPPI

Executive Director Singaporean-German Chamber of Industry and Commerce

Singapore, as a low-lying city-state with limited resources and constrained space, faces several challenges posed by climate change and a high population density. The small nation has come a long way since its founding. It has a flourishing economy and is one of the leading financial and research hubs in the world – where innovative, strategic and long-term planning made it possible.

High population numbers and high population density come with new challenges in Singapore and elsewhere. Amid seemingly endless choices and consumerism, the world struggles with the consequences of handling overwhelming waste masses. A particular issue that threatens our biodiversity and environments is the

sheer longevity of plastic products. PET bottles for example can take up to 450 years to decay, yet it remains as one of the most popularly used daily goods.

Once produced, used and disposed, only 4% of the 700,000 tonnes (2018) of Singapore's overall plastic waste is recycled while the majority is incinerated in order to produce energy and reduce the mass of waste sent to the landfill as incinerated ash. Although burning plastic is the most CO₂-intensive form of energy generation after coal generated electricity, it is therefore speeding up climate change that is threatening the city-state. As the lifespan of Singapore's present landfill is predicted to only last until 2035 at current waste rates, without the necessary recycling technologies, Singapore has no choice but to burn the plastic waste in order to reduce the volume sent to the Semakau landfill.

Singapore has identified and addressed the waste problem in its Zero Waste Masterplan that was released in 2019. The publication points out three major waste streams that Singapore plans to take action on: food waste, electrical and electronic equipment waste, and packaging waste including plastic.

Germany is well known (worldwide) for its waste separation and recycling system and has a plastic recycling rate of 46.7% that will be raised to 63% by 2022. Globally, German companies are leading in plastic recycling technologies. In a position paper published in 2018, the Singapore Environment Council recommends two ways to solve the plastic problem: 1) mitigate the use of single-use plastics and 2) transition from a linear economy to a circular economy by reusing and recycling. One of the strategies proposes to learn from other leaders in plastic waste recycling - such as Germany.

Companies from Germany that have developed cutting-edge recycling technologies and know-how from decades of experience can contribute and support Singapore in founding a Centre of Excellence (CoE) for Plastic Recycling. To start and lay the foundation for the Centre of Excellence, the Singaporean-German Chamber of Industry and Commerce (SGC) proposes a project-based approach in the form of a test-bed plant for PET recycling to develop a strong collaboration. The CoE will further nurture the already established knowledge-pipelines and in the long-term, enable Singapore to support neighbouring countries and the region by exporting the developed and locally adapted solutions.

German companies are ready to support Singapore in achieving its aims to build the three key resiliences. Reducing the incinerated amount of plastics can contribute to meeting the climate goals of reducing CO₂ according to the Paris Agreement. Furthermore, less incinerated plastic supports resource resilience in providing high-quality resources, as PET pellets and the addition of additives can help to achieve a better quality to produce upcycled products made in Singapore. By overcoming carbon and resource constraints, Singapore's economy will stay competitive and future-ready to ensure a high-quality of life for the generations to come.

Not only does Germany have the expertise and innovative recycling solutions to offer, but the whole DACH region, which includes Germany, Austria and Switzerland, has a multitude of small and medium sized companies that are highly specialised in their own niche areas with state-of-the-art solutions and technologies. Together with Singaporean companies that are familiar with the local waste conditions and challenges, the plastic problem can be solved and eventually truly turn waste into treasure.

The SGC hopes that the 'Grün Book' will initiate multinational collaboration in the area of plastic recycling, with the aim of deepening the multilateral relationships and to support in establishing a CoE for Plastic Recycling in Singapore for the region, through the test-bed recycling plant. An extensive list of potential industry partners from Singapore, Germany, Austria and Switzerland builds the last chapter of the 'Grün Book' as a basis for the pilot PET recycling plant.

My thanks go to the SGC's Sustainability Committee, led by Mr Joachim Ihrcke and Mr Jakob Graf von Lambsdorff, that initiated the publication. Furthermore, a special thank you to Mr Edwin Khew, Advisor to the Committee and to our supporting partners, the Austrian Embassy and the Embassy of Switzerland. We appreciate the close multinational cooperation and are looking forward to collaborating together with Singapore and for Singapore.

Jens Rübbert
President SGC

Dr Tim Philippi
Executive Director SGC

1. Introduction: Current Situation in the Region and Singapore

1.1 Waste Situation in Southeast Asia (SEA)

75% of globally exported waste ends up in Asia. Since China banned imports of plastic waste in 2017, Southeast Asia (SEA) has become a “dumping ground” for wealthier countries’ waste. The volume of plastic waste imported into the Philippines, Malaysia and Indonesia has more than doubled. In 2019 Malaysia and the Philippines announced to return waste from countries that have improper labelling. The waste imports were restricted last year with a complete ban planned for the near future. Currently, five Asian countries (China, Indonesia, the Philippines, Vietnam, and Thailand) are responsible for more than half of the eight million tonnes of plastic waste that end up in oceans every year.

Besides the difficulties with import of waste, the actual usage of single-use plastic is still very high in South East Asian countries and many are struggling with waste management. The recycling rates in the region remain low as separation of waste is still not common and the inadequate infrastructure contributes significantly to the plastic pollution problem.¹ Overall waste is increasing, driven by the region’s growth in population and explosive demand for consumer products.

In June 2019, ASEAN leaders signed an agreement to combat marine debris. However, as ASEAN practices a policy of non-interference between member states the outcome is yet to be seen.

Thailand began the year 2020 with a ban on single-use plastic bags at major stores and will subsequently impose a complete ban in 2021 and additionally it will ban certain plastic products like straws, cups, and food containers by 2022.

¹ CNA, When did Southeast Asia become a dumping ground for waste? (<https://www.channelnewsasia.com/news/commentary/malaysia-plastic-waste-philippines-dumping-ground-southeast-asia-11720716>)

Vietnam pledged a single-use plastic ban nationwide by 2025 and Malaysia launched a ‘Roadmap towards Zero Single-Use Plastics’ by 2030.

While there are more than 80 countries that have already introduced bans on single-use plastics according to the UN Environment Programme (UNEP), New Zealand being the latest example, none of the ASEAN countries is currently among them.²

1.2 Waste Situation in Singapore

In the last 40 years, the amount of waste generated has increased seven-fold and reached a total of 7.23 million tonnes in 2019, on average, only 59% of the waste generated was recycled.

Since the late 1970s, the NEA (National Environment Agency) adopted waste-to-energy (WTE) incineration which reduces waste volume by 90% and reduces landfill space. Today, Singapore has four WTE plants, namely Tuas, Senoko, Tuas South and Keppel Seghers Tuas Waste-To-Energy Plant (KSTP) and one landfill, the Semakau Landfill (for non-incinerable waste and incineration ash) via the Tuas Marine Transfer Station. The Semakau landfill is projected to run out of space by 2035.

The Sarimbun Recycling Park that is managed by the NEA, plays an important role in resource recovery, and contributes about 25% of total waste recycled in Singapore. The NEA leases land to recycling companies.

An Integrated Waste Management Facility (IWMF) is planned to be completed by 2024. It will be able to effectively process various waste streams: incinerable waste, household recyclables, source-segregated food waste and sludge from the used water treatment plant co-located with it at Tuas and jointly known as Tuas Nexus.

² The ASEAN Post, Will ASEAN ban single-use plastic? (<https://theaseanpost.com/article/will-asean-ban-single-use-plastic>)

2. Singapore's Zero Waste Plan

2.1 Overview Zero Waste Masterplan

Zero Waste Masterplan

to Achieve a Sustainable, Resource-Efficient and Climate-Resilient Singapore

Our Targets

- 1 Extend Semakau Landfill's lifespan **beyond 2035**
- 2 Reduce amount of **waste sent to landfill per capita per day by 30%** by 2030
- 3 By 2030, achieve a **70% overall recycling rate**:
81% non-domestic recycling rate
30% domestic recycling rate

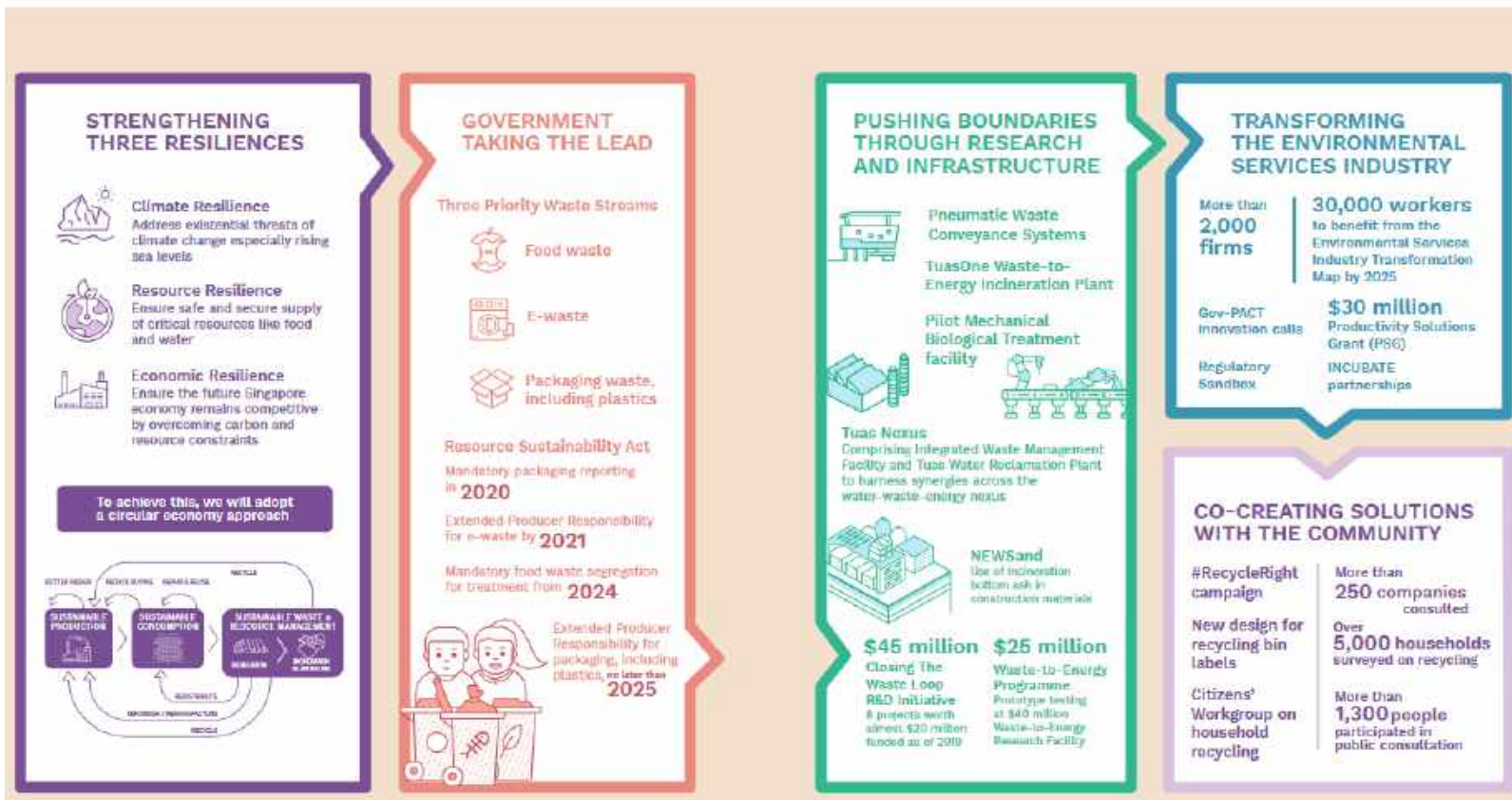


Figure 1 Singapore's Zero Waste Masterplan

© Credit to the MSE (Source: <https://www.towardszerowaste.sg/images/zero-waste-masterplan-summary.pdf>)

The Zero Waste Masterplan is the first step towards Singapore's vision of a Zero Waste Nation. The following summary of the Zero Waste Masterplan is based on the 2019 publication "Zero Waste Masterplan Singapore" by the Ministry of Sustainability and the Environment (MSE) (formerly: Ministry of the Environment and Water Resources (MEWR)) and the NEA.³

As a low-lying island-state, Singapore faces several challenges as climate change brings rising sea-levels and increase strain on resources with rising global consumption, and more waste, due to population growth and rapid urbanization.

To overcome these challenges, Singapore is keen on building three new resiliences: climate resilience to address existential threats of climate change, resource resilience to ensure a safe and secure supply of critical resources and economic resilience to ensure the future Singaporean economy remains competitive by overcoming carbon and resource constraints.

The aims of Singapore's Zero Waste Masterplan are:

- Extension of Semakau Landfill's lifespan beyond 2035
- Reduction of amount of waste sent to landfill per capita per day by 30% by 2030
- Achievement of a 70% overall recycling rate (81% non-domestic, 30% domestic recycling rate)

The government is committed to supporting companies move towards sustainable production and through research and development (R&D), develop new circular economy solutions. Therefore, it will foster partnerships between the industry and academia and upskill the workforce.

2.2 Zero Waste Nation Concept

Singapore's policies on waste management are guided by three principles:

1. Economic development, environmental protection and social inclusion are equally important.
2. Everyone must work together to achieve the best outcome.
3. Plans and policies should be focused on the long term and cater to the local context, with an integrated approach to achieve better synergies and resource efficiencies.

Singapore has an efficient waste collection and disposal system based on incineration. At current waste disposal rates, the landfill capacity of Semakau Landfill is projected to run out by 2035. Due to the space constraints, the current system is not feasible for the long run, and the city-state is compelled to drastically cut the amount of waste to conserve the landfill capacity as long as possible.

Although climate change and growing resource constraints are the key drivers, Singapore is determined to turn these challenges into opportunities. A few examples as follows:

- Chemical recycling that turns plastic into the original chemical building blocks, so that it can re-enter the production process.
- Treated incineration bottom ash can be used as conventional aggregates (e. g. sand) in construction applications.
- E-waste recycling recovers valuable materials from waste.

Conserving resources will also lead to a reduction of greenhouse gas emissions from production and the incineration of waste, which will help mitigate climate change.

In addition, a circular economy approach will provide new economic opportunities creating synergies across the water, energy, food, and waste sectors to enhance resource efficiency. Singapore aims at becoming a leader in

³ Please refer to www.towardszerowaste.sg/images/zero-waste-masterplan.pdf

urban solutions for sustainable cities and to subsequently export the solutions to the region and globally.

2.3 History of Singapore's Waste System

In the 1960s and 1970s Singapore did not have an efficient waste disposal system. Street food stands were common, waste collection was irregular and inefficient and across the island, open dumping grounds could be found. The situation widely contributed to pest problems further worsened by the hot and humid climate.

In the 1970s, Singaporeans moved from village settlements ("kampongs") to high-rise apartments, as competition for land became more intense. At that time, a district-based solid refuse collection system was introduced with daily collection in seven districts. The collection fees were paid through household utility bills. Within these buildings, vertical refuse chutes were introduced. People had to bag their waste and dispose of it into a chute (a duct). Initially, each apartment had its own individual chute installed, until it was changed into the "Central Refuse Chute" (CRC) system, with one common chute at each floor which proved to be more efficient.

Land scarcity made Singapore greatly invest (SGD 130 million) in its first WTE incineration plant in 1973, the first in Asia outside of Japan. Since then, four more WTE plants have been built on the island. In total, they incinerate about 7,600 tonnes of waste a day. While reducing the volume of waste by up to 90% and generating electricity (2% of the overall energy needs, 20% if the generated electricity is used to power the incineration plant, 80% is exported to the grid) which was sufficient in the past, Singapore today plans to do more by recovering valuable materials from waste as part of moving towards a sustainable Singapore.

Another project initiated with the space constraints is the Semakau landfill. In the 1990s the former inland dumping ground reached its capacity and Singapore had to look for a new solution. In an innovative project the sea-space between the

two islands Pulau Sakeng and Pulau Semakau was turned into a landfill by using an impermeable geomembrane to contain the waste. Measures were taken to minimise the impact on the environment due to construction, like replanting mangrove saplings or protecting corals with fine mesh silt screens. The project costed SGD 646 million in total. This landfill has a size of 350 ha and a capacity of 28 million m³. At current waste disposal rates, it is projected to run out of space by 2035.

2.4 Closed-Loop Economy

The aim of the closed-loop economy is to keep resources in use for as long as possible to extract their maximum value. This can be achieved by conscious design, more efficient operations, and less wasteful habits.

Singapore used to have a linear economy model where materials were harvested, used for manufacturing, and eventually discarded. Instead, Singapore now adopts a circular economy approach to waste management where valuable materials can be reintroduced into the production cycle, keeping the resources in use in an endless loop.

Even as Singapore learns from other countries that are pioneering in circular economies, it must adjust the measures to its context. To achieve a circular economy, measures need to be taken across the entire value chain from production and consumption, to waste and resource management, e. g. reduction of resources used at production by an improved product design, consumers who repair instead of replace and recycling of waste and reintroducing the material back into the value chain.

In several areas, the nation has already succeeded in closing several resource loops, like the recycling of construction waste, metals, and the water loop. The city-state with no water resources of its own can endlessly recycle water as every drop of used water is collected and treated to turn it into drinking water again. This circular loop allows Singapore to reintroduce up to almost 800,000 m³ of ultra-pure recycled water into the system per day.

Under the Sustainable Singapore Blueprint in 2015, Singapore set the 2030 target to increase the national recycling rate to 70% (30% domestic recycling rate and 81% non-domestic recycling rate). Indeed, this means reducing the daily waste from 800g per person in 2018 to 640g per person in 2030, which would result in a 30% reduction in incineration ash and non-incinerable waste to allow Semakau landfill's capacity last beyond 2035.

To achieve this target, the various measures outlined in the Masterplan need to be implemented to better manage the priority waste streams (food waste, e-waste and packaging waste, including plastics). Therefore, society and businesses need to work together, and the R&D community is required to develop solutions and technologies to enable the recovery of resources from waste.

Businesses can contribute by producing sustainably like using a sustainable design to improve resource efficiency and adopting industrial symbiosis where companies use the waste of others as raw materials for its own operations.

The NEA launched the Singapore Packaging Agreement, a voluntary agreement to encourage companies to reduce packaging waste. In 2021, the NEA will be introducing mandatory packaging reporting and will implement an Extended Producer Responsibility (EPR) framework for managing packaging waste (including plastics) no later than 2025. Notably, several hospitality companies have banned straws as part of PACT, a voluntary agreement from WWF.

The global material resource use is expected to double between 2015 and 2050 based on current trends. Resource efficiency policies and initiatives can not only help by cutting the resource use by 26%, thereby reducing greenhouse gas emissions by around 20% by 2050, but they could also save SGD 2.9 to 3.7 trillion per year. This opens opportunities for businesses and gives them an incentive to globally reap economic benefits.

The Singapore government is already leading the way for companies by introducing new laws. For instance, the Energy Conservation Act (ECA) requires large energy users to adopt good energy management practices. Another example is that all companies that are listed on the Singapore Exchange must hand in sustainability reports on a "comply or explain" basis that track their usage efficiency for materials. The sustainability reports cover sustainability practices, including environmental, social and governance factors. In 2019, the MSE introduced the Resources Sustainability Act (RSA), an integral part of Singapore's strategy to build a sustainable, resource-efficient and climate resilient nation. The requirements under RSA would be discussed in detail in later sections.

Nevertheless, the commercial and industrial sector contributes about half of the total waste disposed of.

The Sustainable Manufacturing Centre (SMC) of the Agency for Science Technology and Research (A*STAR) is set to enhance sustainability in the manufacturing industry by creating a platform for industry associations, the R&D community and government agencies, so that they can develop and implement sustainable manufacturing technologies together.

Industrial symbiosis takes advantage of one company's waste and transforms it into raw materials for another company. These mutually beneficial collaborations lead to more sustainable industrial processes and cost savings. Ideally, the entities are situated close to each other to minimise transportation costs. For example, on Jurong Island, the waste from some companies is burnt to generate steam for industrial use or Tuas Nexus, where the NEA's IWMF will be integrated with PUB's Tuas Water Reclamation Plant. The output of one facility can be used as feedstock to another, minimising land use and environmental impact.

On the other hand, household consumption remains high and is increasing, partly due to rising income levels. Thus, Singapore is promoting a reduce and reuse mindset by shifting towards the use of green products. The NEA is running several awareness projects, such as projects on Singapore's food waste situation, where consumers learn how to adopt smart food purchasing, storage and preparation habits that includes informational advertisements, user-friendly guides, talks, food waste reduction demonstrations and many more.

While consumption is high, recycling is still low. Only 22% of Singapore's domestic waste was recycled in 2018, while 75% of non-domestic waste was recycled. Although the infrastructure is already provided with all households having access to recycling bins within their estates or landed houses having their own recycling bins, 40% of the contents in recycling bins are contaminated (e. g. with non-recyclables or remnants of food or liquid). To change this, the government has kicked-off recycling campaigns in 2019.

Singapore has already closed the resource loop for construction debris and ferrous metals. For the metal resource loop, the recycling rate is at 99%. Novel processes are used to detect every speck of material by using special magnets to recover metal from incineration bottom ash.

2.5 Circular Economy Approach to Closing Three Resource Loops

Food and packaging are priority waste streams as they are generated in large quantities, but their recycling rate is persistently low. Electrical and electronic waste (e-waste) on the other hand makes up only a small amount of the overall waste generated, at less than 1%. As it could potentially have an extremely negative impact on the environment if not managed properly, it was also chosen as a focus resource loop.

The government will set up a regulatory framework to promote resource sustainability, starting with the Resource Sustainability Act in 2019 (further details below).

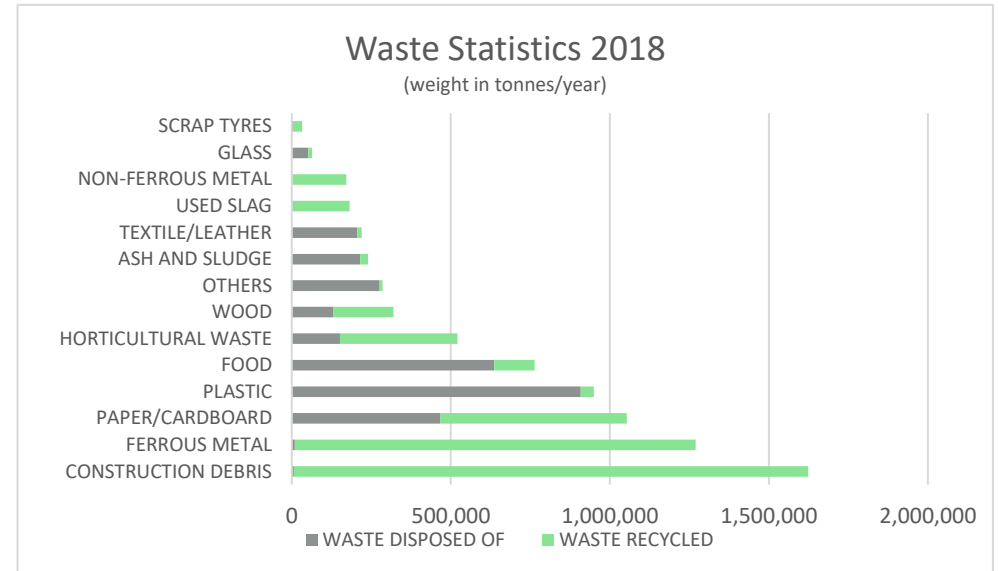


Figure 2 Waste Statistics 2018, based on the MSE's Singapore's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

Through these measures across the entire value chain, innovative circular business models shall be promoted, and Singaporean companies can seize opportunities in the region by becoming specialised in waste treatment, recycling, and remanufacturing.

The three resource loops that Singapore is focusing on to close:

- Food
- Electrical and electronic equipment
- Packaging including plastics



Singaporean households are responsible for half of the **food waste** generated, which has grown by 30% over the last 10 years and is still expected to rise due to a growing population.

A NEA study found that each household disposed 2.5kg of food waste per week that could be avoided. While food waste makes up one fifth of Singapore's waste, only 17% were recycled in 2018. Half of the food waste could be prevented if households were more accurate and mindful when buying and ordering food.

Singapore, being an island-state with virtually no natural resources, imports over 90% of the food supplies from other countries. High food waste impacts food security, if improperly disposed of together with recyclables in recycling bins, would not only cause odour nuisance and attract pests, but would also contaminate recyclables, resulting in them not being recycled. In addition, waste collection, which will need to be done more frequently to minimise odour nuisance and pest infestation, will in turn lead to generation of more emissions from the transportation of waste.

The NEA is helping households, food manufacturing establishments, food retail and supermarkets by providing them with information on reducing food waste in the form of, for instance, guidebooks. Unsold or excess food that is still safe

for consumption can be donated to food distribution organisations such as The Food Bank Singapore, Food from the Heart, Willing Hearts and Fei Yue Community Services.

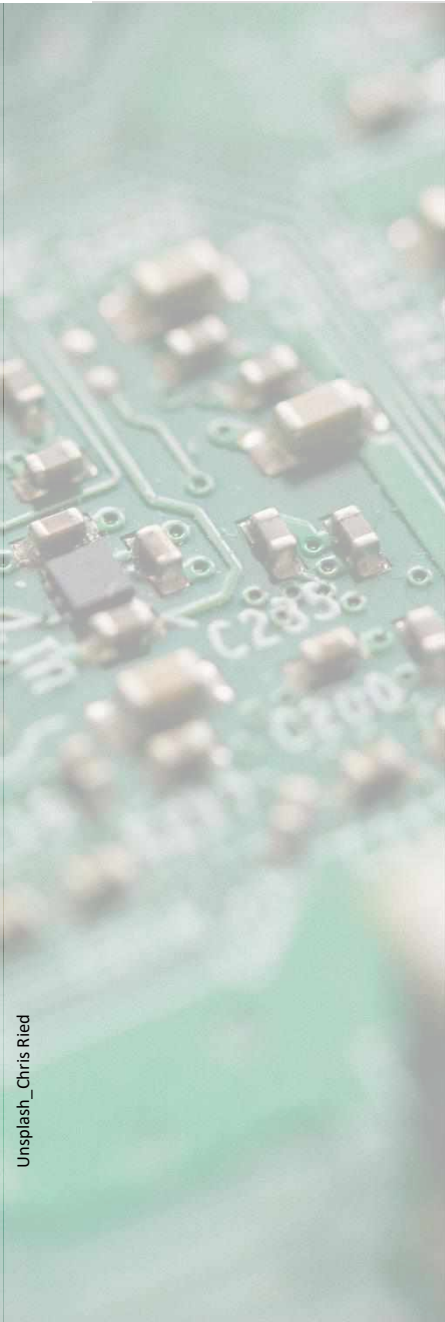
Unavoidable food waste can be converted into non-potable water, liquid nutrient, compost, and biogas for energy generation with the help of modern technology. Companies that implement food waste minimisation projects like on-site food waste treatment systems can make use of the NEA's 3R Fund. This initiative co-funds up to 80% of qualifying costs, up to a cap of SGD 1 million for projects that minimise waste to at least 100 tonnes over the whole project duration time.⁴

The NEA and PUB collaborate to turn food waste and used water sludge into energy. Combining these two waste streams results in triple the biogas yielded, thanks to a process called anaerobic digestion. This process will also be used in Tuas Nexus where the NEA's IWMF is co-located with PUB's Tuas Water Reclamation Plant.

Singapore also started household food waste segregation projects like the "Food Waste? Don't Waste!" programme at the Tampines GreenLace HDB estates, where food waste caddies and bags were used to collect food waste. The project was very successful and provided insights on food waste generation and disposal behaviours.

The food waste segregation roadmap includes measures from 2021 and 2024 onwards. In 2021, large public sector buildings with food and beverage outlets will start segregating their food waste for treatment under the Public Sector Taking the Lead in the Environmental Sustainability (PSTLES) initiative. Furthermore, it will be mandatory for developers of new commercial and industrial premises, where large amounts of food waste are to be expected, to set aside space for on-site food waste treatment systems in their design plans. In the

⁴ NEA, 3R Fund (<https://www.nea.gov.sg/programmes-grants/grants-and-awards/3r-fund>)



second stage from 2024 onwards, large commercial and industrial food waste generators will have to segregate their food waste, but they will have the choice of which method suits their operations best. Additionally, new developments that already set aside space for on-site food waste treatment systems from 2021 are required to implement the on-site treatment of food waste.

While **Waste Electrical and Electronic Equipment (WEEE)** (e-waste/EEE i.e. everything powered by an electrical source) makes up less than 1% of total waste generated in Singapore, it is important to recognise, that this still means 60,000 tonnes annually, which is equivalent to 11kg per person per year.

Recycling WEEE has several advantages. Firstly, it minimises danger to human health and the environment, as it contains small amounts of hazardous substances like mercury and cadmium. Secondly valuable resources such as precious metals and working components can be recovered. By reusing these recycled resources, there is less needed for mining virgin raw material.

Since 2017, Singapore has restricted the presence of six hazardous substances (hexavalent chromium, polybrominated biphenyls, polybrominated biphenyl ethers, lead, mercury, cadmium) in six types of WEEE (i. e. mobile phones, portable computers, refrigerators, air conditioners, wa-

shing machines and panel TVs). In 2018, Singapore also enhanced its control measures on mercury-added batteries. Under the enhanced measures, the manufacture, importation, and exportation of all batteries (including button cell batteries) containing more than 5ppm by weight of mercury per cell are not allowed. Proper recycling and treatment of WEEE is supported by the national voluntary partnership for e-waste recycling by the NEA.

Since 2016, the NEA has supported StarHub's Recycling Nations E-Waste (RENEW) programme to make WEEE recycling easier and more accessible for the public, by placing collection bins in over 400 locations across the country. These bins are meant for cables, mobile phones, tablets, laptops, DVD players, car stereos, telephones and answering machines. As of the end of 2019, 501 tonnes of e-waste have been collected.

The e-waste management roadmap intends to implement the EPR to manage e-waste, and this will be done under the Resource Sustainability Act. The EPR obliges the producers to a proper end-of-life management of their products. From July 2021 onwards, EEE-producers will be physically and/or financially responsible for the recycling of their discarded products, which includes collection of the products and ensuring that the products are recycled by licensed companies. Producers of consumer EEE that are used by the general public, such as laptops, mobile phones, and household appliances, are required to join a Producer Responsibility Scheme (PRS). The operator of the PRS will be appointed by the NEA and take on the producers' responsibilities. It will do so by developing and implementing a collection and recycling system specifically for consumer EEE, e.g. scheduling collection drives, providing e-waste bins, transporting the waste to licensed recyclers, reporting the tonnage of e-waste collected and recycled to the NEA, as well as conducting public education programmes.

EEE retailers are required to provide free one-for-one take-back services for EEE upon requests from consumers during delivery of new EEE products of the same



class or type, while large EEE retailers, floor area 300m², need to provide in-store e-waste collection points for consumer products of the same class or type as that supplied at those premises. For non-consumer EEE it will be mandatory to provide free take-back services to their clients upon request.

The e-waste loop can be closed by incentivising the eco-design of products, lengthening the product lifespan by encouraging repair and reuse and transferring responsibility on producers to take back products for proper end-of-life treatment.

In 2018, about one-third of domestic waste disposed of consisted of **packaging waste**, with 55% of it being plastic packaging, 25% paper packaging and 20% others (glass, metal, wood, composite).

The government started a joint initiative with the industry and NGOs to reduce packaging waste in 2007, called "Singapore Packaging Agreement" (SPA). More than 200 companies have participated since then and together, they have cumulatively reduced about 54,000 tonnes of packaging waste as of 2019, which resulted in an estimated packaging material cost savings of SGD 130 million. The government is committed to keep collaborating closely with the industry to develop a circular economy through sustainable prod-

uction and design and establishing best practices in the 3Rs (Reduce, Reuse, and Recycle).

In addition, Singapore is supporting ground-up initiatives like the "Zero Waste SG's Bring Your Own (BYO)" campaign. This initiative supported by the "3P Partnership Fund" encouraged consumers to use reusable bags and containers for takeaway food, beverages, and groceries. More than 400 retail stores joined the campaign by providing incentives for customers who bring their own reusable container. By that two million pieces of plastic disposables and packaging were saved.

Under the RSA, the Government will introduce mandatory reporting of packaging data and 3R plans for packaging in January 2021. The current mandatory waste reporting framework for large malls and hotels will be expanded to all large industrial and commercial premises, including large convention and exhibition centres. Producers of packaged products and retailers such as supermarkets with an annual turnover of more than SGD 10 million will need to report data on packaging that they put on the market, and 3R plans for packaging to fulfil their obligations. In the future, this framework will build the basis for an EPR framework to ensure producers are responsible for the collection and recycling of the materials they use to package their products. The government is seeking potential approaches by consultation with the industry. The EPR system is planned to come into force no later than 2025.

EPR Mechanisms used in other countries for packaging waste management:

- Take-back with recycling rate targets: Achievement of specific recycling or diversion-from-landfill targets by producers taking back their products.
- Performance standards/restrictions: Enforcement of standards for specific parameters (e. g. minimum recycled content in products, volume space ratio for specific products).

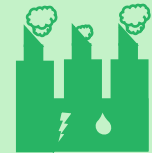
- Deposit refund system: Surcharge on product purchases in combination with a return rebate.
- Ecological material taxes: Tax policy based on the ecological footprint of packaging material (e. g. virgin natural resources, tax based on lifecycle assessment of climate impact).
- Pure financial mechanisms: advance disposal fees (ADF) or advance recycling fees (ARF) (taxes based on product sales to cover the disposal or recycling cost) and tradeable credits (purchasing of tradeable credits by the producers to provide financial incentives for the recycling industry to collect/reprocess packaging waste).

Boosting the recycling rate can be achieved by more intensely using the existing technology of mechanical recycling or by using new, innovative, and up-coming recycling technologies such as chemical recycling. The latter converts separated or mixed plastic in its educts as pyrolysis oil, naphtha, methanol, and syngas which can then be used to produce new plastic products or turned into fuel to replace fossil fuel sources. This process offers opportunities especially for mixed or dirty plastics that cannot be recycled with traditional mechanical processes. Singapore is well positioned for this innovation as it is a petrochemical hub and can use this strength to close the plastics loop. To achieve this, the government is keen on collaborating with stakeholders from various industry sectors to explore how new technologies can be applied in Singapore, so that it is environmentally as well as economically sustainable.

By adopting a circular economy approach to close the three focus resource loops, namely food waste, e-waste and packaging waste (including plastics), Singapore moves closer to its Zero Waste vision where both households and the industry consume less, waste less and recycle more.

2.6 Infrastructure Optimization for Maximum Resource Recovery

Overview: measures and successful synergy projects



- Pneumatic waste conveyance system
- Pilot mechanical and biological treatment plant
- Tuas One: improved Waste-to-Energy Plant
- Tuas Nexus: integrated waste management facility

Figure 3 Overview: measures and successful synergy projects, based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

Singapore plans to make waste-collection more manpower-efficient, improve the energy efficiency of its WTE plants and create new material out of incineration bottom ash.

One measure to achieve this aim is the implementation of the **Pneumatic Waste Conveyance System (PWCS)** to reduce transportation ways and the manpower needed to convey waste from refuse chutes to the bin centre. A PWCS is an automated waste collection system that conveys waste from individual buildings by air suction through a network of pipes to a central location for collection. Thereby further reducing odour and pest problems. Since April 2018, PWCS are mandatory for non-landed private residential developments with 500 dwelling units (DUs) or more. Over 150 PWCS across public, private and commercial developments have been implemented island wide.

To further leverage on the economies of scale, district-level PWCS (DPWCS) are being introduced to tackle future challenges due to increasing manpower shortages and an ageing workforce. For the DPWCS, the bin centres from developments located within the district are consolidated into a single bin centre. This reduces overall land take for refuse collection purposes, reduces refuse truck traffic and minimises smell and noise disamenities to the public. So far DPWCS have been implemented in new HDB estates (e. g. Tampines North,

Punggol North, Bidadari) and Kampong Bugis, a mixed-use development site comprising 4,000 private residential units and 50,000 sqm of space for commercial activities.

To maximise the value of the waste, a 500 tonnes/day **pilot Mechanical and Biological Treatment (MBT)** facility will be set up. The facility will have 2 treatment processes: a mechanical treatment process to recover recyclables like plastics, ferrous and non-ferrous metals, and an aerobic biological treatment process to dry the waste into Solid Recovered Fuel. This facility will recover up to 15% of the waste as recyclables.

2.7 Transformation of the Environmental Services Industry

Currently, the Environmental Services (ES) industry comprises 1,300 cleaning firms, 500 waste management companies, and 300 pest management companies. The ES industry is labour intensive and has low productivity and low technology adoption. By 2025, the transformation effort aims to strengthen the capabilities of the industry and benefit 30,000 professionals with higher-value jobs through skills upgrading and technology adoption.

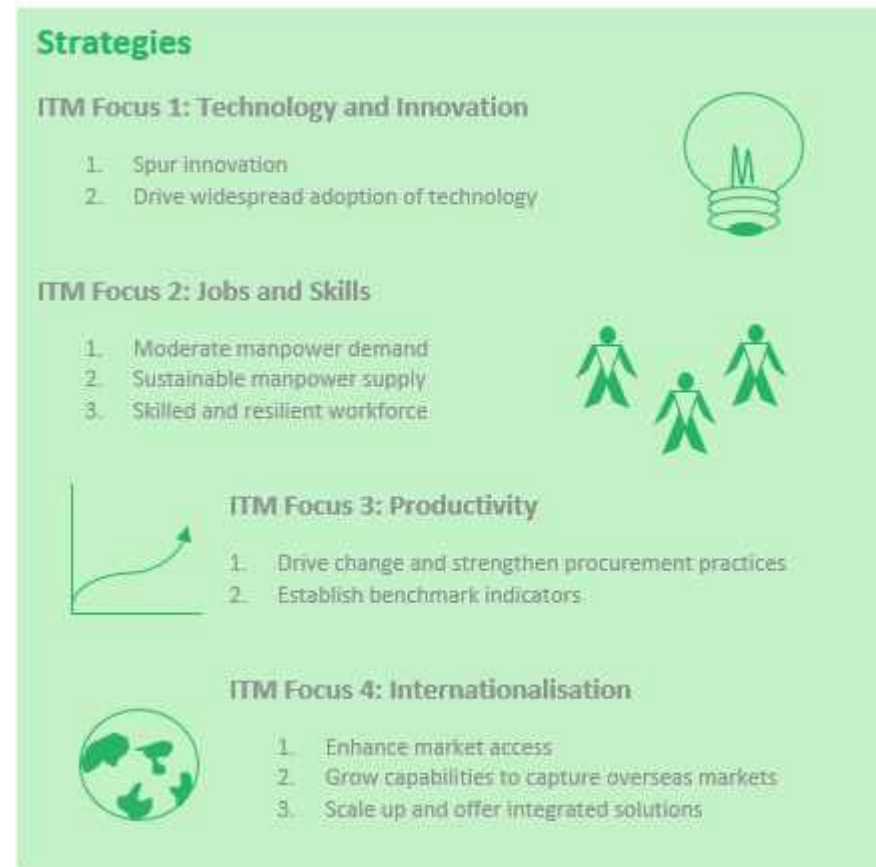


Figure 4 ITM Strategies, based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

The use of new technologies enables the industry to transform labour-intensive jobs into more attractive and highly skilled jobs. For instance, collection of recyclables in Singapore is now almost fully automated, where truck drivers can lift and empty recycling bins with a joystick, instead of having two workers manually pushing the recycling bins to the truck. This allows companies to become more manpower-lean and improves the working conditions for staff. Singapore relies on four approaches to support the development of new

technologies and innovation: 1. New, scalable and replicable ways to clean and manage waste, 2. Providing support to companies to expand capabilities and expand into global markets, 3. Promoting R&D within companies, 4. Positioning Singapore as the technology CoE by showcasing locally developed cleaning and waste management solutions.

Under the Gov-PACT programme, the NEA and Enterprise Singapore launched many innovation calls to develop new ES solutions to tackle challenges faced by the industry. The Gov-PACT programme aims to use lead demand at a national level to develop promising industries, which encourages co-innovation capabilities opportunities between Government agencies and local SMEs/start-ups. This would help the local SMEs/start-ups develop new capabilities to create innovative products and services. The financial support funds up to 70% of the qualifying project costs for local SMEs and start-ups. Eligible applicants are local SMEs/start-ups registered and operating in Singapore with minimum 30% local shareholding.

To promote the adoption of new technologies, Singapore has defined the following steps. Firstly, technologies must be identified that shall be scaled, then partnerships for technology exchanges must be established and lastly, leverage platforms shall be set up. Leverage platforms allow technology providers to link with service buyers, e. g. Whole-of-Government Business Grants Portal.

Job redesign provides a way to create a leaner, more elderly friendly and more efficient industry. Job redesign clinics are also organised to provide one-on-one consultations for companies to learn about the initiative and supporting grant(s). NEA has also established a S\$30 million Productivity Solutions Grant (PSG) for the Environmental Services industry to support the adoption of commercially available and proven environmental services technologies, including equipment and digital solutions (i.e. ready-to-go solutions), to increase operational efficiency and productivity. It is applicable to SMEs and MNCs, looking to adopt equipment and digital solutions that mechanise waste management and

cleaning tasks, as well as adopt more advanced robotics, automation and autonomous systems which will potentially have a greater impact on the level of productivity in the environmental services industry.

To reap the benefits of new technologies, it requires a well-trained and **highly skilled** workforce. To reduce manpower, the island-state relies on designing buildings that make cleaning and waste collection easier and faster.

To ensure a sustainable future manpower supply, the following areas were identified - redesigning jobs and adopting automation to reduce the overall manpower demand and the physical demands of the work for older workers; improving the industry's image to attract mid-career switches and graduates, and enhancing internship opportunities to attract new sources of manpower, with the National Jobs Bank serving as a platform for connecting employers with suitable candidates; and working with the companies to strengthen their human resource policies to better attract and retain the workforce.

By way of example, the NEA is working with partners like WSG and the Institutes of Higher Learning (IHL) to show their appreciation to professionals for their commitment through incentive events or attracting young people by increasing internship opportunities, for example.

Furthermore, Singapore has identified four possible ways to offer workers the opportunity to learn new skills and grow in their jobs. This can be achieved by creating a Skills Framework together with SkillsFuture Singapore (SSG), WSG and industry stakeholders. Developing apprenticeship and scholarship programmes will attract and retain talent, which are targeted at Professionals, Managers, Executives and Technicians (PMETs). Pre-Employment Training (PET) and Continuing Education and Training (CET) Programmes will broaden the current offerings.

The Singapore Workforce Skills Qualifications (WSQ) modules will also be reviewed to ensure they are still relevant to the industry.

Republic Polytechnic has already launched a new Part-Time Diploma in Applied Sciences (ES and Management), which gives participants the opportunity to deepen their skills and knowledge required by the ES industry. More PET and CET programmes will be gradually introduced.

A few examples of upscaling the industry with higher skilled staff and new, innovative technologies includes local SMEs such as Biomax Green Pte Ltd, Westcom Solutions, which operate internationally and offer solutions that convert organic waste into high-grade organic fertilisers, using digesters and enzymes. Plaspulp Union is another notable example of a company exploring recycling solutions for complex waste materials using advanced technology and automation. SembWaste Pte Ltd is another innovative industry pioneer that has adopted a system that leverages sensor technology to track the capacity of waste in compactor bins. A smart device is used to receive waste collection jobs from the command centre to plan the best vehicle route and schedule to optimize resources. This improves the productivity and provides higher-skilled jobs.

To achieve **productivity** enhancement, Singapore recommends service buyers to change their practices by shifting towards performance- or outcome-based contracts instead of the traditional headcount-based approach. Additionally, a change to longer contract periods would allow the supplying companies to make returns on their investments in technology. Another way to enhance productivity is to use land more efficiently, such as by combining various recycling activities in the form of a multi-storied development, also closed landfills shall be reused.

A good example of increasing land productivity is Singapore's first multi-storey recycling facility (MSRF) that will be launched in 2021. It will house recyclers handling different forms of waste streams like metals, e-waste, paper, and plastics. The building will replicate a land-based operating environment in a high-rise setting and the co-location of the recyclers will support the circular

economy approach. In addition, the MSRF will be located close to TimMac @ Kranji, which is a similar project with industry associations from the metal, construction machinery and timer industry.⁵

Singapore successfully turned the Lim Chu Kang Dumping Ground into the Sarimbun Recycling Park (SRP). It is now home to 10 recycling plants that runs a quarter of the country's recycling. For instance, construction waste is turned into recycled material for roads and buildings, horticultural waste into compost and charcoal and scrap plastic into plastic pellets that can re-enter production processes.

Internationalisation is often the only chance for companies to grow due to Singapore's small market size. This allows companies to gain new capabilities and expertise which is essential to be globally competitive.

The NEA supports companies to enhance market access by collaborating with its overseas counterparts, participating in international projects, supporting companies and trade associations in their learning trips overseas and through organizing international platforms and events such as the CleanEnviro Summit Singapore. The NEA also helps companies grow their capabilities to capture overseas markets in identified growth areas with high market potential. Singapore aims to partner with other countries with the same aspirations for a clean and liveable environment. Hence, Singaporean solutions can be adopted by other countries in the region and around the world. To scale up and offer integrated solutions that will enable Singapore to become a world leader requires the whole industry to work together to develop new solutions. The NEA aims to develop integrated solutions by tapping on the unique capabilities of each sector in the Built Environment Cluster for city planning and development projects overseas.

⁵ JTC, TIMMAC @ Kranji (<https://www.jtc.gov.sg/industrial-land-and-space/Pages/timmac-kranji.aspx>)



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Trade associations such as WMRAS and EMAS play a key role in enabling industry-wide collaborations. Enterprise Singapore supports the associations through various initiatives like the Local Enterprise and Association Development (LEAD) programme that includes internships for students and overseas mission trips.

Funding schemes



- **Enterprise Development Grant (EDG)** by Enterprise Singapore: Up to 70% of qualifying project costs (up to 80% for applications received from 1 April 2020 to 31 December 2020) can be funded for projects that help companies upgrade their business, innovate or venture overseas.
- **Research Incentive Scheme for Companies (RISC)** by EDB: Encouragement to develop R&D capabilities and technologies by supporting projects in science and technology fields.
- **Closing the Waste Loop R&D Initiative (CTWL)** by NEA: SGD 45 million to support R&D projects that look at extracting value and resources from key waste and residue streams including plastics, food, e-waste, and incineration bottom ash.
- **Productivity Solutions Grant (PSG)** by the NEA: SGD 30 million fund for the adoption of commercially available and proven ES technologies, like equipment and digital solutions that raise productivity. SMEs and MNCs are eligible.

Figure 5 Funding Schemes, based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

The NEA's Regulatory Sandbox for environmental service companies allows trial innovative technologies and solutions to be tested. Solutions can be tested with regulations being relaxed for a fixed duration and within certain parameters that

do not compromise the environment, public health, and safety. For instance, SP Group's gasification pilot that is being tested under the Regulatory Sandbox initiative converts waste from Gardens by the Bay into heat and biochar. Singapore will continue to participate in the International Organisation for Standardisation (ISO) Technical Committees. The country will be involved in the new areas of waste collection and transportation management, solid recovered fuels, and circular economy. The aim is to support local companies exporting their products and services overseas by meeting international standards.

In the Innovating Curating Better Automation and Technologies for Environmental Services (INCUBATE) partnership, Singapore brings together public and private sectors to prototype, pilot, and profile solutions. Several food waste recycling machines have been tested and helped to close the food waste loop. Food waste digesters have been implemented in Nanyang Polytechnic's and Republic Polytechnic's school food courts, at Changi Airport Group's terminals for its tenants and at City Developments Limited's serviced residences.

Desired Outcomes by 2025	
Best in class & productive enterprises	High degree of automation & innovation
A professional, skilled, and manpower-lean workforce	Environmental services and companies with global footprint

Figure 6 Desired Outcomes by 2025, based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

An excellent example of a partnership that contributes to all 4 ITM focus fields is the joint venture between the local family-owned company Wah & Hua Pte. Ltd. and the ALBA group, a world-leading German recycling specialist and environmental services provider. The joint venture between Wah & Hua Pte Ltd and the ALBA Group successfully received the license to operate in the Jurong area in 2020. The Jurong urban region, with a population of 500,000, is to be served by a digitalised system that meets high environmental standards.

Public Waste Collection Scheme



Source: Based on NEA, Waste Collection Systems – Public Waste Collection Scheme (<https://www.nea.gov.sg/our-services/waste-management/waste-collection-systems>)

Public waste collectors (PWCs) are appointed by the NEA through open tenders to serve domestic and trade premises in Singapore by geographical sectors. Successful bidders get licenses to provide waste and recyclables collection services for the respective sectors for seven to eight years. At the moment, four PWCs operate in Singapore and serve the six sectors as shown in the map.

Jurong: ALBA W&H Smart City Pte Ltd (ALBA W&H)	Woodlands – Yishun & City – Punggol: SembWaste Pte Ltd
Clementi – Bukit Merah: Veolia ES Singapore Pte Ltd	Pasir Ris – Bedok & Ang Mo Kio – Toa Payoh: 800 Super Waste Management

It provides the capacity to collect and treat more than 170,000 tonnes of waste per year. The contract is equivalent to more than SGD 150 million.

The joint venture uses smart city solutions to modernize waste management in one of the six sectors. It is customised to fit the specific situation in Singapore and uses digital route planning and sensors that record the waste containers' fill level to the company's control centre. The trucks will be supplied by German truck maker Mercedes-Benz and some will have solar mats on the roof to cut fuel consumption. To boost household recycling rates, ALBA provides an app to inform about the right way to properly segregate waste. It displays the nearest recycling bins and centres, gives tips on green living and lets users collect bonus points that they can redeem with participating retailers and other partners.

With this concept, the project covers all focus topics of the industry transformation map:

- Technology- and innovation-driven.
- Enhancement of digital job redesign and offering of high-profile positions.
- Improvement of productivity by optimized route planning.
- Internationalization by a local company (Wah & Hua) establishing a partnership with a German partner (ALBA group in Singapore) and developing a successful concept that can potentially be exported in the future.

“Singapore is one of the most modern cities in the world and a leader in digitalization. It is a major project and an honour to contribute to this development process with our Smart City recycling and waste management solutions. Together with our local joint venture partner, we aim to play a pioneering role here and build a collection system that sets the new standard for the future”, said the CEO of ALBA Group, Dr Axel Schweitzer. Furthermore, “Singapore has the goal of becoming the

Figure 7 Public Waste Collection Scheme, own illustration by SGC, based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)



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2.8 Science and Technology for a Greener Future

Key R&D Programmes

- **Closing the Waste Loop (CTWL)** R&D initiative: SGD 45 million
- **WTE** R&D programme: SGD 25 million

Figure 8 Key R&D Programmes, based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

While the current infrastructure and the implementation of policies and regulations to create a greener behaviour is important, the **Research & Development (R&D)** is essential to create and refine new technologies, products or systems that Singapore can use and later share with others by exporting. So far the island has been able to achieve much success in its R&D accomplishments such as microbes converting food waste into compost, the use of slag from high temperature gasification of municipal solid waste for construction applications, Semakau Landfill, the first offshore landfill in the world or Tuas Nexus, the first purpose built facility that integrates a WTE plant with a used water treatment facility.

For R&D to be successful it requires academia, enterprises, and governments to work together. Academia contributes deep scientific knowledge, scholarship, and know-how to turn theoretical concepts into potential solutions, while enterprises provide market experience, ideas and sometimes financial resources or manpower. Companies also provide test-bedding opportunities for R&D outcomes to scale up solutions and translate them into commercially viable

applications. The third player, the government helps to grow a thriving ecosystem, support R&D by providing infrastructure, funding support, policy guidance and platforms for collaboration and test-bedding opportunities.

With this approach academics see their ideas being used for real-life applications and enterprises gain new business opportunities which boost economic growth and create highly skilled jobs and can later be exported into the region to help others. This will position Singapore as a global leader and CoE in waste management and circular economy solutions. The NEA has established two key programmes to boost R&D. The CTWL R&D Initiative that was launched in 2017 has funded a total of about SGD 27 million to 11 projects as of March 2020. The programme has 3 targets:

- *Resource efficiency*: utilising resources efficiently for as long as possible while keeping processes manpower-, energy- and water-efficient.
- *Landfill avoidance*: converting residues and waste, which are currently discarded in the landfill, into useful resources, to prolong the landfill's lifespan beyond 2035.
- *Maintaining high standards of public health*: ensuring waste management is carried out in a safe and hygienic manner.

Future R&D Areas

- **Sustainable Material Substitutes**
- **New Applications for Resources Harvested from Waste**
- **Integrating Waste and Resource Streams**



Figure 9 Future R&D Areas, based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

⁶ ALBA, ALBA Group secures first contract in Singapore – Waste management for urban region with 500,000 population (<https://www.alba.info/en/newsroom/service-for-journalists/press-releases/detail/alba-group-secures-first-contract-in-singapore/>)

The current topics for the CTWL R&D initiative are elaborated in the following, new focus areas of R&D will be identified by the government and supported by industry and R&D stakeholders. Singapore aims to *increase the recovery rate* of valuable, usable materials from the key waste streams of the Zero Waste Masterplan, while lowering the economic cost and environmental impact of current recycling methods. For instance, A*STAR is currently trying to find a solution for recycling plastic-embedded multilayer films as they are used in most F&B and pharmaceutical packaging. If successful, the plastics could be separated from the rest of the packaging material and then be reused multiple times.

To achieve *landfill conservation*, the NEA aims to realize “NEWSand” production, which is an environmentally sustainable product made from waste treatment residues (u. a. incineration bottom ash - IBA). This would extend the lifespan of the landfill and avail a new source of construction material. Although this could potentially be a good solution, strict standards need to be enforced to ensure that no heavy metals pollute soil or water. A suitable site for a field trial to gather data for review of the standards for the use of treated IBA in road construction has already been identified. Republic Polytechnic is also developing a process to turn IBA into construction aggregates that can be added to produce ready-mixed concrete.

To free-up the current landfill space, *environmental remediation* is another focus of the programme. It allows researchers to test-bed innovative solutions, technologies, and techniques to rehabilitate closed landfill sites into usable land again.

Evaluating the effectiveness of the measures taken across the entire waste management value chain, *digital and data-driven management systems* are essential. Information and Communications Technology (ICT) like data analytics could be used to support policy formulation and infrastructure planning.

Even though CTWL is increasing efforts to maximise material resource recovery, WTE remains a key strategy as it produces electrical energy and reduces the

volume of residual waste, thereby extending the lifespan of the landfill. The WTE R&D programme that includes SGD 25 million and was launched in 2014 has two aims. Firstly, the programme looks at solutions *that boost the energy recovery efficiency of WTE processes and methods*. NTU's Nanyang Environment and Water Research Institute's (NEWRI) Singapore Membrane Technology Centre for instance, is exploring possibilities of membranes that can efficiently produce oxygen-enriched air or membranes that can enhance the current incineration process.

Secondly, *suitable alternatives to WTE technologies* shall be explored such as gasification that would provide more renewable energy options and/or higher value products from waste with a minimum of waste residues. The solutions must consider Singapore's solid waste composition. Therefore, foreign solutions may not be immediately applicable but should be adjusted first. Nevertheless, the testing proved to be difficult, as test-bedding at existing WTE facilities is not feasible due to the disruption it would cause. Therefore, the NEA has co-funded SGD 12 million to NEWRI for the building of a WTE Research Facility (WTERF), a SGD 40 million project for its construction and operation over its projected lifetime. The WTERF is the first in Singapore that employs high-temperature slagging gasification using municipal solid waste as feedstock and was officially opened by the then Minister for the Environment and Water Resources in 2019. It combines waste gasification in the upper part with residue melting in the lower part using auxiliary fuel like biomass charcoal. Generating heat up to 1,600°C, incombustible fractions (ash, metal) are melted into a slag that can be used as aggregates or metal granulates that can be recycled.

Singapore has identified three new R&D areas to stay at the forefront of science and technology. By inventing *recyclable substitutes*, recycling and upcycling will be cheaper and easier, like specially formulated non-metal nanostructures made from paper for example, that could replace metal electronic circuits and wiring. As a *new application for resources harvested from waste*, research helps to identify useful substances within common types of food waste and to

hygienically and efficiently extract and convert them into nutraceuticals which have a medical or health benefit in form of health supplements and food additives.

Integrating waste and resource streams by industrial symbiosis can be executed in the form of brokering, where companies mutually profit from transactions. R&D focuses on converting waste from one industry into usable materials for another, as well as exploring new, industrial scale uses of existing waste streams that have yet to be recycled or reused. The water-waste-energy nexus remains especially interesting. New opportunities to pilot tailored circular zero waste solutions have been planned for, as the transformation of housing estates and town centres by R&D innovation.

2.9 Engagement of all Stakeholders

To achieve its goal on becoming a Zero Waste Nation, Singapore must involve all stakeholders at every level. While the government has set the direction for the transformation (set-up of infrastructure, funds for R&D, education projects, etc.) businesses, individuals and organisations need to become partners in order to come up with innovative and effective solutions.

For the Zero Waste Masterplan, the MSE and the NEA consulted relevant stakeholders and sought their views on the topic. The NEA approached over 250 companies and more than 5,000 households were interviewed in two big door-to-door surveys in 2018 and 2019 to better understand household recycling behaviours. Furthermore, NGOs, youths and other partners were asked about their views on the zero waste plans and to explore collaborations. The general public was involved by a public consultation with more than 1,300 participants and two focus group discussions with 90 participants; to discuss how a sustainable consumption and production can be achieved, how waste can be reduced and how a 3R culture can be further established. The results were that the participants generally agreed on the importance of making the 3Rs a norm in Singapore, nevertheless convenience was highlighted as a crucial factor for

people to take action. Additionally, the outcome was the need for more education in order to raise awareness on waste issues and companies to support the promotion of sustainable consumption.



Figure 10 Stakeholders in the Area of Recycling, own Illustration by SGC based on the MSE's Zero Waste Masterplan (www.towardszerowaste.sg/images/zero-waste-masterplan.pdf)

To direct attention towards waste issues and to promote a zero-waste lifestyle, ground-up initiatives are of utmost importance. The MSE and the NEA work closely with partners like schools, businesses, community groups, NGOs, and civil society groups to broaden the network, spread the word and educate people.

These partners also help in gathering feedback and carrying out research in additional studies that complement government research. For instance, the Singapore Environment Council (SEC) conducted a nine-month study on 'Consumer Plastic and Plastic Ecosystem in Singapore' and subsequently launched a month-long campaign 'One Less Plastic' that aligned with their findings and encouraged shoppers to opt for reusable bags.

The Climate Action SG Alliance, which consists of a group of corporate and civil society leaders, produced and shared a series of educational videos on social media about recycling. The Waste Management and Recycling Association of Singapore (WMRAS) is there to help businesses get engaged in Singapore's zero-waste journey. With 160 member companies, the association encourages waste reduction and recycling through educational talks and it also recognises member companies that promote environmental sustainability with their biennial WMRAS Excellence Awards. In addition, WMRAS Academy offers a Professional Course in Waste Management and Resource Recovery in collaboration with the Australian Griffith University. Schools have also been encouraged by the MSE and the NEA to organise ground-up initiatives which promote environmentally friendly practices. Therefore, the MSE together with the National Youth Council, approach youth leaders to hear their views and better understand the youth's perspectives in order to empower them for more ground-up initiatives. Schools and their canteens have started to move towards a greener future, by banning straws, increasing the availability of reusable cutleries and containers, implementing BYO schemes and surcharges on disposable packaging.

The environmental challenges faced by Singapore - increasing waste amounts, greater resource constraints and climate change - are applicable to many other countries as well. Therefore, partnerships would mutually benefit other countries and foreign institutions. Progressive globalisation and interconnections make partnerships especially important to develop solutions for a global circular economy with efficient resource usage, proper recycling, clean

recyclables and innovation and technology of resource recovery. During a product's lifespan: sustainable production, consumption, and finally waste management, it will most probably cross-national borders. Singapore as a highly connected small island-state will continually address environmental challenges and fulfil their international commitments by upholding a rules-based approach. As a result of this commitment, Singapore has partnered with countries like China, Japan, South Korea, the Netherlands, Oman, Jordan and the United Arab Emirates through Memorandums of Understanding (MoUs), policy exchanges, industry workshops and demonstration projects. One example is the Sino-Singapore Tianjin Eco-city (SSTEC) that is one of sixteen pilot zero waste cities/areas. Singapore's contribution enabled SSTEC to meet key environment-related performance indicators on waste reduction and recycling, among others. Another example is the Singapore-Japan E-Waste Management Forum jointly organised by the NEA and the Ministry of Environment of Japan, that attracted 150 industry leaders and delegates.

Singapore will continue to establish partnerships with the 3P (private, public, people) sectors and keep engaging Singaporeans to actively contribute and shape the nation's future. The MSE started a Citizen's Workgroup to minimise the contamination rate of blue recycling bins (currently 40%). The participants from different backgrounds will hear from experts and help to pilot and implement solutions. The NEA will combine efforts with other government agencies, work with businesses, international partners, civil society groups and individuals, to find solutions for a sustainable Singapore and for becoming a Zero Waste Nation together.

2.10 Regulations in Detail

2.10.1 Singapore's Resource Sustainability Act

The Resource Sustainability Act (RSA) was gazetted on 4 October 2019 as part of Singapore's Zero Waste Masterplan. It aims to create a more sustainable living environment and advance the move towards a Zero Waste Nation.

The Act that focuses on three priority waste streams (1. Electrical and electronic waste, 2. Packaging waste, 3. Food waste) will be implemented incrementally from 2020 to 2025. Certain sections have come into force on 1 January 2020.

The Resource Sustainability Act comprises an extended producer responsibility for e-waste, a mandatory reporting framework for packaging and mandatory segregation and treatment regulations for food waste.

2.10.2 Basel Convention and Singaporean Regulations

In 1996 Singapore acceded to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention) in the control of export, import and transit of hazardous wastes. Hence Singapore enacted the Hazardous Waste (Control of Export, Import and Transit) Act and its regulations in accordance with the principles and provisions of the Basel Convention. Under the Hazardous Waste Act and its Regulations, any person who wishes to export, import, or transit hazardous wastes must obtain a permit from the Pollution Control Department (PCD) of the NEA.

Currently, solid plastic waste is listed in Annex IX of the Basel Convention and is regarded as non-hazardous waste. Nevertheless, Parties to the Basel Convention agreed on the need for environmentally sustainable management of plastic waste to address the global challenge of marine litter. This international obligation will come into force on 1 January 2021 and will subject the transboundary movement of these controlled plastic waste to the Prior Informed Consent (PIC) procedure. Therefore, Singapore as a Party to the Basel Convention will put in place measures⁷ to comply with the upcoming obligation of the Convention.

⁷ NEA, Transboundary Movement Control on Plastic Waste under the Basel Convention (<https://www.nea.gov.sg/docs/default-source/default-document-library/transboundary-movement-control-on-plastic-waste.pdf>) & Straits Times “Parliament: Cross-border movement of

certain categories of plastic waste to be regulated under new law” (<https://www.straitstimes.com/politics/parliament-cross-border-movement-of-certain-categories-of-plastic-waste-will-be-regulated>)

3. German Recycling Capabilities

3.1 Waste Legislation

Overview Regulations

	European Law	- European Waste Framework Directive (2008/98/EC) - Packaging Directive
	Federal Law	- Waste Management Act, ('Kreislaufwirtschaftsgesetz', KrWG) - Supplemented by: specific regulations like Packaging Act ('Verpackungsgesetz', VerpackungsG)
	State Law	Differentiation of the Federal Waste Management Act (KrWG) through further acts
	Municipal Law	Municipal ordinances

Figure 11 Overview Waste Regulations, own illustration by SGC

3.1.1 European Law

European regulations and directives build the framework for German waste regulations. The European Waste Framework Directive (2008/98/EC) builds the basis for the German waste disposal law and must be separately transposed into national law by each EU member state.

3.1.2 German Federal Law

Germany started with a national uniform waste disposal act ('Abfallbeseitigungsgesetz', AbfG) as early as 1972 and is still pushing the boundaries in terms of new legislations. The later version, Closed Substance Cycle and Waste Management Act ('Kreislaufwirtschafts- und Abfallgesetzes', KrW-/AbfG) from 1996 and its main structural elements are still the backbone of Germany's leadership in regard to the circular economy. Its succeeding version, the so-called Waste Management Act, ('Kreislaufwirtschaftsgesetz', KrWG) is Germany's current main waste disposal statute. Furthermore, regulations for specific types of product waste can be found in various separate laws, such as the Packaging Act ('Verpackungsgesetz', VerpackG), the End-of-life Vehicle Ordinance ('Altfahrzeugverordnung', AltfahrzeugV), the Batteries Act ('Batteriegesetz', BatterieG) and the Electrical and Electronic Equipment Act ('Elektro- und Elektronikgerätegesetz', ElektroG).

3.1.3 State Law (Bundesländer)

The Federal Waste Management Act (KrWG) is further differentiated through Germany's 16 federal states, the 'Bundesländer', and their individual waste management acts. In these acts, the regional states must follow the federal law and hence, only address aspects that are not yet stated and therefore implement it accordingly (e. g. authorizing bodies for waste disposal matters and municipal waste disposal ordinances).

3.1.4 Municipal Waste Disposal Law

As the municipalities are in charge of the collection and recovery of household waste, they legislate municipal ordinances e. g. regarding usage and integration into the public system or municipal garbage collection charges.⁸

3.1.5 The Packaging Act in Detail

Germany enacted the first Packaging Ordinance ('Verpackungsverordnung', VerpackungsV) in 1991. In 1994 the EU adopted the Packaging Directive and since then, the German law adhered seven times to the EU directive through new versions of the packaging ordinance. The Packaging Ordinance was Germany's first law that assigned responsibility for waste management of packaging to the producers.

In the years that followed, Germany encountered several problems with the ordinance. Firstly, the recycling rates were not ambitious enough. Secondly, there was no fair and transparent competition. For example, Der Grüne Punkt was founded in 1990 by producers and retailers to implement a single full-cost scheme and monopolised the market until it was open for competition in 2001.⁹ Still, the problems of a limited competition remained. Additionally, some producers did not register and thereby avoided to co-finance the system. Therefore, the new Packaging Act ('Verpackungsgesetz', VerpackG) was introduced on 1 January 2019 to replace the Packaging Ordinance.

The new Act contains more ambitious recycling rates and important regulations for a more transparent and fairer economic competition. Packaging producers must financially participate in one or several schemes ('Duale Systeme') to ensure the collection and recovery of the packaging on full-coverage basis. But now the producers have to register with the Central Agency Packaging Register

(Stiftung Zentrale Stelle Verpackungsregister') before circulating packaging. Also, they are obligated to report the packaging masses, materials, participation periods, company, and brand names, which makes the whole system more transparent and easier to control than producers registering with non-centralised schemes.

The dual system schemes in turn must proof annually with a flow record that they meet the mandatory targets for the recycling rates. In addition, a new recycling rate was introduced in the new act compared to the previous ordinance: dual schemes need to recycle at least 50% of the yellow bags/yellow bins (used in Germany for light packaging waste). Nevertheless, the system is faced with current challenges, as the correctly licensed packaging is mixed with certain amounts of unauthorized packaging or non-packaging items wrongly disposed by the consumers.¹⁰

3.2 Implementation of the Regulations in Germany

3.2.1 Implementation Packaging Act: Extended Producer Responsibility (EPR)

The Packaging Act obligates so-called first circulators of packaging (producers, importers and online retailers that manufacture, import or additionally package) to participate in at least one dual system scheme. They must register with the Central Agency Packaging Register and license their packaging with one or several dual system schemes. This applies for packaging that will get disposed primarily by the end consumer or where waste occurs, as restaurants, hotels, hospitals, education facilities, freelancer offices, small crafts workshops, and agricultural businesses. The registration takes place via the online packaging registry LUCID. Initial circulators license with one of the official dual system

⁸ Umwelt Bundesamt (Federal Environmental Agency), Waste Regulations (<https://www.umweltbundesamt.de/en/topics/waste-resources/waste-management/waste-regulations>)

⁹ Der Grüne Punkt, EPR for Packaging in Germany – Der Grüne Punkt (<https://www.gruene-punkt.de/media/2866/2017-11-22-denison-dsd-oslo-final.pdf>)

¹⁰ Umwelt Bundesamt (Federal Environmental Agency), Packaging (<https://www.umweltbundesamt.de/en/topics/waste-resources/product-stewardship-waste-management/packaging#packaging-in-germany->)

scheme operators by handing in an estimation of packaging for the different materials (glass, paper/carton, plastic, metal).¹¹ Major initial circulators (> 80t glass, 50t paper/carton or 30t packaging) need to hand in a declaration of completeness. In the event of breaching the regulations, high penalties and prohibition of sales may be enacted.

The Packaging Act does not apply to customers of the industry, retail, or bigger craft workshops. There is no obligation for licensing and registration, but a compulsory take-back must be observed.

In addition to the voluntary deposit refund scheme for reusable bottles which existed already before the new regulation, the Packaging Act enacts a compulsory-deposit on one-way drinks packaging. The packaging will be returned through a network of deposit machines that are integrated in a federal system nationwide. This regulation applies to bottles with a volume of 0.1 to 3.0l for beer and beer-mix beverages, water, refreshment drinks, alcoholic-mix drink and carbonated fruit and vegetable juices with at least 50% whey content.¹²

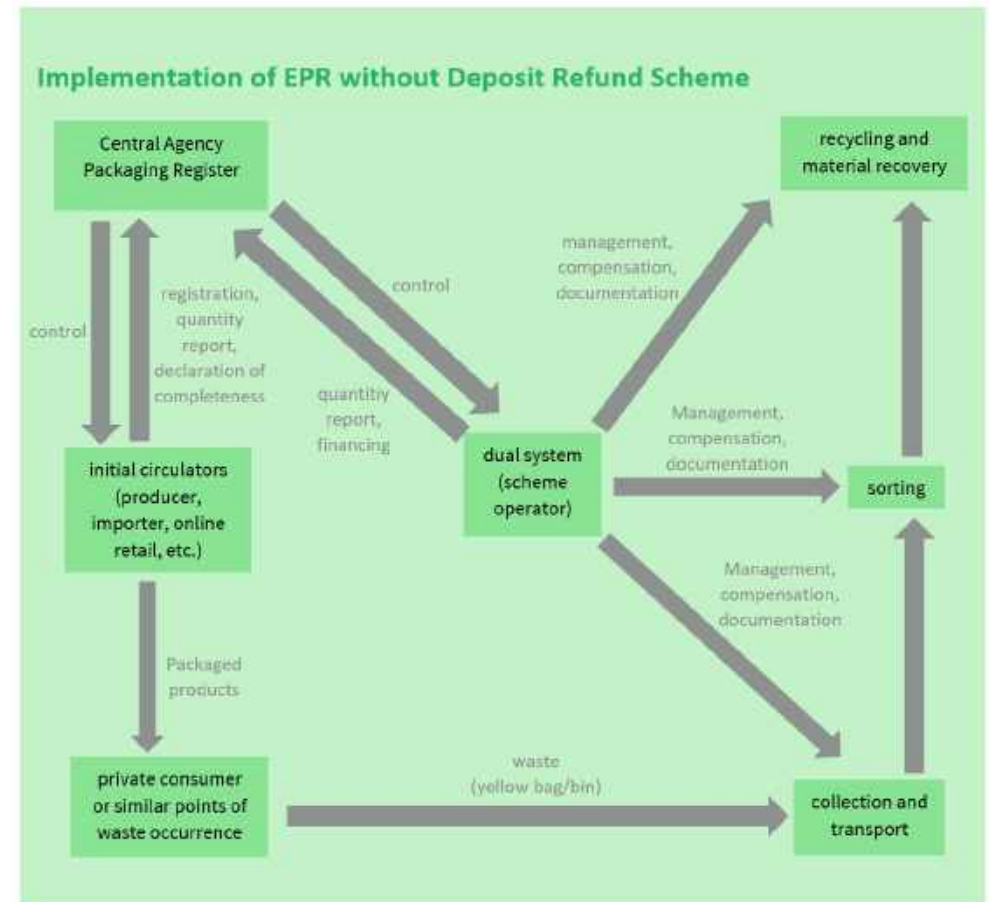


Figure 12 Implementation of EPR without Deposit Refund Scheme, own Illustration by SGC, based on Bellandvision, Duales System BELLANDDual (<https://www.bellandvision.de/duales-System-bellanddual-BellandVision.htm>)

¹¹ A list of all licensed scheme operators with contact details can be found here: www.verpackungsregister.org/information-orientierung/hilfe-erklaerung/service/

¹² IHK München, Verpackungsgesetz: Registrierungspflicht für Unternehmen (www.ihk-muenchen.de/umwelt/verpackungsgesetz/)

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3.2.2 Deposit Refund Scheme for Bottles

Germany has implemented different schemes for disposing of bottles:

- Deposit for single-use bottles
- Deposit for reusable bottles
- Deposit-free bottles

Single-use bottles with refundable deposits are marked with the DPG logo. Since 2003, a refundable deposit is compulsory for certain single-use bottles. Since 2006, consumers have been able to return the bottles for the deposit refund in all retail stores and similar venues that sell beverages packed in the same material (plastic, glass, metal). The distributor must take back the bottles regardless of whether the consumer bought them from this store or elsewhere. Since 2009 distributors must mark the compulsory deposit one-way drinks and participate in a nation-wide deposit scheme that allows the members of the scheme to manage deposit return claims among themselves. An exception are small stores with a sales area below 200m², they are eligible to only accept bottles from brands that they sell themselves.

The DPG offers an organisational and legal framework system for the deposit clearing of single-use bottles with compulsory deposit. It is organised and managed by representatives of the participating companies, industry, and retail to help fulfil their obligations regarding deposit refund. In this system the initial circulators (beverage manufacturer, importers) must mark the bottles accordingly and insert the bottle's individual data record into the DPG master database. Upon selling their compulsory deposit products the initial circulators must levy the deposit and hold it on trust.

For marking the bottle labels, the so-called DPG-colour is used. Every party that prints the DPG logo (container producer, label printer) must meet several

requirements in order to be certified by DPG certification partners (initial security certification, yearly process certification).

The retailers act as collectors of the single-use bottles. The refundable deposits immediately disburse, and the customer receives the 25 cent deposit upon bottle return. The deposit settlement between the retailer (deposit charger) and the initial circulator (deposit account administrator) takes place via the DPG system. When the consumer returns a DPG-bottle to a DPG-machine at the retail store, the reverse vending machine checks the authenticity of the DPG and recognises the packaging according to the printed article number (GTIN) and automatically creates a clearable electronic data record. Alternatively, retailers can choose to do the process manually via counting centres. The data sets are retrieved by the retailer (deposit charger) or a service provider for deposit claiming. The clearable electronic data records get aligned with the DPG master database and matched with the initial circulators. Subsequently the initial circulators receive deposit claims from DPG, based on the data of returned deposit bottles from the retailers.

Reverse vending machine producers must be certified by DPG. Clearing service providers can be commissioned to fulfil the tasks and processes on behalf of the deposit charger (retail) or deposit account administrator (initial circulator).

All users of the DPG system pay a fee to DPG.¹³

Reusable deposit bottles are the most ecofriendly solution, if the bottles are not transported long distances, as the process of transport and cleaning requires less energy and resources. The material for reusable bottles can be either hard plastic or glass and they can be identified with the aid of the logos 'Mehrweg – Für die Umwelt' (engl. reusable – for the environment) or the 'Blauer Engel' (blue angel) but marking it as reusable is not compulsory.¹⁴ The multi-use system is voluntary for the producers and was introduced before the single-use bottles with

¹³ DPG, www.dpg-pfandsystem.de

¹⁴ Umwelt Bundesamt (Federal Environmental Agency), Mehrwegflaschen (www.umweltbundesamt.de/umwelttipps-fuer-den-alltag/essen-trinken/mehrwegflaschen#gewusst-wie)

refundable deposit. The system is less centralized and popular and therefore it can be less convenient for consumers as the bottles can only be returned at the retailer's premises that sells the kind of product. This system is truly circular, as the returned bottle is transported back from the retailer to the initial circulator, e. g. a brewery. There, the container gets cleaned thoroughly before it is used to be filled and transported back to the retailers again. A glass bottle can be refilled up to 50 times while a PET reusable bottle may be refilled 20 times.

The reusable deposit bottle system was introduced with standardised bottles, the so-called pool-bottles. Nowadays there are numerous variations of bottle forms and colours to be found that are offered by the manufacturers individually. In 2017, Germany accounted for 1,500 individual bottle types and 3,000 different bottle crates. This variety developed a more decentralised system. The German Federal Environment Agency aims to enhance the percentage of reusable bottles from 42% in 2017 to 70%, which is only feasible with a well-established infrastructure between retailers and manufacturers.¹⁵ In general, the multi-use deposit system is more efficient and eco-friendly but as the individualised bottles must be transported back to the beverage manufacturers, the high transportation volume and the potentially long distances (especially for small beverage producers) pose disadvantages compared to the single-use bottle deposit system.¹⁶ On the other hand, the currently used pool-bottles are the best option, as there are 1,800 fillers which leads to short transportation distances, while there are less fillers for single-use bottles (only 150). This results in half the transportation distance for standardised pool bottles compared to single-use bottles. At the end of their lifecycle the reusable bottles are recycled. As the

material is already sorted, the recycling process is very efficient. 99% of the deposit of the reusable bottles are returned and recycled.¹⁷

3.3 Waste Industry in Germany

Germany is well-known worldwide for its waste separation and recycling system.

Waste management in Germany is a powerful economic sector. More than 270,000 people work in waste management companies with an annual turnover of around EUR 70 billion (ca. SGD 107 billion), according to the Federal Ministry of Environment. More than 15,500 waste management facilities help to conserve resources through recycling and recovery. The industry is expected to grow at a rate of 5.2% per year up to 2025.

The new act that has come into force at the start of 2019 raised the bar for recycling of packaging. The goals have increased to 63% for plastics by 2022 and 90% for metal, glass, and paper. As a result, shops are forced to distinguish between reusable and non-reusable bottles on their shelves. The act also offers incentives for packaging producers to incorporate recyclability considerations into packaging design, and to use recycled or renewable materials. Retailers are obliged to clearly highlight on store shelves whether the beverage packaging is reusable or disposable, with a target of 80% of such packaging being recycled. In general, recycling, and better use of resources will certainly be core issues in both the public and private sectors in the years ahead. The rise of one and two-person households, eating out, and mail order (especially the rise of e-commerce and online purchases) have all added to the packaging problem. But with its industrial strength and forward-looking attitude, Germany is an excellent location for developing and applying new solutions.¹⁸

¹⁵ Spiegel, Anteil der Einwegflaschen nimmt weiter zu (www.spiegel.de/wirtschaft/anteil-der-einwegflaschen-steigt-weiter-a-1287329.html)

¹⁶ EinWeg mit Pfand, Mehrweg – Alles, was Sie wissen müssen (www.einweg-mit-pfand.de/beitrag/Mehrweg-alles-was-sie-wissen-muessen.html)

¹⁷ Deutsche Umwelthilfe, Klassische Getränkeverpackungen (www.duh.de/fileadmin/user_upload/download/Projektinformation/Kreislaufwirtschaft/Mehrweg/190208_FAQs_Klassische_Getr%C3%A4nkeverpackungen_FINAL.pdf)

¹⁸ Germany Works, 'The art of recycling: Is Germany providing the whole package?' (<https://germanyworks.com/news/the-art-of-recycling/>)

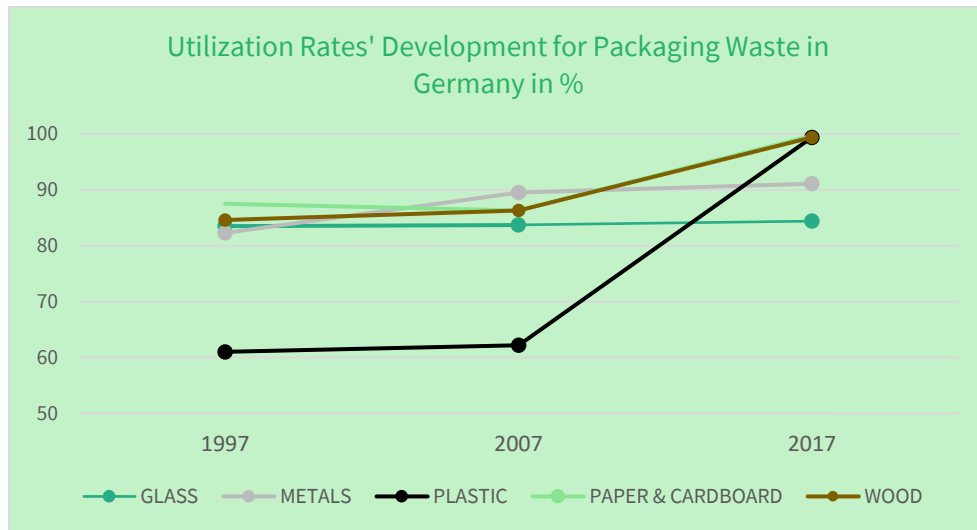


Figure 13 Utilization Rates' Development for Packaging Waste in Germany, source: Federal Ministry of Environment, Nature Conservation and Nuclear Safety (<https://www.bmu.de/themen/wasser-abfall-boden/abfallwirtschaft/statistiken/verpackungsabfaellen/>)

Ways of utilizing the waste are mechanical recycling, feedstock recycling and energy recovery. While utilization rates in Germany are relatively high (between 80 and 90%), actual recycling rates are lower. A new national legislation on recycling packaging increased recycling goals until 2022. The new law has entered into force on January 1, 2019.

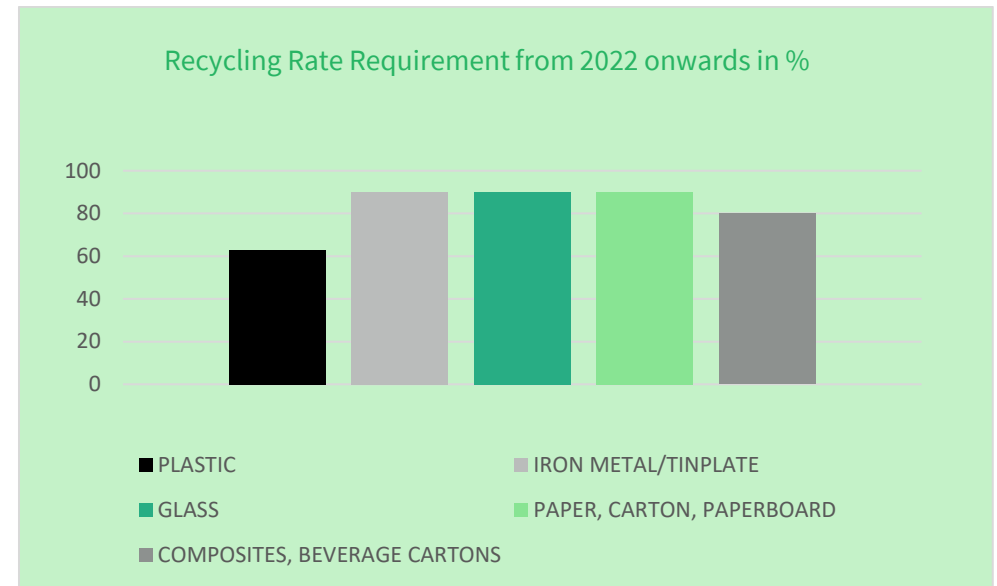


Figure 14 Recycling Rate Requirement from 2022 onwards, source: Federal Ministry of Environment, Nature Conservation and Nuclear Safety (<https://www.bmu.de/media/recycling-quoten-fuer-wertstoffe/>)

3.4 Plastic Recycling in Germany

In 2017 Germany used 11.8 million tonnes of plastics, 94% of it got either recycled or used for energy recovery. 46.7% of the total plastic waste was recycled (45.9% mechanical recycling, 0.8% feedstock recycling). In 2022 the recycling rate is targeted at 63%.

In Europe, Germany is among the countries with the best recycling rates according to PLASTICSEUROPE's report on 'Plastics – The Facts 2019'.

Besides the top five countries (Czechia, Spain, Netherlands, Estonia, Germany), nine other countries also have packaging recycling rates over the EU 28+2 requirement of 42%: Norway, Sweden, Latvia, Italy, UK, Lithuania, Slovakia, Slovenia, and Belgium. Most of the recycling is mechanical recycling. Even though the shares are still relatively negligible in comparison to mechanical

recycling, two countries have started to increase chemical recycling: Germany and Italy.

At the same time, Germany is one of the countries worldwide producing most amounts of waste, especially plastic waste, and is therefore still partially exporting waste to dispose to other countries.

4. Case Study

4.1 Decision for Focus Topic: Consumer Plastic Recycling

The total solid waste generated in Singapore in 2018 was 7.7m tonnes. Of this, 0.7 m tonnes were plastic, with a recycling rate of only 4%. Burning plastic creates harmful dioxins and if incinerators are inefficient, these substances could leak into the environment. Even though modern incinerators have largely solved this problem, burning plastic is the most CO₂-intensive form of energy generation after coal generated electricity, and is therefore, speeding up climate change¹⁹ that will continue to threaten Singapore.

Waste Type	Total Disposed (t)	Total Recycled (t)	Total Generated (t)	Recycling Rate
Construction debris	6,600	1,617,900	1,624,500	99%
Ferrous metal	9,300	1,260,200	1,269,500	99%
Non-ferrous metal	1,700	169,600	171,300	99%
Used slag	2,300	178,900	181,200	99%
Scrap tyres	3,200	29,300	32,500	90%
Horticultural	151,100	370,100	521,200	71%
Wood	131,800	187,900	319,700	59%
Paper/Cardboard	467,400	586,400	1,053,800	56%
Glass	51,500	12,200	63,700	19%
Food	636,900	126,200	763,100	17%
Ash and sludge	215,200	24,600	239,800	10%
Textile/Leather	205,800	14,000	219,800	6%
Plastic	908,600	40,700	949,300	4%
Others (stones, ceramic, rubber, etc.)	274,300	11,400	285,700	4%
Total	3,065,700	4,629,400	7,695,100	60%

Figure 15 Overview Waste Streams in Singapore and Recycling Rates, based on NEA, "Waste Statistics and Overall Recycling", (<https://www.nea.gov.sg/our-services/waste-management/waste-statistics-and-overall-recycling>)

A position paper done by the Singapore Environment Council in 2018 on "Consumer Plastic and Plastic Resource Ecosystem in Singapore" found that Singapore needs to urgently address its high plastic consumption rates and improve its low and stagnating recycling rates. The position paper proposes two ways to approach the plastic problem: mitigate the use of single-use plastics and transition from a linear economy to a circular economy by reusing and recycling. To achieve a circular economy within Singapore, an effective management of plastic waste is necessary. The paper also proposes to learn from other leaders in plastic waste recycling such as Taiwan and Germany.

4.2 Establishing a Centre of Excellence for Plastics Recycling, building a Technology Pipeline, Training, and empowering the local Workforce

In the past, Singapore has established several CoEs in various areas. For example, Singapore initiated the CoE programme for the water sector to develop world-class R&D centres for key water technologies. The programme was very successful as Singapore today is widely recognised for its leading R&D capabilities in water technologies and research and is home to the world's top two universities in water research as well as five of the world's top 30 global thought leaders in water research. The aim of the programme is to build critical R&D capabilities, develop a skilled workforce, attract international companies and grow local companies.²⁰ In total SGD 670 million worth of funds were allocated in two phases to support R&D, innovation and enterprises.²¹ The water industry has come into focus as Singapore faces water resource constraints and needs to secure its long-term water supply. Given that the Water Agreement with Malaysia expires in 2061, Singapore must develop key technologies to safeguard its independence. For the small city-state, it is essential to stay competitive and sustainable, thereby remaining attractive to international business.

¹⁹ BBC, Should we burn or bury waste plastic? (<https://www.bbc.com/news/science-environment-43120041>)

²⁰ PUB, Centre of Excellence, (www.pub.gov.sg/globalhydrohub/funding/coes)

²¹ PUB, About Global Hydro-Hub (<https://www.pub.gov.sg/globalhydrohub/about>)

Since its founding, the country's economy flourished against all odds and gained an international reputation as a future-ready leader of modern, pioneering technologies. One major factor of Singapore's success-strategy is the continuous fostering of international collaboration and projects. In the water industry, this can be seen during the biennial Singapore International Water Week (SIWW) where Singapore gathers the world leading companies and institutions of the water industry and lays the foundation for future international projects.

Singapore's Zero Waste Masterplan clearly shows that the nation is in dire need for recycling solutions due to its constrained space (Semakau Landfill in particular) and to meet the targets of international agreements (like the 2015 Paris Agreement) in order to protect Singapore from the grave impacts of climate change.

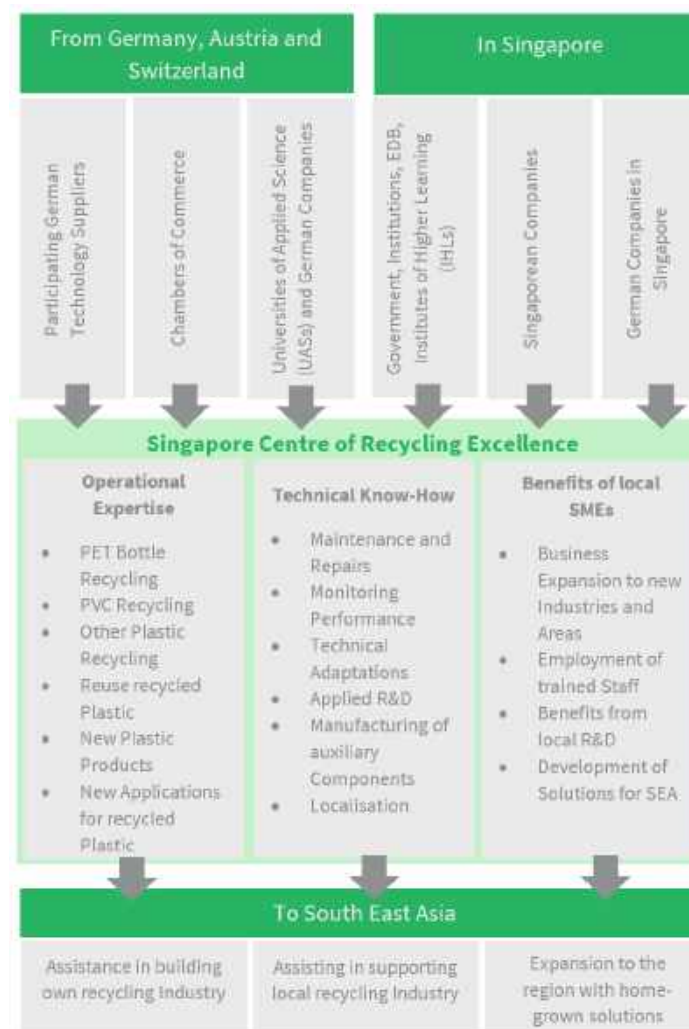


Figure 16 Process of setting up a Recycling CoE in Singapore for SEA in collaboration with Partners from the DACH-Region, own Illustration by SGC

Establishing a CoE in Singapore to develop research capabilities and implement pioneering technologies will offer solutions to the current challenges. A similar approach like the programme for the water sector is proposed to establish a CoE.

Areas of impact and capacity building through a CoE according to OECD:

- R&D capacities
- Technology, innovation, and technical co-operation
- Socio-economic development
- Infrastructure
- Training and skills
- Quality assurance
- Internationalisation (foreign direct investment, joint ventures, network participation, research partnerships)

Figure 17 Areas of Impact and Capacity building through a CoE, source: OECD, *Centres of Excellence as a Tool for Capacity Building* (https://www.oecd.org/sti/Draft_OECD%20synthesis%20report_final.pdf)

Companies from Germany that developed cutting-edge recycling technologies and know-how from decades of experience (please refer to chapter 3) can contribute and support Singapore in founding a CoE. To start and lay the foundation for the CoE, the SGC proposes a project-based approach in form of a test-bed plant for PET recycling to develop a strong collaboration. The considerations for the test plant will be elaborated in the subsequent chapter.

As per the experience with previous CoEs, this CoE for PET recycling will result in manifold benefits for local SMEs. It will enable them to expand their business in new industries and areas, employ staff that are more qualified and better trained; by further nurturing existing and expanding know-how pipelines between Singapore and Germany (please refer to chapter 4.3.8) and make use of the R&D findings.

Additionally, the CoE will allow them to develop better solutions for the regions and to testbed these first before scaling up. The recycling CoE in Singapore will be able to offer assistance to the surrounding countries in the region to build their own recycling industry or support the existing local recycling industry and further develop it. As shown in the first chapter, the potential for recycling solutions in SEA is immense. This can be achieved by offering regional countries home-grown solutions that are adjusted to the conditions of the ASEAN-region.

The SGC and its Sustainability Committee propose that a kick-off meeting should first be held in Singapore, involving parties from Germany, Austria, and Switzerland. Through this meeting, German, Austrian and Swiss companies that are already based in Singapore and internationally could come together with various chambers of commerce, Singaporean recycling companies, Singaporean ministries, and government agencies as well. The German and local universities already have viable knowledge pipelines and together with the corporate world, this has the potential for expansion between the two countries through this project (further information in chapter 4.3.11). The exchange of operational expertise, technical know-how in the areas of maintenance and repairs, monitoring performance, technical adaption, applied R&D, manufacturing of auxiliary components and localisation will be the focus of the project. The recycling test plant will be the starting point to build operational expertise that shall be expanded to other types of plastic recycling, such as PVC and other plastics. Additionally, recycling capabilities in the fields of reusing recycled plastic, upcycling plastic waste into new products and new applications for recycled plastic shall be built. This expertise and knowledge fits into the proposed CoE for recycling, which in turn will become the beacon of recycling knowledge for Singapore, SEA, and Asia.

4.3 Reasons for the Consideration of PET Bottle Recycling

4.3.1 Commercial Considerations

A PET recycling project should not only have an environmental impact but should be commercially viable too. In the past, using virgin material for bottle production was cheaper than using pellets made from recycled material. But this is now changing, especially when taking the whole value creation chain into consideration.

Singapore may best be known as a financial centre for SEA, but the manufacturing sector represents about 20% of the GDP. Companies are attracted by the technical education system, the highly trained workforce, the proximity of world-class multi-national companies (MNC), the lack of corruption and the best IP regime in Asia.

The size of the Singaporean market and the scarcity of land limit the opportunities for large-scale recycling facilities.

30 years ago, Singapore was the pioneer of waste removal and collection as the government introduced the 'refuse chute' system. At least every level in a residential building is equipped with a chute (in some instances, there are two, one for waste, one for recycling), where tenants bundle their waste into a plastic bag and drop it down the chute. Recyclables are collected separately under the National Recycling Programme (NRP). Once a day, a designated cleaner opens the central collection station on the ground level and prepares the waste for daily collection by government appointed waste removal companies. This method of waste disposal has worked for many years and Singaporeans are comfortable with it. To ask them to begin waste separation at the source is not seen as an advantage and the take-up rate among the population is slow. Most of all, waste collected today is still extremely wet. This makes recycling and waste processing

a major challenge. As the recyclables are supposed to be collected separately the remaining waste is less attractive for recycling. One informal method of waste collection exists in the form of '*karang guni*' men. They are informal waste collectors that go from door to door and collect all forms of recyclables and items that can be given a second lease of life, including electronics²² that can be sold to dealers, along with recyclable waste that will go to recycling companies.

Another commercial consideration is the enhancing effect that plastic has in the incineration process, as it lowers the energy that is required to dry and incinerate wet waste. Subsequently, the plastic separation will lead to an energy increase of the incineration of wet waste.

From an economic point of view, the current situation of incinerating the waste and dumping the bottom ash at Semakau Landfill is cheaper than recycling the plastic, but according to the Singapore Zero Waste Masterplan the country has realised that these waste processes must change long-term and has started to do so. Singapore declared at the world environment conference in Paris 2015 that it would become greener economically. Furthermore, that it will reduce its emissions intensity (volume of emissions per unit of GDP) by 36 per cent from 2005 levels by 2030 and aim to peak emissions around 2030. In December 2019, Minister Masagos Zulkifli called for nearly 200 countries to update their targets and introduce a long-term low emissions strategy as agreed. At the end of 2019, Singapore announced at the UN Climate Change Conference in Madrid that it will soon update its current climate pledge (based on the UN Climate Change Conference, Paris 2015) in 2020 to guide its policies over the long term. Subsequently, Singapore published its enhanced climate pledge for 2030 and a long-term low-emissions development strategy (LEDS) on 31 March 2020. Singapore's enhanced Nationally Determined Contribution (NDC) under the Paris Agreement aims to peak emissions at no higher than 65 million tonnes of carbon

²² CNA, Commentary: Why doesn't recycling rope in the *karang guni*?
(https://www.channelnewsasia.com/news/singapore/singapore-recycling-rag-a-bone-karang-guni-climate-change-11491692?cid=h3_referral_inarticlelinks_24082018_cna)

dioxide equivalent (MtCO₂e) around 2030. Beyond 2030, Singapore's LEDS aspires to halve emissions from its peak to 33 MtCO₂e by 2050, with a view to achieving net-zero emissions as soon as viable in the second half of the century. This level of CO₂ reduction is not possible with present technologies and continued waste incineration. Singapore already uses the cleanest fossil fuel possible – natural gas – for power generation (and there is nearly no heavy industry present in Singapore). Therefore, Singapore's options to further reduce CO₂ are limited.

4.3.2 Environmental Considerations for Singapore

Singapore as a low-lying island with one of the world's most open economies, will be highly impacted by climate change, as daily mean temperatures are projected to increase by 1.4 to 4.6 degrees Celsius and mean sea levels are projected to rise by up to about 1m by the end of the century. With 30% of the island lying less than 5m above sea level, the rising sea levels are particularly concerning. Heavy rainfalls and drought periods will happen more regularly and intensely, which would result in floods and pose a threat to Singapore's water supply, biodiversity and greenery.²³ As climate change poses an immediate and existential threat to the nation, the government is committed to reduce Singapore's carbon footprint and to adapting measures to keep the city safe. The estimated costs for these measures are significant. To tackle rising sea levels alone is projected to cost Singapore around SGD 100 billion over 50 to 100 years, according to Prime Minister LEE Hsien Loong in 2019. Hence, the financial burden of climate change needs to be taken into consideration as well.

²³ NCCS, Impact Of Climate Change And Adaptation Measures

(<https://www.nccs.gov.sg/faqs/impact-of-climate-change-and-adaptation-measures/>)

²⁴ MSE, Parliament Q&A (<https://www.mewr.gov.sg/news/oral-reply-by-senior-minister-of-state-for-the-environment-and-water-resources-dr-amy-khor-to-parliamentary-question-on-carbon-emissions-on-4-nov-2019>)

Even though sending incineration ash to Semakau Landfill might be cheaper, it is projected that the overall capacity will be reached by 2035 if the ash volume is not significantly reduced (official target: 30%).

Additionally, incineration contributes about 3% of Singapore's total of almost 60 million tonnes of carbon dioxide in 2017.²⁴ Reducing the plastics incineration will help in achieving and is therefore explicitly mentioned as a measure.

As explicated in the earlier chapter, one of the materials with the lowest recycling rates is plastic with only 4%. With a total of close to 1 million tonnes (12% of the total waste amount in Singapore), plastic might not be a major waste material, but through the low recycling rate, it has the most potential for improvement. Without any treatment, plastic takes a long time to break down, in a range between 20 and 500 years for different products. Plastic bottles are projected to take 450 years to decay.²⁵ In Singapore no plastic ends up in the landfill to decay, as non-recycled waste including plastic is currently completely incinerated.

A study for the Singapore Environment Council (SEC) done by Deloitte found that Singapore uses 467 million PET bottles – almost half a billion per year.²⁶ Given that an average 500ml PET bottle weighs about 10 grams, the total weight of plastic bottles that amounts to 5,000 tonnes per year, could potentially be recycled to enter the production cycle again.

4.3.3 Recent Waste-related Regulatory Initiatives

Since 1988, around half of the world's plastic waste has been sent to China to be melted down and turned into pellets. In 2018 China introduced new regulations that almost equalled a ban for most waste imports as the regulations are almost impossible to meet. For plastic, this means that China would only accept bales of

²⁵ WWF, The Lifecycle of Plastics (<https://www.wwf.org.au/news/blogs/the-lifecycle-of-plastics#gs.xeq5wn>)

²⁶ Straits Times, Singapore goes through 1.76 billion plastic items a year, recycles less than 20% (<https://www.straitstimes.com/singapore/singapore-goes-through-167-billion-plastic-items-a-year-recycles-less-than-20-per-cent-of>)

plastic waste with less than 0.5% contamination by non-recyclable materials which cannot be achieved by most countries as their own contamination rates are much higher.²⁷

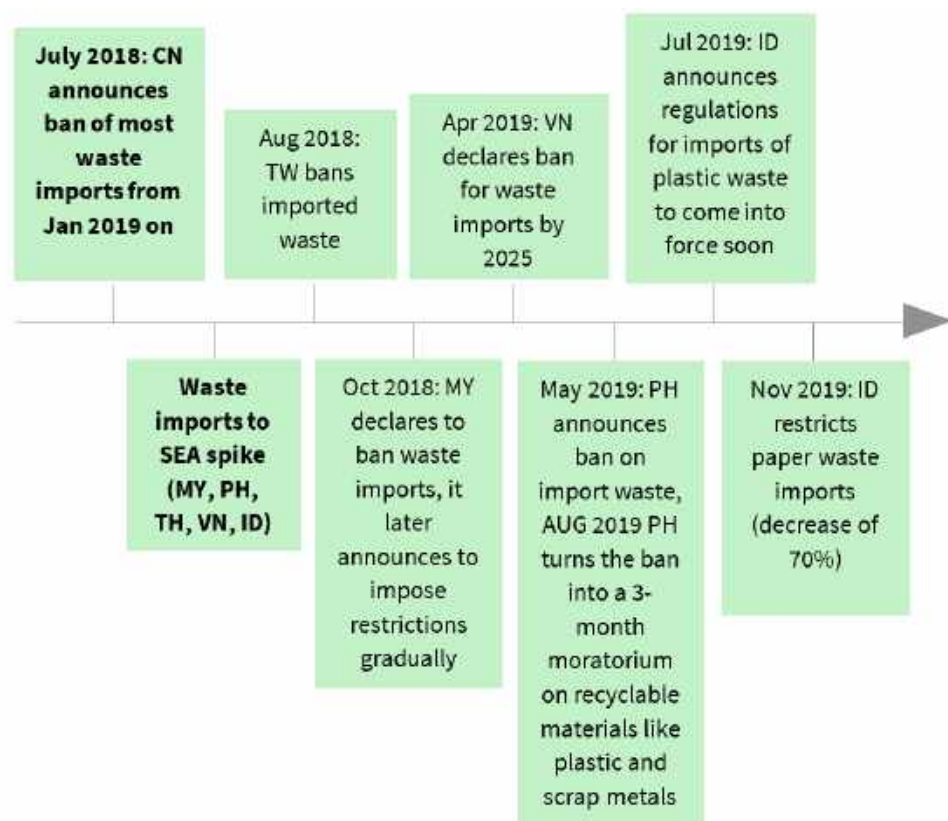


Figure 18 Timeline of Regulatory Initiatives in Asia, own illustration by SGC
Used ISO Country Codes: CN China, MY Malaysia, PH Philippines, TH Thailand, VN Vietnam, ID Indonesia, TW Taiwan.

The new regulations have come into effect in January 2019. Consequently, China's plastic waste imports dropped from more than 600,000 tonnes per month in 2016 to less than 30,000 tonnes after the announcement. Other means for excess waste disposal had to be found, subsequently the waste imports in SEA countries grew often more than 100%. What followed was a series of bans in the region, in the countries' attempt to save themselves from being drowned in waste, seeing that they do not have the capacities nor the capabilities to recycle.

With Singapore's space constraints, the stricter regulations and additional waste import bans result in a greater difficulty for Singapore to export recyclables to other countries. Thus, the small city-state must process its own waste, especially plastics, domestically or alternatively export it outside the region for recycling.

With global consumption on the rise, forecasts predict that the waste recycling services market could grow from SGD 370 billion in 2017 up to SGD 525 billion in 2024.²⁸ In the coming years, several studies forecast between 5.9 and 8.6% market growth annually, which makes it a highly interesting market full of opportunities.²⁹

Singapore's government continuously analyses urgent action fields and strategically addresses them at an early point in time since the founding of the nation more than 50 years ago. To address the waste problem the NEA launched the 3R (Reduce, Reuse, Recycle) programme to minimise waste and give recycling a boost through education and providing the necessary infrastructure. The 3Rs builds the basis of the Zero Waste Masterplan that was introduced in 2019, the year that Singapore designated as the Year Towards Zero Waste. The change is supported by the PSTLES (Public Sector taking the Lead in Environmental Sustainability) initiative to demonstrate the government's commitment to

²⁷ Heinrich Boell Stiftung, Waste Exports: The rubbish dump is closed (<https://www.boell.de/en/2019/11/04/waste-exports-rubbish-dump-closed>)

²⁸ Statista, Size of the waste recycling services market worldwide in 2017 and 2024 (<https://www.statista.com/statistics/239662/size-of-the-global-recycling-market/>)

²⁹ According to research done by P&S Intelligence Consulting and bcc Research

sustainability by initiating the change process and taking the lead for the industry and the private sector.

A big regulation that was entered into force in 2019 is the carbon tax, announced under the Carbon Pricing Act (CPA). It concerns industrial facilities that emit direct greenhouse gases (GHG) equal to or above 2,000 tonnes of CO₂ annually. These companies need to register and submit an Emissions Report annually. Facilities emitting direct GHG equal to or above 25,000 tonnes of CO₂ equivalent annually will pay SGD 5 per tonne of GHG emitted. Singapore will review the carbon tax in the coming years and plans to increase it to between SGD 10 and SGD 15 per tonne of GHG by 2030.³⁰

By introducing the Resource Sustainability, Singapore shifts from a voluntary to a mandatory approach in ensuring resource sustainability (for further details about the Act's content please refer to chapter 2.10.1: Singapore's Resource Sustainability Act). The Act focuses on three waste streams that have a relatively high generation but low recycling rate.

Senior Minister of State for Sustainability and the Environment, Dr Amy KHOR, said that the Act was only passed after careful consideration, but will help to turn trash into treasure, thereby supply resources that prepare Singapore to buffer against global supplying shocks and create new economic and job opportunities.³¹

Major commercial and industrial food waste generators will successively have to segregate food waste. Under the PSTLES initiative the MSE and the NEA will work with large public sector building owners with F&B outlets to implement segregation and treatment of food waste from 2021 onwards. Subsequently,

from 2024 onwards, food waste segregation will be made mandatory for owners and operators of commercial and industrial premises (e. g. hotels, malls, large companies, institutes, caterers, etc.) that generate large amounts of food waste as well. The affected parties will be able to choose the most suitable waste treatment method, such as recycling food waste into animal feed, using on-site food waste treatment systems or send it to an off-site facility for treatment.³²

Upon the launch of the Zero Waste Masterplan Dr Amy KHOR, Senior Minister of State for Sustainability and the Environment pictured Singapore's vision and aim of the Masterplan of establishing Singapore with a leading role as a CoE in a circular economy.

To achieve this vision, Singapore must further build up its three resiliences: climate resilience, resource resilience and economic resilience (for more details refer to chapter 2.1). The main target is to reduce the amount of waste sent to the landfill by 30% by 2030 and requires a joint effort between the industry, government, and households.

Dr Khor also said that the government has launched a new regulatory framework that targets the three priority waste streams: e-waste, packaging waste including plastic and food waste. The Senior Minister of State for Sustainability and the Environment emphasised that Singapore "need[s] innovative enterprises to test-bed promising technologies and scale them up to commercial viability". Furthermore, the launched "\$45 million Closing the Waste Loop R&D initiative is propelling research to extract valuable components from packaging waste; spearheading solutions to turn incineration bottom ash into construction materials; and synthesizing novel methods to recycle e-waste."

³⁰ NEA, Carbon Tax (<https://www.nea.gov.sg/our-services/climate-change-energy-efficiency/climate-change/carbon-tax>)

³¹ Straits Times, Parliament: New zero-waste law to compel big firms to take greater action (<https://www.straitstimes.com/singapore/new-zero-waste-law-to-compel-big-firms-to-take-greater-action>)

³² NEA, Food Waste Segregation For Treatment By Large Commercial & Industrial Food Waste Generators To Be Mandatory From 2024 (<https://www.nea.gov.sg/media/news/news/index/food-waste-segregation-for-treatment-by-large-commercial-industrial-food-waste-generators-to-be-mandatory-from-2024>)

In order to implement the Zero Waste Masterplan, Dr Khor stressed that Singapore relies on all parties to contribute and that the nation “need[s] individuals, businesses and organizations to partner [with Singapore] to co-create and co-deliver effective solutions”.³³

In October 2019 Singapore introduced 10 reverse vending machines that gives out discount coupons in return for empty aluminum drink cans and plastic drink bottles. This programme “Recycle N Save” is a joint initiative by the NEA and the beverage manufacturer F&N. It started off with a discount coupon worth 20 cents given for every four drink containers deposited. The coupons could be redeemed at any outlet of the supermarket chain NTUC FairPrice, as well as FairPrice Xpress stores and Cheers outlets (convenience stores). 50 machines were rolled out island wide as part of the initiative.³⁴ According to the official website, as of January 2020, for every 20 drink containers deposited, a discount coupon worth 20 cents would be given (please refer to chapter 4.3.7: Case Study: Recycling of PET Material in Singapore).³⁵

4.3.4 Summary: Findings of the Considerations

To conclude, under an economic view, PET recycling is not the most profitable solution as the separation of waste is complex and therefore expensive, while virgin plastic is the more economical option. On the other hand, the environmental considerations clearly show that the PET recycling is the more climate friendly alternative and with Singapore’s space constraints, this has the potential to extend the lifespan of the landfill. Even though the landfill is considered to be a “cheaper” option in economic aspects, its limitations make it a valuable place worth conserving.

Nevertheless, some companies tend to be more profit-driven and prioritize economic aspects above environmental considerations. Hence, the Singapore government intervened with the regulatory framework as the Extended Producer Responsibility. With the regulatory framework, companies are now forced to prioritize the environment to a certain extent. As Singapore is well known for creating an atmosphere that promotes the ease of doing business, it turns challenges into opportunities. With well-structured funding opportunities, the government enables businesses and R&D to be economically successful and to position themselves in a competitive but very promising area to establish a leadership in the field of closed-loop economy and environmental technologies and solutions in the long run.

Our analysis shows that Singapore faces the daily challenge of huge amounts of waste being produced, incinerated, and then transferred to the landfill. As the landfill is limited, precious space and waste exports became highly problematic due to recent political developments. Therefore, Singapore needs to reduce waste which ends up as incinerated ash in the landfill. The three main waste streams that Singapore has identified, due to a high amount with low recycling rates, are e-waste, food waste and packaging waste including plastic.

In the past, most plastic recyclers struggled to cope with the complexity of the waste and its separation, small market size in Singapore, low price of virgin material and low public acceptance of recycled materials as it is seen as inferior. All these factors resulted in the difficulty to run a profitable business.

With the government taking the lead towards a circular economy, things have started to change. The waste is now sorted at the source, environmental considerations have proven to outweigh the need for immediate profitability,

³³ Ministry of Foreign Affairs, Speech by Dr Amy KHOR, Senior Minister of State for Sustainability and the Environment, at the Launch of the Zero Waste Masterplan, 30 Aug 2019 (<https://www.mfa.gov.sg/Overseas-Mission/ASEAN/Press-Statements-Speeches/2019/09/Speech-by-Dr-Amy-Khor-at-the-Launch-of-the-Zero-Waste-Masterplan-30-Aug-2019>)

³⁴ NEA, Reverse Vending Machines (<https://www.nea.gov.sg/our-services/waste-management/reverse-vending-machines>)

³⁵ Straits Times, 50 vending machines that accept used drink containers for recycling to be rolled out island wide by March (<https://www.straitstimes.com/singapore/50-reverse-vending-machines-that-can-accept-drinks-containers-to-be-rolled-out-islandwide>)

due to new regulations, and Singapore is actively looking for partners to co-create and co-deliver effective solutions.

Germany is well-known for their extensive recycling systems, especially for its state-of-the-art companies that are technology leaders, and Singaporean companies having the knowledge about the local conditions, a big potential for collaboration lies here. Now is the time for specialist companies from Germany to assist Singapore in practical ways to share knowledge, overcome the challenges together and to establish a technology CoE in Singapore for the region.

4.3.5 First Example: Project Plan PET Recycling - Bottle to Bottle (BTB)



Figure 19 Process Steps of the PET BTB Recycling Project Plan, own Illustration by SGC

The SGC proposes the recycling of PET bottles as a concrete first step towards a Singaporean-German sustainable recycling-cooperation, that aims to support the realization of the Zero Waste Masterplan. Singapore has identified three major waste streams with plastics being one of them. Recycling plastic instead of incinerating has manifold benefits for the city-state: the incineration ash going to the limited last landfill can be reduced and therefore prolong the lifespan of Semakau landfill beyond 2035, supporting the goal of reaching the targets of the Paris Climate Agreement by reducing CO₂. Furthermore, projected costs caused through CO₂-induced climate change, greatly exceed the costs of moving towards a more environmentally friendly waste management system. From a purely environmental point of view, the CO₂ emissions from the incineration process place a heavy environmental burden on society. Moreover, increasing global consumption, will only result in larger waste volumes in the future than ever before. Additionally, plastic recycling offers a source of high-quality production material. Establishing a CoE taps on the mentioned advantages and offers training opportunities and future-ready, high-skill jobs to the local workforce. The CoE shall also build upon a knowledge and technology pipeline between Singapore and Germany. The universities and institutions are already working closely together. As the next step in the international partnership, the industry's knowledge will be shared through a project-based approach, with a first PET bottle recycling plant, to enable local corporate partners.

As compared to international standards of PET bottle to bottle recycling, Germany leads by example in terms of specialized companies and regulatory excellence. Implementing and further developing the PET recycling system could greatly reduce the overall amount of plastic produced and, in turn, expedite efforts towards a sustainable, zero waste environment. As the forerunner in technological advancement and innovation in ASEAN, Singapore will be in an excellent position to inspire other nations to join efforts in fighting plastic waste and become a sustainability hub for plastics recycling in the SEA region.

With excellent connections to both Singapore and Germany, the SGC is well positioned to act as a partner and/or point of contact for the Singaporean government, as well as individual companies that are looking to enter the market.

Bringing these market heavy-weights together for a kick-off seminar to explain concepts, exchange ideas and network with potential complementors is the beginning of what could be the birth of a CoE for plastic recycling in Singapore: The Centre should be a regional Knowledge Centre and an Institution for the exchange of information, upgrading of hard- and software, as well as a central point for the development of Asia-specific recycling solutions. A German-Singapore Technology pipeline would ensure up-to-date information flowing from West to East and from East to West.

The CoE requires a supporting infrastructure and we therefore propose to establish a pilot plant in Singapore for the recycling of PET bottles. By signing a MoU for the establishment of a PET bottle recycling facility, the foundation of an actual pilot plant can be laid.

The project itself will feature contemporary German technology standards that will be further developed and adjusted in Singapore. Local SMEs will benefit significantly through business expansions to new industries and areas as well as tapping into local R&D innovation. Sharing know-how and training local

specialists will ascertain Singapore's position as regional Hub for Recycling Technologies.

Furthermore, other ASEAN member states can be invited to participate as regional partners and export their nation's used PET bottles to Singapore, where the plastic bottles are recycled and the resulting pellets are of the same quality as the virgin material from which they were made. Using special additives in the recycling process potentially enables the recycling plant to produce pellets of a quality that may be even better than the original. Should industry standards change, additives can make recycled material fire retardant or more environmentally friendly.

The CoE will thus be able to develop key technologies and processes that are adapted to Asia-specific conditions, environments, and industry regulations. The concept of Bottle to Bottle (BTB) recycling would open opportunities for a new branch of the already strong waste management industry within the region, and further propel manufacturing that revolves around producing required machinery. As a result, local partners stand to gain greater benefits and will ultimately boost the Singaporean economy.

4.3.6 Assembling the best Companies Germany has to offer

German products are well known for their high quality and their technology and German firms are increasingly focusing on the command of the processes, rather than the pure manufacturing of their machines. Therefore, they are seeking local cooperation partners for local production.

The German recycling industry consists of an enormous variety of yet highly specialized companies, most of which command a significant market share in their respective industry niches like collecting, pre-sorting, bundling, shredding, washing, processing, and re-using.

The long-term goal to set-up a specialised and knowledgeable recycling-production facility in Singapore.



Figure 20 Potential Cooperation Partners in Europe, own Illustration by SGC

This can be facilitated if the companies are represented and supported by well-established partners in the market, like the chambers of industry and commerce and associations, with the initiating SGC in the lead. With the backing of the government, the outreach to the local companies would be even more extensive and potential partners can be strategically involved. The collaboration between all the previously mentioned market players would result in attracting the best specialists from Germany and would thereby profit all parties involved.

4.3.7 Case Study: Potential in Recycling of PET Beverage Containers in Singapore

Infrastructure

An important step towards boosting recycling of packaging including plastics is the introduction of a trial of a Reverse Vending Machines (RVM) system in October 2019 in Singapore. The RVM is able to recognize and only accept beverage containers, which would make recycling easier. This helps to achieve a pre-sorted bottles-only waste which would be a great basis for BTB recycling and production.

Furthermore, NEA announced in March 2020 to implement an actual Deposit Refund Scheme (DRS) for beverage containers by 2022 as first phase of the EPR framework for packaging waste management. NEA will start industry consultations in 2020 and put up a Request for Information to gather industry feedback by 2022. The gathered information will then be used to develop a framework suitable for Singapore's context. The DRS will contribute to developing Singapore's Plastic Recycling Industry, as it will aggregate post-consumer plastic waste to provide a steady supply of feedstock for recycling. Currently Singapore has mechanical recycling plants to treat the industrial plastic waste. MSE and NEA are working closely with the government and industry partners to look into establishing a pilot plant for chemical recycling of plastics that are not suitable for mechanical recycling (e. g. contaminated plastic bags and other single-use plastics). Chemical recycling that makes it possible to convert plastics into higher-value products, such as pyrolysis oil as "NEWOil", which is a potential feedstock for Singapore's petrochemical sector, would strengthen the nation's resource resilience.³⁶

³⁶ NEA, NEA to Implement Deposit Refund Scheme (DRS) By 2022 As First Phase of Extended Producer Responsibility (EPR) Framework For Packaging Waste Management

³⁷ The DPG provides an organizational and legal frame for the returning and deposit claiming of returnable single-use bottles.

Since its founding in 2005, the Deutsche Pfandsystem GmbH³⁷ (DPG) supported to enforce the government regulations, so that every shop, with an area of 200 sqm and above, will have to collect beverage containers made from the same material they have in their product portfolio. As a result, the recollecting and recycling rate of PET bottles, with monetary deposit included in its retail price, is an astounding 97.2%.³⁸

Implementing a similar system in Singapore has high potential to promote the first step towards better recycling habits, which involves the collection and pre-sorting of reusable polymer waste. To instil the behaviour of collecting their used bottles separately and bringing them to a reverse vending machine, the system must be convenient and give Singaporeans a real incentive. Through this, the practice of dumping and throwing it down the waste chute, can be strategically eradicated. Contemporary research in the field of behavioural economics suggests that immediate cash gratification is the most effective incentive to induce a change in behaviour.³⁹

³⁸ Zmak, Hartmann, Current state of the plastic waste recycling system in the European Union and in Germany, Technical Journal Vol. 11, No. 3, July 2017

³⁹ Streich, Levy, Time Horizons, Discounting, and Intertemporal Choice, Journal of Conflict Solution, Vol 39, No. 4, July 2013



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Relative to international standards, the financial incentive for returning bottles in Singapore is currently low. Though, it has to be pointed out that the RVM is only the trial and not yet the actual DRS. Additionally, the current financial incentive is unlike in Germany not a deposit paid when buying the product, but instead a direct monetary incentive by the government. At the moment, Singaporean residents only get SGD 0.01 per bottle (SGD 0.20 per 20 bottles) while other countries offer up to SGD 0.62 per bottle. In the following sections, incentives by other countries are listed. In comparison to other countries, Singapore is below average regarding the monetary incentives (please refer to the country comparison table at the end of the chapter).

Besides the financial incentive, Singapore's 'convenience-culture' will require a steady network of RVMs in order to become widely accepted and utilized by the population.

To make the plastic bottle recycling as convenient as possible, easy access to the machines must be ensured. As most people living in Singapore do not own a car due to the reliable and excellent public transport system and car ownership limitations it can be foreseeable that people are unlikely to transport the empty plastic bottles in big bulks. Additionally, a lot of beverage consumption happens on the spot, therefore the recycling of single bottles should be made possible. Another location-suggestion in addition to the supermarkets, could be placed near MRT-stations, such as MRT entrances. The public transport network is comprehensive and an essential part of everyday life for most of the population. This network could be leveraged by combining it with return points for plastic bottles. It could even be combined with the established EZ-link card system. The

EZ-link card is a reusable public transport card that stores cash value and deducts the ticket fare when commuters tap the card at the gantries of the MRT.

Additionally, EZ link cards are increasingly becoming a common payment method as F&B retailers successively implement it. Not only does this system reduce the overall cost of the project in the long-term, it also raises general awareness about the Zero-Waste-Initiative among citizens to act more responsibly and sustainably. Current efforts to foster a culture of returning used bottles appear to lack monetary incentives for consumers. By ensuring a functioning, convenient infrastructure, enough material will be available for an effective bottle-to-bottle recycling.

Country	Financial Incentives per Bottle
Croatia	All beverage packaging: SGD 0.10⁴⁰
Estonia	Marked beverage packaging (bottles, cans): SGD 0.15⁴¹
Finland	- Plastic bottles below 0.5 litres: SGD 0.15 - Plastic bottles between 0.5l and 1.0l: SGD 0.31 - Plastic bottles above 1l: SGD 0.61⁴²
Germany	- One-way containers: SGD 0.38⁴³ - Refillable beer in 0.33 and 0.5l bottles: SGD 0.12 (not mandatory) - Refillable water, soft drink or juice bottles in 0.5, 0.7 and 1.0l bottles: SGD 0.23 (not mandatory)⁴⁴
Lithuania	All marked packaging: SGD 0.15⁴⁵

⁴⁰ Bottle Bill Resource Guide, Croatia (<http://www.bottlebill.org/index.php/current-and-proposed-laws/worldwide/croatia>)

⁴¹ Eesti Pandipakend, How does the deposit system work? (<https://eestipandipakend.ee/en/how-does-the-deposit-system-work/>)

⁴² Bottle Bill Resource Guide, Finland (<http://www.bottlebill.org/index.php/current-and-proposed-laws/worldwide/finland>)

⁴³ Verbraucherzentrale, Fragen und Antworten zum Einweg-Pfand („Dosenpfand“) (<https://www.verbraucherzentrale.de/wissen/umwelt-haushalt/abfall/fragen-und-antworten-zum-einwegpfand-dosenpfand-11505>)

⁴⁴ Verbraucherzentrale, Mehrweg oder Einweg: Verwirrung total beim Pfand (<https://www.verbraucherzentrale.de/wissen/umwelt-haushalt/abfall/mehrweg-oder-einweg-verwirrung-total-beim-pfand-11504>)

⁴⁵ Grazinti Verta, About the system (<https://grazintiverta.lt/en/>)

Netherlands	• All marked plastic bottles: SGD 0.38⁴⁶
Norway	• Plastic bottles below 0.5l: SGD 0.32 • Plastic bottles above 0.5l: SGD 0.48⁴⁷
Singapore	• Plastic bottles: 0.01 SGD (only in bulks of 20 bottles) → unlike most other listed financial incentives, it's a direct monetary incentive, not a deposit aid by the consumers upon purchase of products
Sweden	• Small bottles: SGD 0.14 • Large bottles: SGD 0.28⁴⁸
USA	• One-way beverage containers in several states: SGD 0.07

Figure 21 Overview of Deposit Incentives per Bottle in other Countries, own Illustration by SGC

Recycling Processes

Since used PET material is potentially contaminated, degraded and/or old, new manufacturing techniques and industry standards, such as additive formulations, are needed to help restore PET materials into recycled plastics or even achieve a higher quality than the original product.

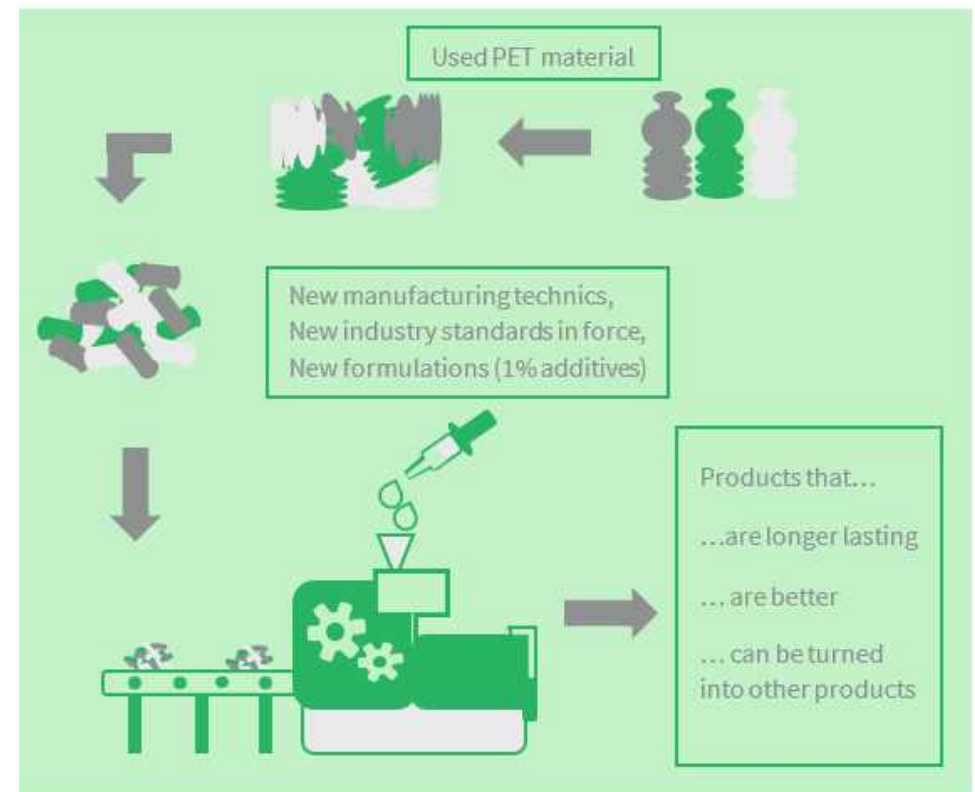


Figure 22 Recycling Process, own Illustration by SGC

Before the actual recycling process begins, however, collection and pre-sorting of plastics is necessary. Once bundled, the material is shredded, washed, and sorted before finally being processed into pellets which can be used in the same way as virgin material, as they have the same high quality. Each of these steps

⁴⁶ How Holland Works, Statiegeld (deposit) on Bottles

(<http://www.howhollandworks.com/2017/09/09/statiegeld-on-bottles/>)

⁴⁷ The Guardian, Can Norway help us solve the plastic crisis, one bottle at a time?

(<https://www.theguardian.com/environment/2018/jul/12/can-norway-help-us-solve-the-plastic-crisis-one-bottle-at-a-time>)

⁴⁸ The Local SE, That's pant! The story behind Sweden's bottle recycling scheme

(<https://www.thelocal.se/20180328/thats-pant-the-story-behind-swedens-bottle-recycling-system>)

requires advanced technology and technical proficiency that the German specialists are internationally renowned for.

For reasons outlined in 4.3.2 above, a collaboration between Singaporean IHLs, Government Institutions, local enterprises and German specialist firms would be an ideal platform to demonstrate the joint capabilities of Germany and Singapore in the establishment of a long-lasting and high-quality recycling system in Singapore.

While the global fashion industry is already successfully using recycled PET as product base for jewellery, clothing and handbags, the most recent example for upcycling PET bottles is the German automobile manufacturer Audi. The enterprise manufactures one set of seat covers from 45 PET bottles and 62 PET bottles for the carpet material used in the new generation of Audi's model A3. In total, more than 100 PET bottles are processed per car. The German company is dedicated to increase the use of recyclates. Currently 89% of the textile is made from PET bottles, and this percentage shall be increased to a full 100%. Prospectively, Audi aims to introduce the new recycled fabric to other models as well. Audi has emphasised that the new materials will meet the premium standard Audi's clients are used to.⁴⁹

⁴⁹ K Zeitung Online, Von der PET-Flasche zum Audi-Sitzbezug (<https://www.k-zeitung.de/von-der-pet-flasche-zum-audi-sitzbezug/>), Audi Media TV, Konsequent nachhaltig: von der PET-Flasche

4.3.8 Strategic Seminar on the Concept and to connect potential Cooperation Partners

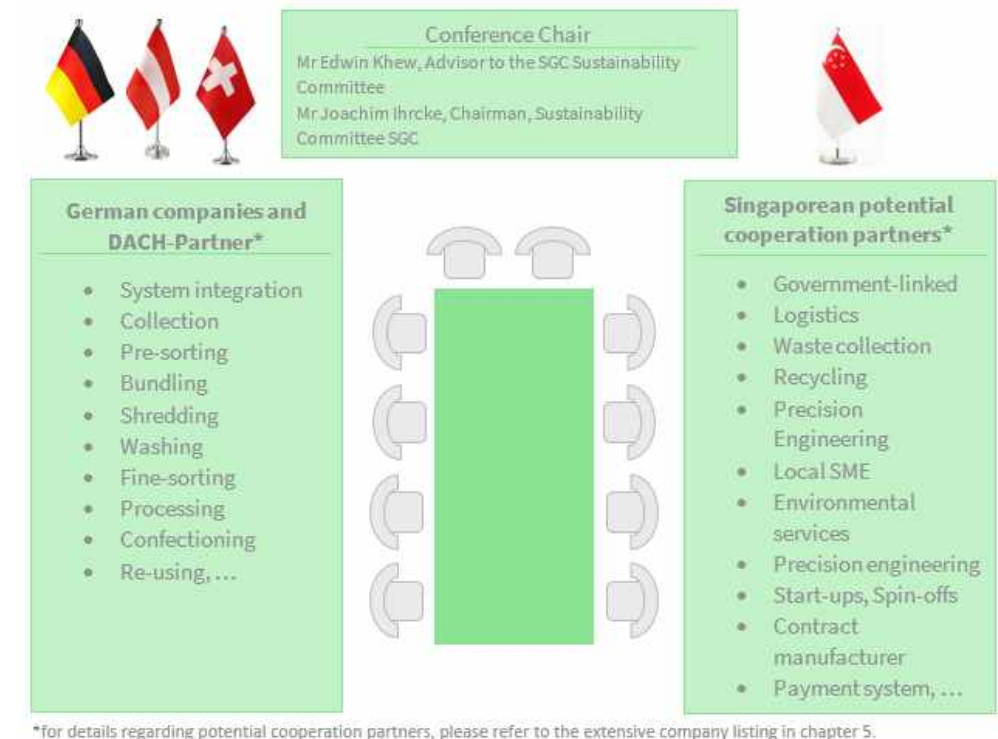


Figure 23 Exemplary Illustration of Strategic Seminar, Contributions and Functions of the potential Participants, own Illustration by SGC

zum Sitzbezug (<https://www.audi-mediacycenter.com/de/audimediacytv/video/konsequent-nachhaltig-von-der-pet-flasche-zum-sitzbezug-4973>)

The individual steps are proposed to be carried out by specialised companies. Potential Singaporean cooperation partners for the collection of PET bottles could be F&B companies, supermarkets, hotels, or MRT-station operators. These enterprises qualify as promising partners due to their lines of business and they already established points of contact with consumers. Production companies are especially likely to have a strong interest to collaborate due to the EPR framework.

Collection and logistics companies are needed along the process to transport the PET bottles to the recycling plant. In order to provide the manpower for laborious tasks such as pre-sorting and bundling, temporary employment agencies can provide jobs for people from lower education backgrounds. For more mechanically demanding tasks in the process such as shredding, washing, fine-sorting, and processing, Singaporean SMEs operating in mechanical engineering offer promising prospects. As a result of different configurations for the fine-sorters, the possibilities of processing polymeric structures in the recycling course offer a big range of opportunities: fine-sorted plastic flakes and granulates can be used to produce various materials or they can be shaped and later manufactured and individualised in order to meet varying consumer demands and quality-standards. There is also the option to upcycle the 'waste-material' into new products with a long lifespan, as illustrated by the fashion or automotive industry (e. g. seats, foot mats, etc.).

To identify and get on board committed project partners, a strategic seminar shall mark the start for the project. It intends to bring interested and potential partners from Singapore, Germany together. The conference chairmen Mr Edwin Khew, Advisor to the SGC Sustainability Committee, and Mr Joachim Ihrcke, Chairman to the Sustainability Committee at the SGC will share details and background information about the set-up and operation of the PET bottle test plant and the establishment of the CoE for plastic recycling in Singapore. The strategic seminar offers a unique networking platform where the international, potential partners can meet and explore opportunities on how to get involved

and contribute. For the German companies, this joint project offers the prospect of having excellent market access. Singaporean companies benefit from the knowledge of the German plastic circular economy and associated technologies and best practices of the German 'Mittelstand' (SMEs).

4.3.9 Recommendation of MoU Signing for the Establishment of a PET Bottle Recycling Test Plant



Figure 24 Exemplary MoU Signing, © Photo by SGC: An exemplary photo of an MoU signing between Singapore Water Association (SWA) and SGC

To initiate the cooperation project between German and Singaporean companies starting with the set-up of a test plant for PET bottle-to-bottle recycling, a MoU is recommended to be signed.

The MoU shall show the mutual interest to work together to close the plastic waste-loop in Singapore, and to establish a CoE for the region.

4.3.10 Pilot Plant as Test Case for Technology Transfer and for Cooperation (co-financed)

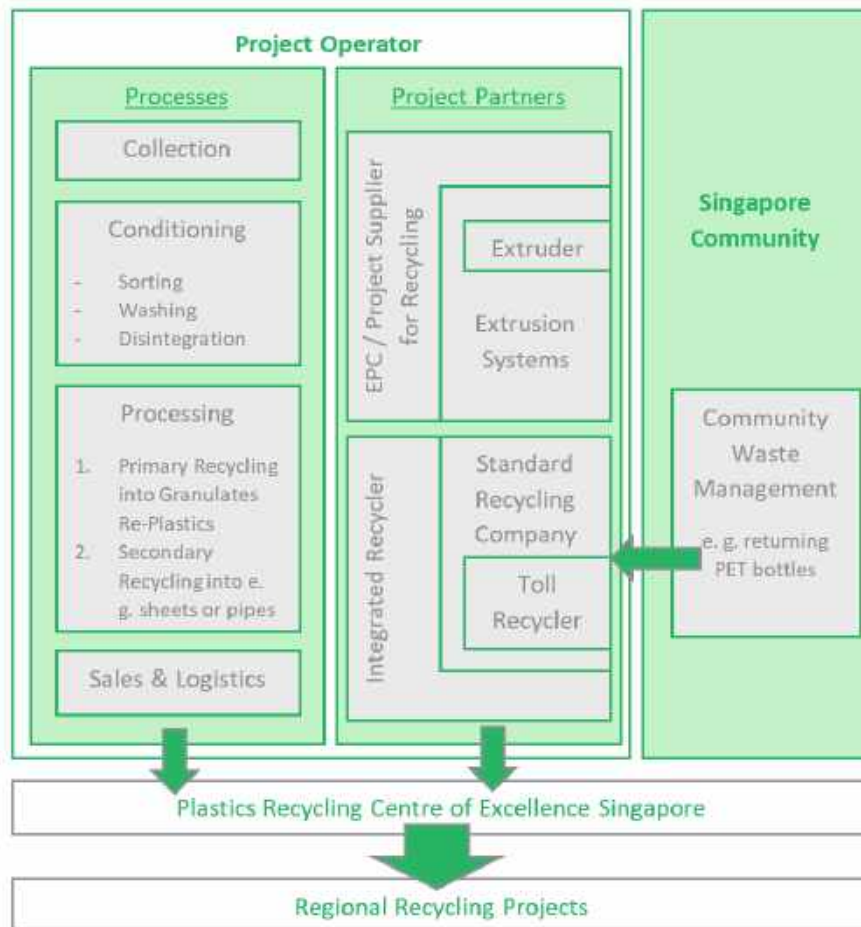


Figure 25 Functioning of the Pilot Plant, own Illustration by SGC

Based on the signed MoU, the set-up of the co-financed pilot plant can begin. The project operator identifies and oversees the necessary processes like collection, conditioning (sorting, washing, disintegration), processing, sales, and logistics.

Also, the project operator facilitates the communication between the different Singaporean and German and supporting project partners and specialists that participated the seminar in Singapore, to receive information about the project and for a first meeting with other potential partners. One main intention is to engage niche SME that would otherwise be unable to independently enter the Singapore market. Nevertheless, there is a huge range of companies in this industry, from small and medium sized companies to big market players. Therefore, more general working companies, such as integrated recycler or EPCs, will go in the lead for the niche specialists, under the lead of the project operator.

The engagement of the community in Singapore is essential for the success of the pilot plant. Without enough PET bottles being returned, the plant will not be able to carry out tests. Hence, good communication, further public education, as demonstrated by the MSE and the NEA today, as well as an efficient network of collection stations and attractive financial incentives are key for a permanent behavioural change.

The findings of the pilot plant regarding collaboration between the international project partners from Singapore, Germany, and the built process-knowledge in combination with the awareness and inclusion of the community will enable Singapore to establish a recycling CoE for various plastics in Singapore.

The pilot plant, in combination with future and current funding schemes (e. g. EDG, RISC, CTWL, PSG by Enterprise Singapore, EDB and NEA), will result in product development, test-bedding as well as solution implementation and regional adjustment of solutions. Once the solutions are successfully implemented in Singapore, the next phase begins as regionalisation. The city-state can invite other countries to view the solutions, partner with them and/or export the products and technologies in the region. As the demand in the region for recycling solutions is immense, this will open various opportunities for Singaporean businesses and boost the nation's economy.

4.3.11 Know-How Cooperation between Singaporean and German Institutions and Companies

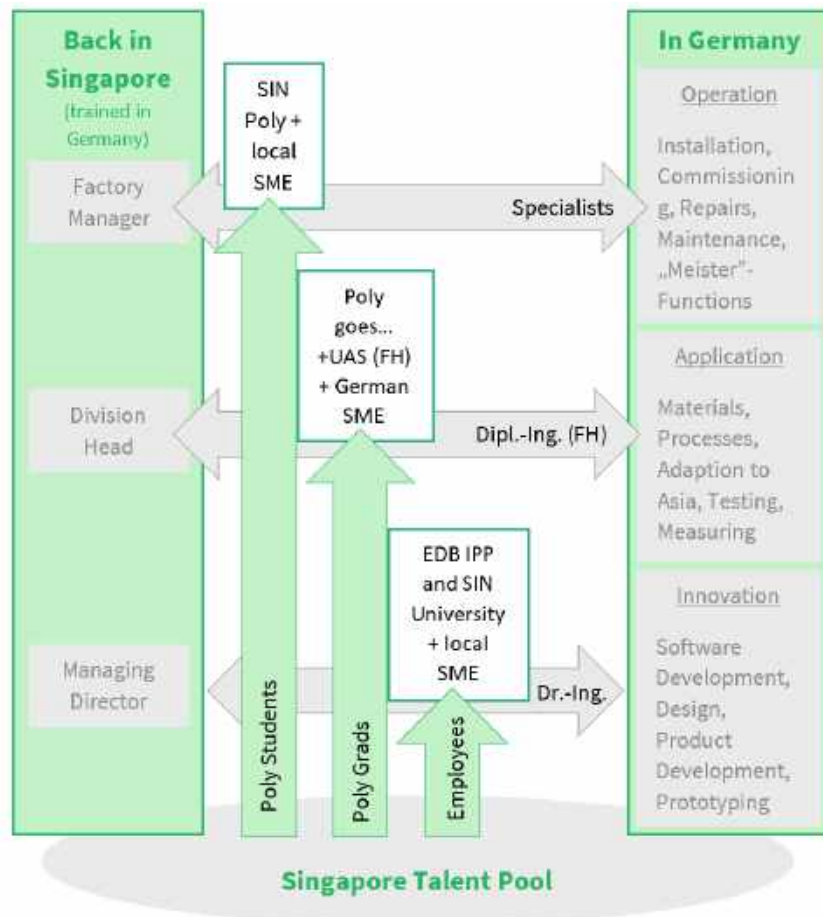


Figure 26 Educational Cooperation between Singaporean and German Institutions, own Illustration by SGC

⁵⁰ i. a. refer to A* Star, 2nd Singapore-Germany Academic-Industry (2+2) International Collaboration (<https://www.a-star.edu.sg/Research/funding-opportunities/grants-sponsorship/a-star-bmbf>), TUM Asia (<https://tum-asia.edu.sg/admissions/graduate/>)

⁵¹ MTI, Speech by Second Minister S Iswaran at the inaugural Precisions Engineering Master Craftsman Graduation Ceremony at Nanyang Polytechnic

Singapore and Germany could collaborate together in establishing the dual education system, which aims to bring forth a steady stream of graduates with practical knowledge and these are sought after by the industries. First collaboration projects were successful and are ongoing.⁵⁰ Recently, this cooperation was expanded by post-graduate schemes. For example, the “Precision Engineering Master Craftsman” enables local technical managers with enough practical experience to obtain a certificate which is equivalent to a German “Meister” and certified by the Chamber of Industry and Commerce in Munich.⁵¹ Another scheme is the “Poly goes to UAS” where Singaporean Polytechnic graduates subsequently study in Germany at a University of Applied Science in Stuttgart or Munich, and graduate as a Bachelor/Master.⁵²

Other Singapore Government Statutory Board schemes exist, and all offer a great basis for a sustainable way to help build talent pipelines, thereby increasing productivity in local firms.

(www.mti.gov.sg/Newsroom/Speeches/2014/05/Mr-S-Iswaran-at-the-Inaugural-Precision-Engineering-Master-Craftsman-Graduation-Ceremony)

⁵² Refer to Poly Goes UAS (www.polygoesuas.com/)

4.3.12 Regionalisation

Once Singapore has implemented the test plant for plastic recycling, it can encourage surrounding countries to send their PET waste here. Singapore can then process the waste into recycled material or even upcycle it through processes such as chemical recycling or additives and export it to the countries of origin. This system will also enable the city-state to later export solutions that result from the CoE as the infrastructure and network in the region is by then already established.

Once this is developed, Singapore will be able to export the technologies in the region, thereby enabling the countries in SEA to recycle their own plastic waste, given that this is the most sustainable and environmental-friendly approach. Singapore can partner with other countries to set-up recycling plants and establish collection points for recyclables. The regionalisation plans give Singaporean companies a huge opportunity as the potential for the recycling industry in the region is immense.

SEA, which is home to 641 million people across 10 countries, is a major contributor to land-based plastic waste leaking into the world's oceans. With the expected population growth, the waste problems will become increasingly urgent. Being able to turn waste into valuable material, that can re-enter the production process, would change today's perception of plastic waste. Thus, it would prove to become a valuable asset, especially amid stricter regulations worldwide.

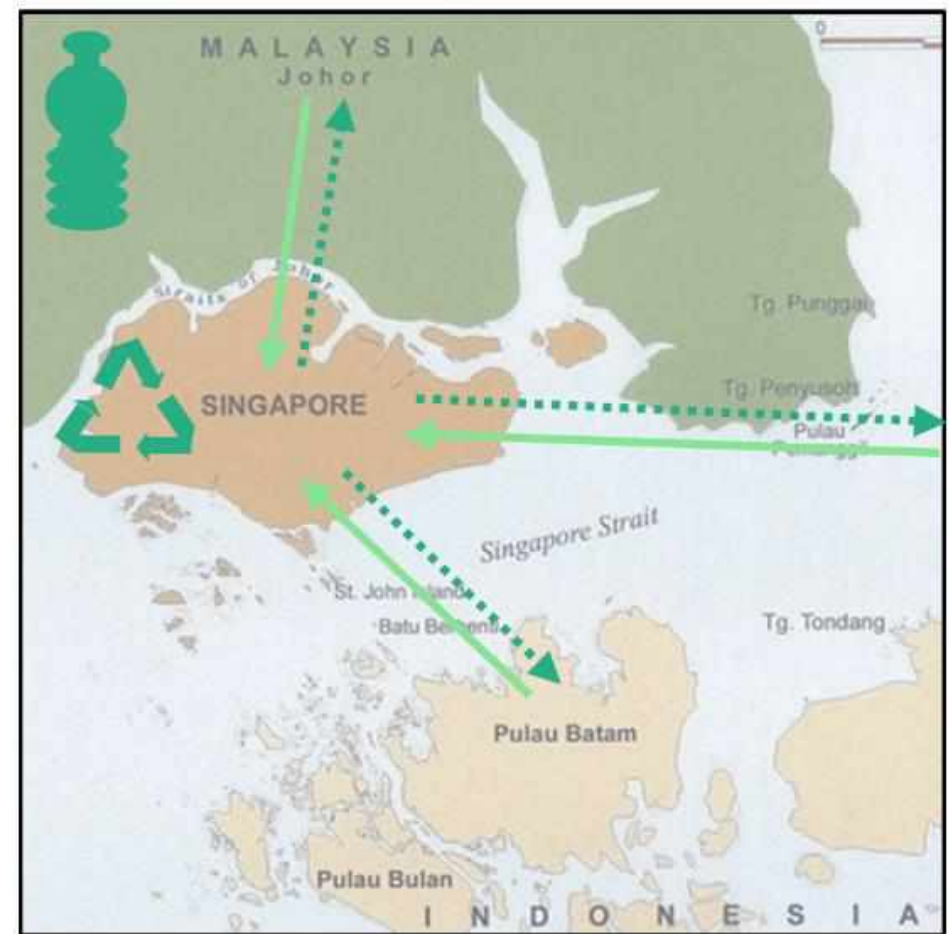


Figure 27 Regionalisation of the Recycling CoE, own Illustration by SGC



- Turnkey recycling lines
- Maximum flexibility
- Inline process control
- Application & process know-how for circular economy concepts



extruders.leistritz.com | extruder@leistritz.com



REDUCE

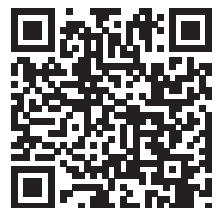


REUSE



RECYCLE

Made in
Germany



4.3.13 Establishing Production Plants for Manufacturing Recycling Machines in Cooperation with local Partners



Figure 28 Steps to the "Singapore Way to Recycle", own Illustration by SGC

German companies are shifting from control of their supply chain to command of the processes. "Made in Germany" will be followed by "Designed by Germany, Made in Singapore". Singapore has more than 30 Free Trade Agreements and setting up a production facility in Singapore would eliminate most import duties into ASEAN countries, the EU and USA.

An excellent example of this production would be an extruder which consolidates multiple essential steps in the polymer revaluation cycle: Shredded polymer flakes are allocated and pressed into a thread. The components that could be manufactured or sourced locally include motors, flanges, gearboxes, machine beds and auxiliary equipment. Complex core parts such as screw shafts or barrels, which are usually protected by patents, would be shipped from Germany, whereas the electronic controls and the machine monitoring systems could be designed, developed, and manufactured in Singapore. Together with the Asia-specific solutions coming from the Applied R&D of the CoE, the final product could indeed qualify as "Made in Singapore". That way, Singapore is marketed as the forerunner of comprehensive recycling excellence in the region and would yet again prove successful as a hub for SEA.

4.3.14 Singapore as SEA Hub of Excellence in Plastic Recycling

In conclusion, after the founding of the CoE, the overall process to turn Singapore in the SEA Hub of Excellence in Plastic Recycling starts with conducting a seminar with the relevant industry players (companies from Germany, Singaporean companies, Singaporean ministry and government agencies, the chambers of industry and commerce and German companies already located in Singapore). Here, they will have a platform where they can explore potential for collaborations for the PET recycling test plant together.

Once committed partner companies have been found for all the relevant tasks, the project can proceed with the building and later the operation of the pilot plant led by the project operator.

The PET recycling test plant will be the starting point to build operational expertise that shall be expanded to other types of plastic recycling, such as PVC and other plastics. Additionally, recycling capabilities in the fields of reusing recycled plastic, up-cycling plastic waste into new products and new applications for recycled plastic shall be built. Along with the operational expertise, technical know-how will be gained in the areas of maintenance and repairs, monitoring performance, technical adaptation, applied R&D, man-

ufacturing of auxiliary components and localisation. All these expertise and knowledge created fits ideally into the proposed CoE for recycling, which in turn will become the beacon of Recycling Knowledge for Singapore, SEA, and Asia.

The multi-national cooperation, operational expertise and technical know-how gained through the pilot plant are crucial for establishing a Recycling Centre in Singapore.

The universities of the involved countries partner together in education and professional programmes to build capabilities in R&D and operations, which will further boost the R&D sector in the recycling industry and enhance competencies in the corporate sector.

Experience, education, skills, and home-grown solutions enable Singapore to develop and offer technical solutions for local and regional recycling problems. Therefore, it will develop a knowledge base in Singapore for recycling and can offer training opportunities for local SMEs to build and operate recycling equipment.

Other SEA countries that also have an urgent need for recycling technologies can send their PET bottles to Singapore for recycled and get invited to see the technologies, processes and upscaled recycling plants.

With steadfast knowledge and competencies, Singapore will be able to produce most of the recycling equipment locally which can later also be exported into the region.

The “Singapore way to recycle” and “Designed by Germany, Made in Singapore” recycling products will be marketed in the region to make known the recycling CoE in SEA, as a result of strategic and long-term planning ahead and close collaboration on a multinational basis.

5. Supporting Partner DACH-Region

5.1 Austria⁵³

5.1.1 Industry Overview Austria

With an export value of more than two billion euro, the plastics machinery sector is one of the flagships of the Austrian mechanical engineering industry, which is one of the country's most important lines of industry.

On average, the export ratio of the companies amounts to more than 90%. Injection moulding machines constitute a large part of the production (around 2/3), while extruders are another important export hit.

Besides plastics machinery Austrian companies also produce high-quality modules and tools, as well as automation solutions of the highest quality and productivity. The well-trained, skilled workforce is another considerable factor for the branch's success.

Naturally, with all this plastics expertise, Austrian companies are also leaders in the field of recycling technologies – and export this knowledge around the world through their international orientation.

Durable plastics also contribute to environmental protection in the supply and disposal of important resources (drinking water, gas, wastewater, etc.). Here Austrian companies offer innovative and hygienic solutions to improve the access to water and other resources and to ensure environmentally friendly disposal.

Austrian plastics companies also invest significantly into research and development - on average companies invest 4% of revenue into R&D.

5.1.2 Focus on Collaboration

Austrian plastics companies are characterised by a particular ability to collaborate. They work on current topics in platforms and with university and non-university research partners. For instance, the “Smart Plastics” initiative is the professional service and knowhow network for projects at the interface of mechatronics, plastics, and design.⁵⁴

Since 1999, firms in the plastics industry in Upper Austria have also been collaborating as part of the Plastics Cluster, an initiative of the states of Upper Austria, Lower Austria and Salzburg, connecting member companies, research institutes and decision-makers to drive innovation in the plastics sector.⁵⁵

Furthermore, recycling is also one of the focal points of the Linz Institute of Technology (LIT) research factory at the Johannes Kepler University Linz (JKU), which allows companies to test digitised production technologies in a test laboratory without disturbing their own operations.

5.1.3 Plastics Recycling in Austria

The ambitious goals of the EU plastics strategy are challenging for plastics companies. At the same time, however, the Austrian plastics industry recognises a functioning recycling economy as a great opportunity to improve the image of plastics as a material.

Success depends on the cooperation of all parties involved - from the collection of used plastics to recycling technology and reuse in processing. Austrian companies are world leaders in recycling plant construction and work together with stakeholders along the entire plastics value chain in order to position Austria as a model region for the recycling of plastics.

“Responsible Care” is the global chemical industry's voluntary initiative for continuous improvements in health, safety, and environmental performance.

⁵³ Chapter was written by Advantage Austria Singapore (supporting partner)

⁵⁴ For more information: www.smart-plastics.com/

⁵⁵ For more information: www.kunststoff-cluster.at/en/

Austria became the first country to hold an external audit of compliance with the RC specifications. External audits are now obligatory for the participating Austrian companies. Austria thus holds a unique position in Europe.

Finally, Austria is also a European leader in the recycling of post-consumer plastic waste with a recycling rate around 30% with the rest directed to waste-to-energy operations – thanks to Austria's strict landfill restrictions of recyclable waste less than 1% of post-consumer plastic waste ends up on landfills.

5.2 Switzerland⁵⁶

5.2.1 Waste Industry in Switzerland

The first guidelines on waste management in Switzerland, which defined principles and goals for an environmentally sound waste management, were issued in 1986.⁵⁷ Based on these guidelines, the Federal Office for Environment (FOEN) (formerly named Swiss Agency for the Environment, Forests and Landscape, SAEFL) developed, in 1992, the **Waste Concept**, in which strategies and measures to reach the goals and principles stated in the **Guidelines on Waste Management** were defined.⁵⁸ The four strategies addressed in the Waste Concept for Switzerland are:

- to avoid waste at the source.
- to reduce pollutants in production and in goods.
- to reduce waste through improved recycling.
- to preserve the environment through environmentally sound disposal of the remaining wastes inland.

The strategies defined in the Waste Concept for Switzerland are reflected in the **Swiss Environmental Protection Act** (USG)⁵⁹ as the principle of waste avoidance, the polluter pays principle and the obligation for an environmentally sound disposal. Waste management in Switzerland is subject to federal laws and ordinances as well as cantonal laws and municipal regulations.

In addition, in 2000, Switzerland introduced a ban on landfilling of combustible waste and took steps to ensure that incineration capacity was expanded accordingly. Today, all non-recycled combustible waste in Switzerland must be incinerated in appropriate plants and end up in one of the country's municipal solid waste incinerators, with recovery of energy as well as of metals from the incineration residues.

More recently, in March 2013, the Federal Council passed the **Green Economy Action Plan** which includes 27 existing and new measures.⁶⁰ In doing so, it intended to conserve natural resources, make consumption more environmentally friendly and strengthen the transition to a circular economy. Voluntary initiatives involving business, science and society are being promoted.

In 2015 the water supply, sewerage, waste management and remediation activities industry in Switzerland produced a turnover of approximately 5.12 billion euros.⁶¹ Switzerland produces today about 80 to 90 million tonnes of waste each year. Most of it consists of uncontaminated excavated materials and deconstruction materials. The second largest waste category is the constantly increasing quantity of municipal solid waste and the third largest waste category is biowaste. Because of its high standard of living, Switzerland has one of the

⁵⁶ Chapter was written by the Embassy of Switzerland (supporting partner)

⁵⁷ Federal Office for the Environment, Leitbild für die Schweizerische Abfallwirtschaft, Schriftenreihe Umweltschutz Nr. 51, Bern (1986)

⁵⁸ Swiss Agency for the Environment, Forests and Landscape, Abfallkonzept für die Schweiz. Ziele, Massnahmen, 24. Wirkung, Schriftenreihe Umwelt Nr. 173, Bern (1992)

⁵⁹ Environmental Protection Act, EPA (www.admin.ch/opc/en/classified-compilation/19830267/index.html)

⁶⁰ Swiss Green Economy Action Plan (www.bafu.admin.ch/bafu/en/home/topics/economy-consumption/info-specialists/green-economy/green-economy-action-plan--priority-areas.html)

⁶¹ Statista (www.statista.com/statistics/442580/turnover-sector-water-supply-sewerage-wastewater-switzerland/0)

highest municipal solid waste volumes in the world, at 700 kg of waste per person and year. While the share of municipal solid waste that could not be recycled remained stable, the **percentage of recycled waste** increased (**from 45% in 2000 to 53% in 2016**).⁶² This means that more than half of all waste is recycled or composted. This makes Switzerland one of the highest recyclers worldwide.

Switzerland has established a well-functioning waste disposal system in which public and private waste disposal companies work together. The public authorities encourage everyone to recycle as much as possible and regularly run advertising campaigns to raise awareness of the issue. **In 2018, Swiss residents recycled 94% of glass, 94% of aluminum cans, 82% of plastic bottles made of PET, 82% of paper, and 63% of batteries.**⁶³

The disposal of all waste costs Switzerland a good CHF 3 billion a year. The **polluter pays principle** is widely applied in Switzerland: whoever creates the waste must also pay for its disposal. Well over 90% of the municipalities successfully apply this principle (for example bin bags are taxed with pay-per-bag fees) producing on average a good 80 kg less waste per capita to be incinerated each year than in municipalities without a refuse bag fee.⁶⁴

5.2.2 Plastic Recycling in Switzerland

Around 1,000,000 tonnes or 125 kg of plastics per capita are consumed in Switzerland per annum (reference year 2010). Around 40% of this plastic consumed in Switzerland, is disposable packaging material. According to the Federal Office for the Environment (FOEN), Switzerland stopped burying

rubbish in landfills in 2000, which means that all plastic waste in Switzerland are either recycled in an environmentally friendly manner or incinerated to produce energy.⁶⁵ According to a report from industry association Plastics Europe, Switzerland recycles about 10% of its plastic waste.⁶⁶

A well-functioning collection system for separation already exists for PET beverage containers. New PET bottles can only be manufactured from collected PET bottles if the collection is kept as homogeneous and unmixed as possible. The non-selective collection of PET bottles would reduce the quality of these collected items and make the recycling process more difficult, if not impossible.⁶⁷

5.2.3 PET Beverage Containers

On average, 82% of PET plastic bottles are recycled in Switzerland, a figure which has been stable for the past ten years.⁶⁸

The Ordinance on Beverage Containers (BCO)⁶⁹ prescribes a minimum recycling rate of 75 %. In accordance with the BCO, all traders, producers and importers who sell beverages in PET containers must take the empty containers back and submit them for recycling. The market participants can transfer this obligation to a recycling organisation. Today 98% of Swiss beverage producers, importers, bottlers, and retailers are participating in the PET Recycling Switzerland's collection system. PET-Recycling Switzerland (PRS) is a non-profit organisation, which was founded in 1990.⁷⁰ Since 1991 the association has been charging an advance recycling contribution of 1.9 respectively 2.3 centimes on PET single-use drinking bottles without deposit. Through this, PRS was able to finance the

⁶² Federal Office for the Environment (www.bafu.admin.ch/bafu/en/home/topics/waste/in-brief.html)

⁶³ Federal Office for the Environment (www.bafu.admin.ch/bafu/en/home/topics/waste/inbrief.html)

⁶⁴ Federal Office for the Environment (www.bafu.admin.ch/bafu/en/home/topics/waste/in-brief.html)

⁶⁵ Federal Office for the Environment, Plastics (www.bafu.admin.ch/bafu/en/home/topics/waste/guide-to-waste-a-z/plastics.html)

⁶⁶ Federal Office for the Environment, Plastics (www.bafu.admin.ch/bafu/en/home/topics/waste/guide-to-waste-a-z/plastics.html)

⁶⁷ Kunststoff.swiss (www.kunststoff.swiss/downloads/daten-und-fakten/wirtschaftsdaten_2018_final.pdf)

⁶⁸ Federal Office for the Environment, PET beverage containers (www.bafu.admin.ch/bafu/en/home/topics/waste/guide-to-waste-a-z/plastics.html)

⁶⁹ FOEN, Ordinance on Beverage Containers (www.admin.ch/opc/en/classified-compilation/20001238/index.html)

⁷⁰ PET-Recycling, Avis (www.petrecycling.ch/fr/home)

reintroduction of used PET single-use bottles into economic circulation. The advance contribution is a purely financial instrument with no profit or management objectives.

The collection network across Switzerland has been growing continuously since 1990. There are presently 50,000 collection points available for consumers. Approximately 18% of these collection points are located in the Swiss retail trade, which is legally obliged to collect bottles by the Ordinance on Beverage Containers, and approximately 82% in the public service sectors such as workplaces, schools and communities. The collection points can arrange to have the collected PET bottles picked up free of charge. In addition, the PRS works in collaboration with 40 transport partners to cover the whole of Switzerland. The collection rate is presently 82%. 8 out of 10 bottles are collected and recycled.

All collected PET bottles are transported to one of four sorting centres, where they are sorted either manually, mechanically or electronically according to colour and quality. The result is a purity grade of 98-99.9% within each grouping. This purity is necessary for the "from bottle to bottle" cycle. More than 95% of the recycled material will be re-employed in Switzerland.⁷¹

Thanks to the new URRC recycling technology, it has been possible to produce single-layered bottles from recycled material in Switzerland since the year 2000. This new technology represents the important last step on the way to closing the

materials cycle. The first plastic bottles, made completely out of recycled PET plastic (R-PET), appeared in Switzerland last year. The average proportion of recycled material in Swiss PET beverage bottles has risen in recent months from around 30 to almost 40%.⁷² From 2025, all PET bottles in the European Union will have to be manufactured using a minimum of 25% of recycled PET.⁷³

PET recycling is clearly environmentally friendly. Recycling PET beverage bottles reduces the impact on the environment by 74% compared to incineration in a power plant. This is because recycling avoids the emission of greenhouse gases (mainly CO₂), which is good for the climate. Currently, recycling PET avoids the emission of 138,000 tonnes of greenhouse gases per year in Switzerland.⁹

The seven Swiss recycling organisations: FERRO-Recycling (tin cans), IGORA (household aluminium), INOBAT (household batteries), PET-Recycling Switzerland (PET beverage bottles), the SENS Foundation (electrical and electronic equipment), TEXAID (textiles) and VetroSwiss (glass) are united in the umbrella organisation **Swiss Recycling**. "This association exploits the communication synergies that exist between the individual recycling organisations by providing a common platform for disseminating information on the separate collection and appropriate recycling of materials. The association's independence and expertise make it a key contact for official bodies, politicians, retailers and schools throughout Switzerland on all issues relating to recycling."⁷⁴

⁷¹ European Association of Plastics Recycling (www.e-pro-plasticsrecycling.org)

⁷² PET-Recycling, Recycling-PET (<https://www.petrecycling.ch/de/wissen/recycling-pet/schweizer-rohstoff>)

⁷³ Swissinfo.ch, Plastic bottle recycling gets easier in Switzerland, (www.swissinfo.ch/eng/recycling_plastic-bottle-recycling-gets-easier-in-switzerland-/45477432)

⁷⁴ Swiss Recycling, Bouteilles à boissons en PET (www.swissrecycling.ch/fr/substances-valorisables/bouteilles-de-boissons-en-pet/)

Reference: PowerPoint Presentation from the SGC Sustainability Committee⁷⁵

To Develop Singapore's Proposed Plastic Recycling Centre of Excellence (PRCOE) including a Pilot Scale PET Recycling Plant



⁷⁵ Presentation done by Mr Joachim Ihrcke, Chairman of the SGC Sustainability Committee

Preamble: Commercial considerations of PET bottle production & recycling



- Bottle production from Virgin material is cheaper than from recycled PET pellets (not considering environmental impact)
- Singapore's domestic waste is difficult to separate because of the "Refuse Chute" system in >85% of households.
- Contamination of PET bottles with food and liquids means it cannot be recycled for reuse.
- Singapore is not a manufacturing hub for recycled plastics, because of the small market size.
- Singapore's incinerators need calorific energy from plastics to dry and incinerate high % of wet MSW.
- Cheaper to incinerate PET and plastic waste and dump bottom ash at Semakau than to recycle but this is not sustainable for SG.
- 50 "Reverse vending machines" installed in 2019, bar-coded, issuing 5-cent discount vouchers-many of these bottles may be too contaminated for reuse.



Preamble: Environmental considerations for Singapore

- Climate change will bring 1.4 - 4.6°C increase in temperature and sea level rise by >1m by 2100.
- Semakau landfill reaches full capacity by 2035, if ash volume is not reduced (by 30%). New direction and target is to produce Zero Waste.
- Incinerating waste increases Singapore's CO2 footprint (presently standing at about 60mio tons pa)
- Singapore's update of Paris climate pledge (2015) for 2030 and a LEDS in 2020: Singapore's enhanced NDC under the Paris Agreement aims to peak emissions at no higher than 65 million tonnes of carbon dioxide equivalent (MtCO2e) around 2030. Beyond 2030, Singapore's LEDS aspires to halve emissions from its peak to 33 MtCO2e by 2050, with a view to achieving net-zero emissions as soon as viable in the second half of the century.
- Singapore uses 500million plastic bottles/year*, generates a total of 1million tons of plastic waste, of which only 4% is recycled. Quality of recycled material using existing technology is lower than original.

* 500mio bottles @10g each (for a 500ml bottle) would translate into 5,000 tonnes of recycled PET/year

1. Setting up of a Plastic Recycling Centre of Excellence in SG



1.1: Assemble the best companies Europe has to offer on Plastic Recycling



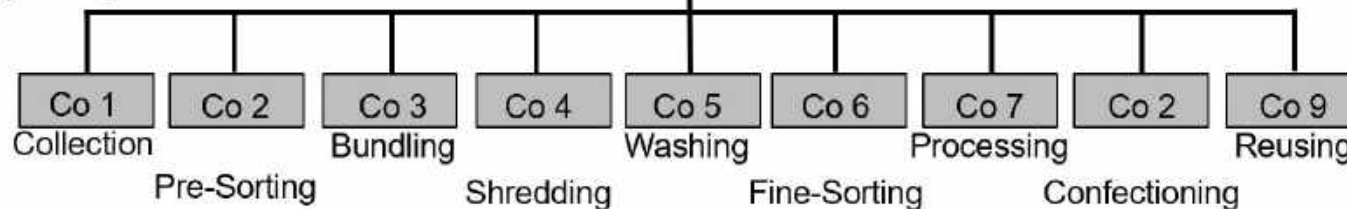
Potential cooperation partners in Europe



Singapore German Chamber in the lead



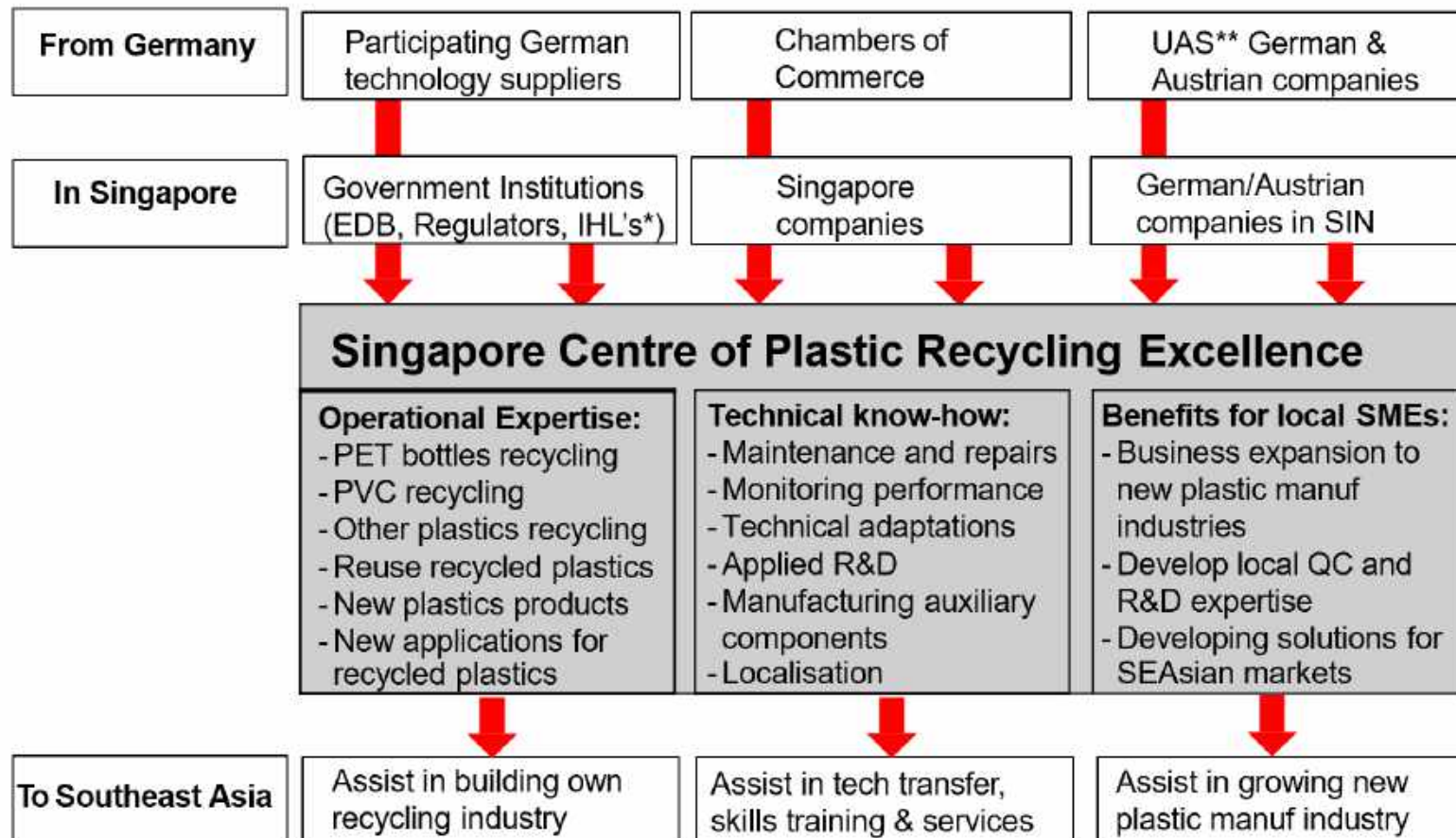
Each team-member provides technology in his specialty section



WKO: Wirtschaftskammer Österreich
 SIHK: Schweizer Industrie- und Handelskammer
 IHK: Industrie- und Handelskammer

AHK: Auslandshandelskammer
 Bvse: Bundesverband Sekundärrohstoffe und Entsorgung e. V.

1.2: Establish a Centre of Excellence for plastics recycling, build technology pipeline, train & empower local partners



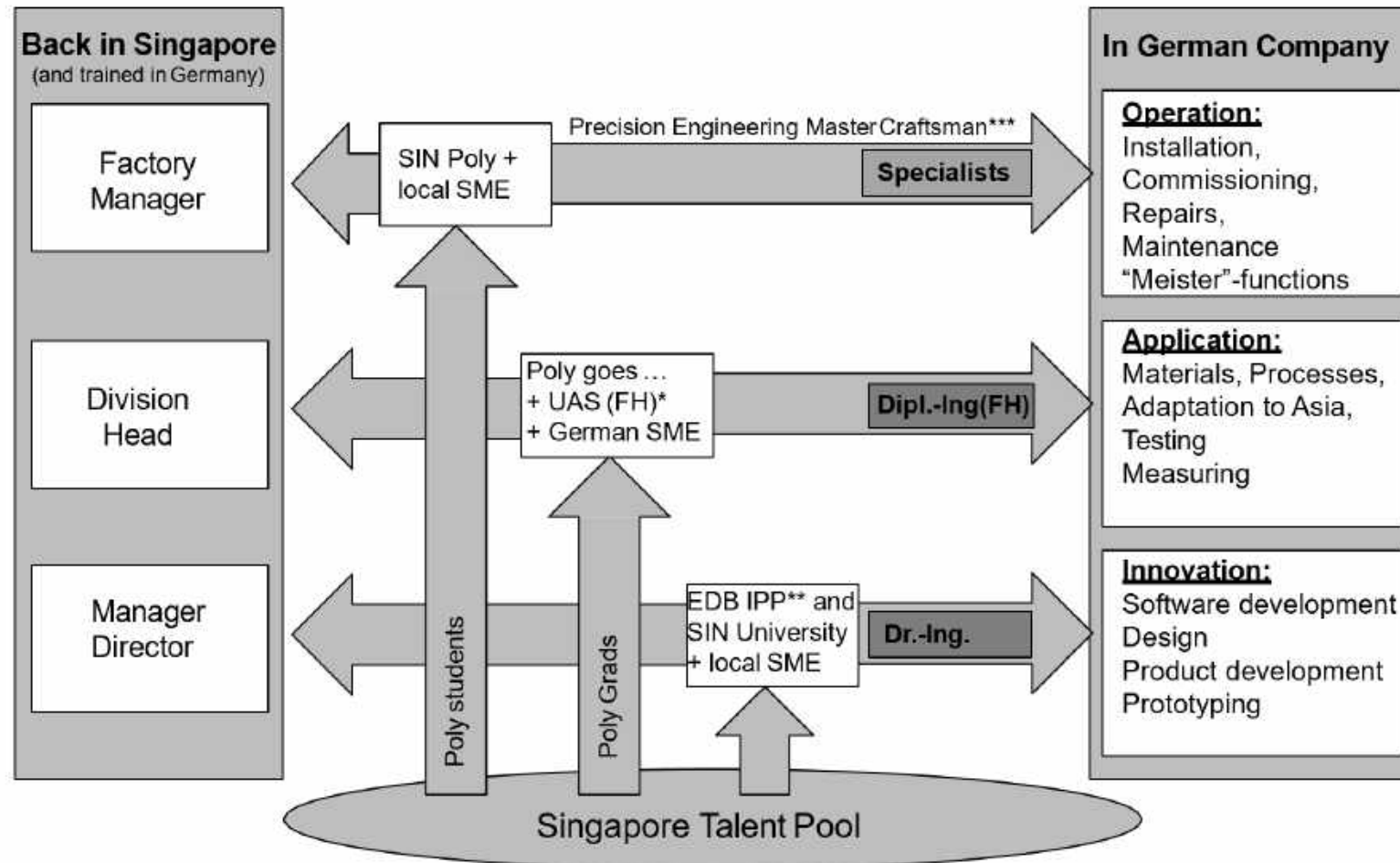
* IHL: Institutes of Higher Learning (Universities etc)

**UAS: University of Applied Science. Cooperation between German dual-education IHLs, Singapore IHLs and German companies. Please refer to next page

1.3: Singapore Institutions and German companies are already cooperating



SIN-Government Stat-Board-schemes help build talent pipelines to increase productivity in local firms



* University of Applied Science (Duale Hochschule BaWü Stuttgart and Hochschule München)

** Economic Development Board Industrial Postgraduate Programme

*** Nanyang Poly, certified by Chamber of Industry and Commerce in Munich, Germany

1.4: Establish production plants for manufacture of recycling machines and sub-systems in cooperation with local partners.



Stages of localization, example Extruder:

1. CKD in Singapore
2. Local procurement of components
3. Gradual localization of components
4. Core elements & Know-How to be provided from Germany
5. Assembly, electronic controls, Applied R&D, etc in Singapore
6. Export "Made in Singapore" to SEA



Components to be sourced/made locally:

- Motor
- Flange
- Gearbox
- Machine bed
- Auxiliary equipment

...

Components ex Germany:

- Screwshaft
- Barrels
- Electronic controls
- Machine monitoring

...

2. Pilot Project: PET recycling plant



2.1: Bring recycling expert companies to Singapore for a seminar to explain concept and to meet potential Singapore Corporate partners



Exemplary Illustration:



Seminar Co-Chairs:
Edwin Khew, Chairman, Sustainable Energy Association
Singapore/Specialist Advisor to SGC.

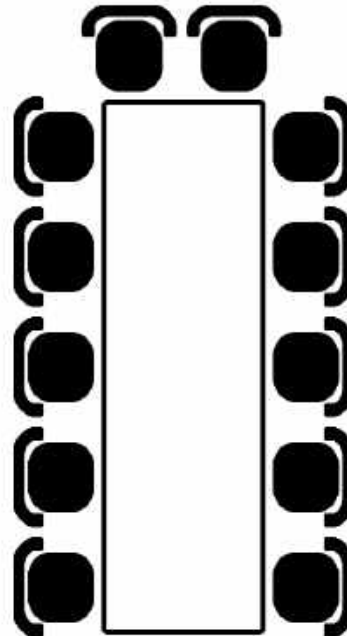
J Ihrcke, Chairman, Sustainability Committee
Singapore German Chamber of Commerce



German/Austrian/Swiss specialist companies*

- System integration
- Collection
- Pre-sorting
- Bundling
- Shredding
- Washing
- Fine-sorting
- Processing
- Reuse
- Reformulation of New-Plastics

...



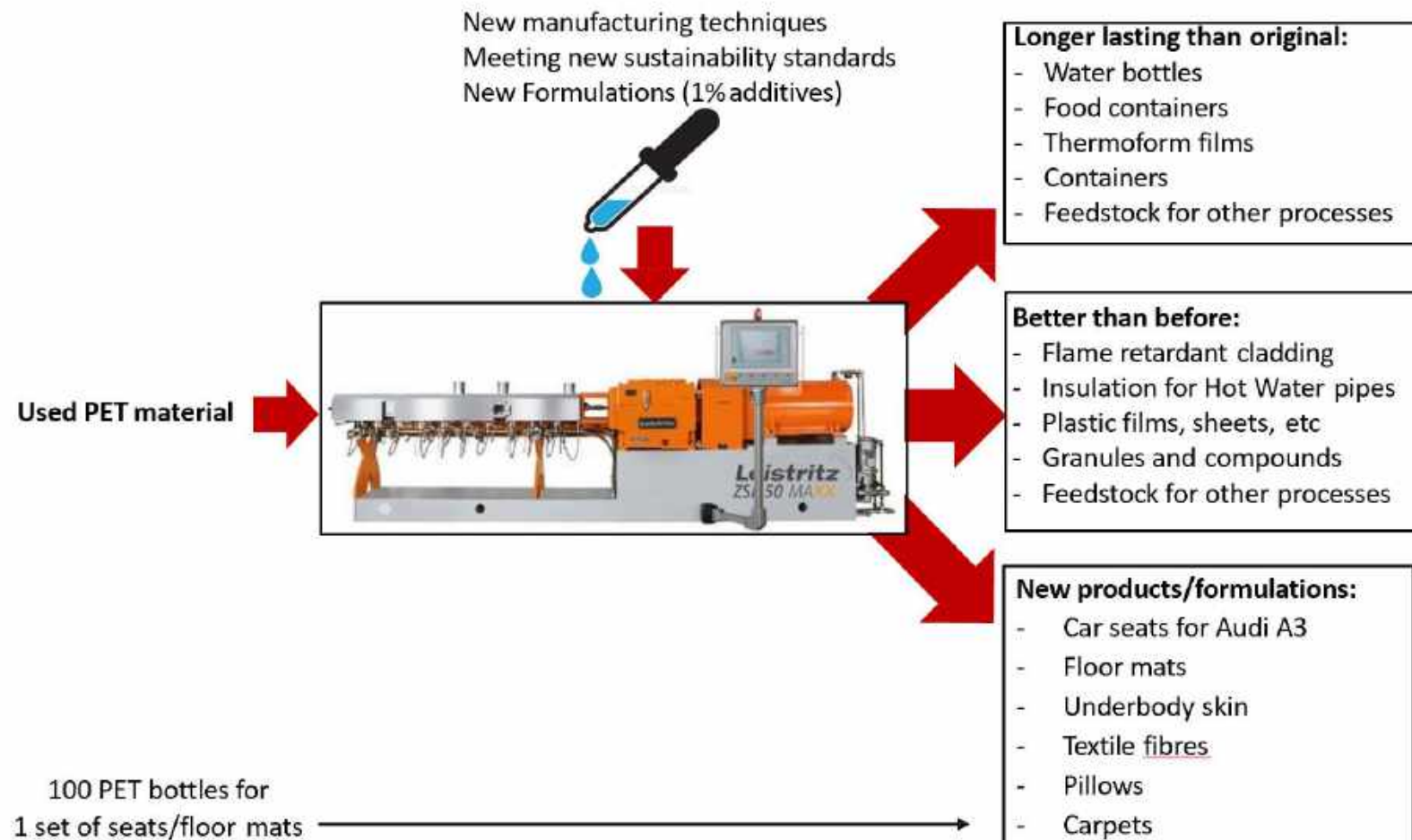
Singaporean potential cooperation partners*

- Government-linked
- Logistics
- Waste collectors
- Recycling Cos
- Precision Engineering
- Local Manuf SMEs
- Environmental Services
- Start-ups, Spin-offs
- Contract manufacturers
- M&E Servicing & Maintenance

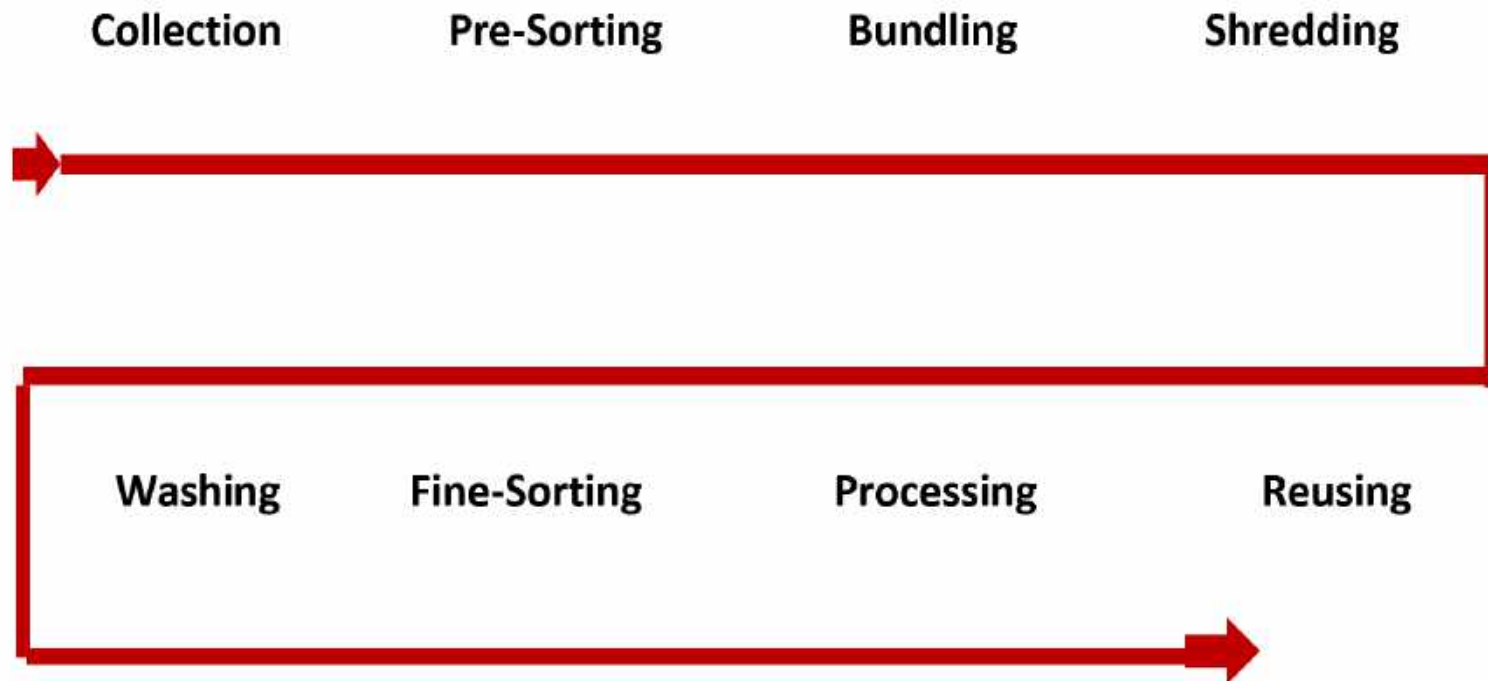
...

* For details regarding potential cooperation partners, please refer to the company listings in the attachment of the Grün Book

2.2: Pilot Project: Recycling of PET material



2.3: Schematics Process of a PET-Recycling project



System integrator mediates between parties and coordinates Internally to ensure total design integrity and functionality of the processing plant.

3. Sign an MoU for the establishment of a PET recycling plant



Memorandum of Understanding:

- Participants, Goals
- Deliverables
- Timetable
- Milestones
- Cost and distribution
- Overall project leader
- Project leaders in Singapore and Germany
- ...

4. Build other plastic recycling pilot plants in Singapore (co-financed)



3. Conclusion



Singaporean-German Chamber
of Industry and Commerce
Deutsch-Singapurische
Industrie- und Handelskammer

3.1: Build Singapore to be the ASEAN Hub of Excellence in plastics recycling.



Proposed Roadmap:

1. Establish a Plastic Recycling Centre of Excellence (PRCOE)
2. Conduct seminar with relevant industry players from Germany/Austria/Switzerland
3. Build Pilot plant beginning with a PET recycling plant
4. Train local specialists in Singapore--training done in Germany/Austria/Switzerland
5. Develop technical solutions to local and regional recycling problems
6. Develop knowledge base in Singapore for ASEAN and Asiarecycling
7. Train local SMEs to build/operate/maintain recycling equipment
8. Manufacture recycling equipment and components locally in SG
9. Market "Singapore as a regional Plastic Recycling Centre of Excellence" in ASEAN and throughout Asia.

4. Listing of Recycling firms in Germany/Austria/Switzerland and Singapore (Grün Book Publication)



Addresses of Recycling Companies

Company	Country	Address	Website	General Email	Direct Contact	Email	Telephone	Company Profile
800 Super Waste Management Pte Ltd	Singapore	66 Woodlands Industrial Park E9 Singapore 757834	www.800super.com.sg	enquiries@800super.com.sg				
ACE Apparatebau construction & engineering GmbH	Austria	Hans-Thalhammer-Straße 18 8501 Lieboch Austria	www.christof-group.com/ace	ace.office@christof-group.com			+43 3136 636 00	The company ACE Apparatebau construction & engineering GmbH is a member of the versatile Christof Group and an international apparatus construction firm. For decades ACE has been developing special solutions for industrial equipment which are recognized worldwide. Products and services: • Pressure vessels • Heat exchangers • Columns • Reactors • FCC-components • Special products • Repair and maintenance work International clients in the petrochemical and chemical industries, as well as in the plastics, paper and foodstuffs industries, appreciate ACE as a reliable partner.
ACH solution GmbH	Austria	Gewerbepark 5 4652 Fischlham Austria	www.ach-solution.at		Mr Robert KÖTTNER	robert.koettner@ach-solution.at	+43 7245 255 70 - 0	ACH solution GmbH is the world's leading company in toolmaking and automation technology for processing LSR (liquid silicone rubber), HTV silicone rubber and special elastomers such as FPM. In addition, ACH manufactures tools for 2-K applications (LSR/thermoplastic). ACH offers complete turnkey solutions for a wide range of industries. Many years of experience in cold runner technology and valve gate systems are the guarantee for high-quality moulded parts. The company employs 74 people at its head- quarters in Upper Austria. In the US state of Florida, a state-of-the-

								art Technical Center is available for customers in the American market.
Advantage Austria (Austrian Embassy, Commercial Section)	Austria/ Singapore	600 North Bridge Road #24-04/05 Parkview Square Singapore 188778	www.advantageaustria.org/sg	contact@advantageaustria.org				Visit the international portal www.advantageaustria.org to learn more about Austrian expertise and know-how in plastic recycling, and Austria as a business location. As internationalisation experts, Advantage Austria be happy to support you in your search for suitable Austrian partners.
AGRU Kunststofftechnik Gesellschaft m.b.H.	Austria	Ing.-Pesendorfer-Strasse 31 4540 Bad Hall Austria	www.agru.at	office@agru.at			+43 7258 790 - 0	AGRU The Plastics Experts. High-quality products made from engineering plastics. AGRU is one of the world's most important single-source suppliers for high-quality piping systems, semi-finished products, concrete protection liners and lining systems made from engineering plastics. Application areas include water and gas infrastructure, the energy sector, chemical and heavy industries, semiconductor and life- sciences, tank and apparatus building, naval and aviation industries, civil engineering and mining, as well as building construction. The possibilities opened up by AGRU products are as diverse as the varying requirements of their customers worldwide.
Ahlert GmbH & Co. KG	Germany	Werner-von-Siemens- Straße 30 48268 Greven Germany	www.ahlert24.de	info@ahlert24.de			+49 2575 9775 50	

Alba tooling & engineering GmbH	Austria	Winkl 133 5552 Forstau Austria	www.albatools.com	office@albatools.com			+43 6454 78 00 - 6100	Alba tooling & engineering GmbH is an internationally active group of companies with more than 400 employees worldwide. The company is headquartered in Salzburg, Austria. Alba develops and manufactures highly complex tools, machines and equipment for the automobile supply industry and, as a reliable systems partner, provides individual services on site. Alba tooling & engineering GmbH is the global tool, plant construction and service partner for OEMs and tier 1 suppliers, as well as special applications in the field of PUR (polyurethane).
ALBA W&H SMART CITY PTE LTD	Singapore	18 Tuas Ave 10 Singapore 639142	www.alba-wh.sg		Mr Jakob GRAF LAMBSDORFF	j.lambsdorff@alba-wh.sg	+65 9344 2201	ALBA W&H Smart City Pte Ltd is a Singapore based public and commercial waste collector currently servicing the Jurong public waste collection sector. ALBA WH is a Joint Venture of the German ALBA Group, a full service provider along the entire solid waste management value chain, and Wah & Hua, one of the leading Singaporean Waste Management companies. ALBA Group operates several plastics sorting plants, PET recycling plants and HDPE & PP extrusion lines. In Slovenia ALBA via its subsidiary Interseroh is running a R&D lab researching on improvements in plastics recycling and compounding, which was awarded with the Plastics Recycling Awards Europe 2019. ALBA's plastic recycling business is handling more than 1 Million tons of plastics per year worldwide resulting in GHG emission savings of over 800,000 tons per year.
Alfons Fischer & Söhne GmbH	Germany	Altenbochumer Str. 15 - 21 44803 Bochum Germany	www.fischersoehne.de	bochum@fischersoehne.de			+49 2349 3721 0	

ALS GmbH	Germany	Hecken 11 D-85461 Bockhorn Germany	www.als- gmbh.eu	als@als- gmbh.eu	Mr Leonhard SCHAAL		+49 8122 2275 008	ALS GmbH delivers planning and consulting services for plant engineering and risk analysis in the fields of fuel depot construction, recycling plants, sorting plants, distillation, and solvent recovery. ALS GmbH has international experience. In 2016 the company executed a plant construction project 'Alternative fuel - biomass firing plant with supply of power generator and electrical distributing system' in Ethiopia. Furthermore, ALS GmbH partnered with the Ministry for Development and a construction company as executing partner for recycling plants with own waste-to-energy systems and a composting plant. Unfortunately, the project was not completed due to the unstable political situation. Currently ALS GmbH is working on two plant projects for plastic recycling. 1. PP, PS, PE, and ABS as granules. Completion May 2020, Germany 2. Separate PE and PA with solvents with four external partners.
Amandus Kahl GmbH & Co. KG	Germany	Dieselstr. 5 - 9 21465 Reinbek Germany	www.akahl.de	info@amandus- kahl-group.de				
Ammer Entsorgungs GmbH & Co. KG	Germany	Baldhamerstraße 33 85604 Zorneding Germany	www.ammer- entsorgung.de	info@ammerkg. de			+49 8106 2420 11	
Ammon Kunststoffe	Germany	Eugen-Bolz-Str. 20, 72829 Engstingen Germany	www.ammon- kunststoffe.com	info@ammon- kunststoffe.com				
APK Aluminium und Kunststoffe AG	Germany	Beunaer Straße 2 06217 Merseburg Germany	www.apk.ag	info@apk.ag			+49 3461 7945 729	

AREG mbH	Germany	Hauptstraße 91 94127 Neuburg Germany	www.ereg- mbh.de	info@ereg- mbh.de			+49 8502 9003 0	
Arrow Plast Kunststoffrec- ycling GmbH	Germany	Im Grein 13-15, 76829 Landau Germany	www.arrowplas- t.de	mail@arrowpla- st.de				
ASCON Gesellschaft für Abfall und Sekundärrohst- off Consulting mbH	Germany	Margaretenstra- ße 1 53175 Bonn Germany	www.ascon- net.de	info@ascon- net.de			+49 2289 4377 3	
Asia Recycling Resources Pte Ltd	Singapore	5 Fourth Lok Yang Road Singapore 629702	www.asia- recycling.com	asiarecycling@s- ingnet.com.sg				
A-Star Plastics Pte Ltd	Singapore	No. 2 Tuas Link 2, Singapore 638551	www.astarplast- ics.com					
Aurora Kunststoffe GmbH	Germany	Max-Eyth-Str. 14 - 16, 74632 Neuenstein Germany	www.aurora- kunststoffe.de	kut@aurora- kunststoffe.de				
AVA GmbH u. Co. KG	Germany	Heinestraße 5 82211 Herrsching Germany	www.ava- huep.de	info@ava- huep.de				
Axpo	Switzerla- nd	Parkstrasse 23 5401 Baden Schweiz	www.axpo.com	info@axpo.com			+41 5620 0311 1	
B & B Recycling GmbH	Germany	Mittenwalder Straße 15 12529 Schönefeld Germany	www.bb- recycling.de	info@bb- recycling.de			+49 3379 2078 80	
B+B Anlagenbau GmbH	Germany	Gildestrasse 11b 32760 Detmold Germany	www.bub- anlagenbau.de	info@bub- anlagenbau.de				

bage plastics GmbH	Austria	Eisenstrasse 1 4502 St. Marien Austria	www.bage-plastics.com	office@bage-plastics.com			+43 7227 222 10	bage plastics is an innovative recycling company that recycles post-consumer plastic waste from electrical and electronic scrap and turns it into high-quality recyclates. At bage plastics, over 25,000 tonnes of high-quality PS, ABS and PP plastic granules from old plastic waste are produced each year for applications in extrusion and injection moulding and are delivered all over the world. The company produces various standard recycled granules in PS, ABS und PP, as well as different compounds in accordance with its customers' wishes and for special applications. The high-quality regranulates and compounds are mainly used in the following industries: electronics, domestic appliances, office products, sanitary facilities, automotive and construction.
Bartscherer & Co. Recycling GmbH	Germany	Montanstraße 17 - 21 13407 Berlin Germany	www.bartscherer-recycling.de	bartscherer@bartscherer-recycling.de			+49 3040 8893 0	
Becker + Armbrust GmbH	Germany	Großbeerenstr. 171A, 12277 Berlin Germany	www.pav-recyclate.de	pav@becker-armbrust.de				
becker+brügesch Entsorgungs GmbH	Germany	Warturmer Heerstraße 120 28197 Bremen Germany	www.becker-bruegesch.de	info@becker-bruegesch.de			+49 4215 2163 33	
Beckmann Technik & Service KG	Germany	Böckerhof 3 D-33034 Brakel Germany	www.bts-recycling-equipment.com	info@bts-recycling-equipment.com				
Behrendt Rohstoffverwertung GmbH	Germany	Leinestraße 31-33 24539 Neumünster Germany	www.electronic-recycling.de	info@behrendt.com			+49 4321 9326 0	
BellandVision GmbH	Germany	Bahnhofstraße 9 91257 Pegnitz Germany	www.bellandvision.de	vertrieb@bellandvision.de				

Bellersheim Abfallwirtschaft GmbH	Germany	Niederahrer Straße 2 56412 Boden Germany	www.bellersheim.de	abfallwirtschaft@bellersheim.de			+49 2602 9276 0	
BEOS-Polymer GmbH	Germany	Markritz 1A, 04720 Döbeln, OT Markritz Germany	www.beos-polymer.de	info@beos-polymer.de				
BeRec GmbH	Germany	Löhmer Dorfstr. 1B, 16356 Werneuchen OT Seefeld-Löhme Germany	www.berec.de	mail@berec.de				
Bergler GmbH & Co. KG	Germany	Etzenrichter Straße 12 92729 Weiherhammer Germany	www.bergler.de	kontakt@bergler.de			+49 9605 9202 0	
BERZELIUS Metall GmbH	Germany	Emser Straße 11 56338 Braubach Germany	www.berzelius.de	info@berzelius.de			+49 2627 9830	
Best Plastic Management GmbH	Germany	Industriestr. 20-24, 26219 Bösel Germany	www.best-plastic.de	info@best-plastic.de				
BHS-Sonthofen GmbH	Germany	An der Eisenschmelze 47 87527 Sonthofen Germany	www.bhs-sonthofen.de	info@bhs-sonthofen.de				

Blue Air Systems GmbH	Austria	Achenfeldweg 8 6250 Kundl Austria	www.blue-air.at	info@blue-air.at			+43 5338 211 71	BLUE AIR SYSTEMS GmbH, an Austrian- based company founded in 2010, supplies the plastics industry with innovative technology. Blue Air Systems offers the high-quality, energy-saving RD resin dryer series for material preparation, based on compressed air drying technology and with hopper sizes ranging from 0.5 to 1,000 litres. In climate technology solutions, the core business is focused on dehumidification units (series MSP) and internal product cooling (series CAC). The DMS-system (series DMS), a completely new technology for condensation-free production conditions, enables energy-efficient mould dehumidification without cooling water and consequently a great energy-saving potential of up to 85%.
Boerger Pumps Asia Pte Ltd	Germany/ Singapore	16 Boon Lay Way, #01-48 TradeHub21 Singapore, 609965	www.boerger.com		Mr Domonik STRAETLING	asia@boerger.com	+65 6562 9540	Boerger GmbH is a world's leading German manufacturer of Rotary Lobe Pumps and Macerating Technologies since 1975. With pumping volumes up to 1,600m³/h in 24 pump sizes, Boerger Pump provides a wide selection for various Industries. Macerating Technologies includes: Multicrusher, Multichopper and Rotorrake, providing efficient chopping operations, ensuring the downstream machines and pumps operate smoothly.
bomatic Umwelt- und Verfahrenstechnik GmbH	Germany	Germakehre 7 25479 Ellerau Germany	www.bomatic.de	info@bomatic.de				
Borchers Kreislaufwirtschaft GmbH	Germany	Hansestraße 44 46325 Borken Germany	www.borchers-entsorgung.de	info@borchers-entsorgung.de			+49 2861 9341 0	

Borealis AG	Austria	Wagramerstraße 17 - 19 1220 Wien Austria	www.borealisgroup.com	info@borealisgroup.com			+43 1 224 000	Borealis is a leading provider of innovative solutions in the fields of polyolefins, base chemicals, and fertilizers. With the aim of creating added value through innovation, Borealis develops solutions for global challenges. Building on its proprietary technologies and more than 50 years of experience in poly-olefins, the company supplies key industries in the fields of energy, automotive, pipes, consumer products, healthcare and advanced packaging with a wide range of polyolefin applications. Borealis has taken several initiatives to promote the circular economy of plastics and has taken on a pioneering role in recycling. The company employs a global workforce of 6,800 and supplies customers in 120 countries.
Breitsamer Entsorgung Recycling GmbH	Germany	Dachauer Straße 535 80993 München Germany	www.breitsamer.com	jm@breitsamer.com			+49 8930 9098 90	
BREWELO GmbH & Co. KG	Germany	Hermann-Funk- Straße 4 28309 Bremen Germany	www.brewelo.de	mail@brewelo.de			+49 4214 3536 3	
BVR Kunststoff GmbH	Germany	Im Heetwinkel 53, 46514 Schermbeck Germany	www.bvr-production.eu	info@bvr-production.eu				
bvse - Bundesverband Sekundärrohstoffe und Entsorgung e. V. (Association)	Germany	Fränkische Straße 2 53229 Bonn Germany	www.bvse.de	info@bvse.de				

C2P Germany GmbH	Germany	Hüttenstraße 6 38642 Goslar Germany	www.recylex-germany.com	marketing-c2p-germany@recylex.de			+49 5321 6880	
CABKA Group GmbH	Germany	Wintersteinstrasse 22 10587 Berlin Germany	www.cabka.com				+49 2253 9307 33	
CAS-Kunststoffe GmbH & Co. KG	Germany	Ailersbach 3, 91315 Höchstadt Germany	www.cas-kunststoffe.de	service@cas-kunststoffe.de				
CCR Logistics Systems AG	Germany	Karl-Hammerschmidt-Str. 36, Eingang: Haus Nr. 42 D 85609 Dornach (München) Germany	www.ccr-revlog.com	info@rev-log.com				
CEDERBAUM Container GmbH	Germany	Hannoversche Straße 65 38116 Braunschweig Germany	www.cederbaum.de	container@cederbaum.de			+49 5315 8005 0	
Cellumation	Germany	Linzer Str. 5 28359 Bremen Germany	www.cellumation.com	info@cellumation.com				
Chye Thiam Maintenance (CTM)	Singapore	14 Tampines Industrial Drive, CTM Building, Singapore 528530	www.chyethiam.com	hq@chyethiam.com				
Cifra Recycling GmbH	Germany	Weserstraße 12, 47506 Neukirchen-Vluyn Germany	www.cifra-recycling.com	info@cifra-recycling.de				
Colex Environmental Pte Ltd	Singapore	8 Tuas South Street 13 Singapore 637083	www.colex.com.sg	wastemgt@colex.com.sg				

Columbus GmbH	Austria	Tabakfabrik, Peter-Behrens- Platz 7 4020 Linz Austria	www.columbus- tech.com	office@columb- us-tech.com	Ms Ruth Christine KOPPENBERGE R		+43 732 931 641 - 0	For more than 40 years Columbus has been researching, developing and producing outstanding vacuum press technology, thus offering its customers an inexhaustible potential of possibilities. With Columbus vacuum presses, plastic processors are able to produce complexly shaped prototypes, individual and serial products out of innovative materials that would not be producible with conventional equipment. Advantages of Columbus vacuum presses: • short set-up times • easiest operation • enormous range of applications • low investment and operating costs • competent application support Columbus vacuum presses - ideal tools to master all forming and pressing tasks and to inspire customers.
Comes Maschinen- und Apparatebau GmbH	Germany	Seiferstraße 16 54293 Trier- Ehrang Germany	www.comes- trier.de	info@comes- trier.de				
Comptek Kunststoffverarbeitung GmbH	Germany	Heinrich-Hertz- Str. 15, 65582 Diez Germany	www.comptek. de	info@comptek. de				
ConVerta GmbH	Germany	Poststraße 6a 95615 Marktredwitz Germany	www.converta. com	info@converta. com			+49 9231 9611 0	
Copo Plast	Germany	Business Park Hörpolding 2, 83301 Traunreut Germany	www.copo- plast.de	info@copo- plast.de				
CPE Entsorgung GmbH	Germany	Am Recyclingpark 1 - 10 31618 Liebenau Germany	www.cpe- recycling.de	info@cpe- recycling.de			+49 5023 9803 0	

CRH Recycling GmbH	Germany	Ludwig-Erhard-Straße 5, 74564 Crailsheim Germany	www.crh-recycling.de	info@crh-recycling.de				
Crimson General Contract Co.	Singapore	Blk 501, Jurong West St51, #02-253 Singapore 640501	www.crimsongeneral.com.sg	crimson6@singnet.com.sg				
CSD INGENIEURE AG	Switzerland	Chemin de Montelly 78 Case postale 60 1000 Lausanne 20 Switzerland	www.csd.ch					
Cubicure GmbH	Austria	Gutheil-Schoder-Gasse 17 1230 Wien Austria	www.cubicure.com	info@cubicure.com	Mr Markus PFAFFINGER		+43 1 581 04 39 - 10	Founded in 2015 as a spin-off of the TU Wien, Cubicure supplies high-performance photopolymers for additive manufacturing (stereolithographic 3D-printing) for industrial applications. These highly viscous resins are characterised by high strength, impact strength and heat resistance. Using the patented and innovative Hot Lithography Technology developed by Cubicure, the “Caligma 200” 3D-printing machine can process highly viscous resins with the utmost precision – for functional prototypes as well as small and medium- sized series. With “CSS”, a comprehensive software solution for creating support geometries and slicing, 3D-models can be prepared for various additive manufacturing technologies.
CWK-Recycling GmbH	Germany	Am Hasselbruch 4, 32107 Bad Salzuflen Germany	www.cwkrecycling.de	pw@cwkreycling.de				
CYPOL GmbH	Germany	Baldusstraße 18, 47138 Duisburg Germany	www.cypol.de	info@cypol.de				

Dawn Plastic Industries Pte Ltd	Singapore	BLK 2020, Bukit Batok Ind. Park A #02-236 Singapore 659525	www.dawnplastic.com.sg	andydawn@singnet.com.sg				
Degenkolbe Recycling GmbH	Germany	Neckartalstraße 225 70376 Stuttgart Germany	www.degenkolbe-recycling.de	info@henry-degenkolbe.de			+49 7119 5453 0	
Dekura GmbH	Germany	Eugen-Diesel-Str. 3, 37671 Hötter Germany	www.dekura.de	info@dekura.de				
Der Grüne Punkt - Duales System Deutschland GmbH	Germany	Frankfurter Straße 720-726 51145 Köln-Porz-Eil Germany	www.verpackgo.de	info@gruener-punkt.de			+49 2203 9370	
Design Composite GmbH	Austria	Gewerbegebiet Lengdorf 4 5722 Niedernsill Austria	www.design-composite.com	info@design-composite.com			+43 6548 203 97 0	Design Composite GmbH produces and distributes composite panels for use in lightweight construction, architecture, and design, as well as acoustics. The core competency lies above all in the bonding of different components to novel composites. A wide range of translucent panels are on offer for the architectural and design sector, which can be used both for exterior applications (facades, porches) and for interior fixtures and fittings (partition walls, doors) in the construction of shops, stores and trade fair stands, for fitting out hotels and restaurants and in the designer furniture industry. The translucent AIR-board® acoustic panels, consisting of micro-perforated, translucent covering layers and a colourless or coloured honeycomb core, are highly sound-absorbing and therefore unique in their functionality.

DI MATTEO Förderanlage n GmbH & Co. KG	Germany	Römerstr. 1-16 59269 Beckum Germany	www.dimatteo. de	info@dimatteo. de				
diamat Maschinenba u GmbH	Germany	Amperestrasse 13 91550 Dinkelsbühl Germany	www.diamat.co m	diamat@diamat .com				
Dienstleistun g, Handel and Transport Gm bH	Germany	Haferkuhle 2, 31600 Uchte Germany	www.dht- streitbuerger.de	info@dht- streitbuerger.de				
DIGI Deutschland GmbH	Germany	Reisertstraße 8 53773 Hennef Germany	www.digisyste m.com	info@de.digi- group.com				
DKL- Kunststoffe mbH	Germany	Bahnhofstraße 17, 96253 Untersiema Germany	www.dkl- kunststoffe.de	info@dkl- kunststoffe.de				
DMH Dichtungs- und Maschinenha ndel GmbH	Austria	Industriepark West 11 8772 Traboch Austria	www.dmh.at	office@dmh.at			+43 3833 200 60 - 0	DMH Dichtungs- und Maschinenhandel GmbH is the provider of the DMH SYSTEM, a seal production concept that covers the entire spectrum, from the CNC lathe for machining seals to the corresponding semi-finished parts, the necessary tools and DMH soft-ware. The company produces around 50 different materials (such as high-grade polyurethane and elastomer materials, PTFE and others) that are processed to make the semi-finished parts needed for seal production. As the 3rd pillar of DMH SYSTEMS, on request the company can provide its customers with special purpose seals with a diameter of up to 2,500 mm, that are produced in the seal machining centre and complement the product range.
Dockhorn- Kunststoffe e.K.	Germany	Kölner Str. 22, 40885 Ratingen Germany	www.dockhorn- kunststoffe.de	info@dockhorn- kunststoffe.de				

Dörr Bruchsaler Kunststoffe GmbH	Germany	Im Schollengarten 28, 76646 Bruchsal-Untergrombach Germany	www.bruchsale-r-kunststoffe.de	info@bruchsale-r-kunststoffe.de				
Dorr GmbH & Co. KG	Germany	Dieselstraße 32 87437 Kempten Germany	www.dorr.de	info@dorr.de			+49 8315 9117 611	
Dortmunder Gesellschaft für Abfall mbH	Germany	Sunderweg 98 44147 Dortmund Germany	www.doga.de	info@doga.de			+49 2319 1115 00	
Dr. Steger Abfall - Entsorgung GmbH	Germany	Siebenlindenstr., 37-39, 72108 Rottenburg Germany	www.steger-entsorgung.de	info@steger-entsorgung.de				
DSD – Duales System Holding GmbH & Co. KG	Germany	Frankfurter Straße 720–726, 51145 Köln-Porz-Eil Germany	www.gruener-punkt.de	info@gruener-punkt.de				
Durmin Entsorgung und Logistik GmbH	Germany	Antwerpener Str. 19 90451 Nürnberg Germany	www.diegruene-nengel.com	info@diegruene-nengel.com			+49 9116 4681 0	

E+E Elektronik Ges.m.b.H.	Austria	Langwiesen 7 4209 Engerwitzdorf Austria	www.epluse.com	info@epluse.at			+43 7235 605 - 0	E+E Elektronik develops and produces sensors and transmitters for relative humidity, temperature, dew point, humidity in oil, air velocity, CO2, mass flow and pressure. The measuring devices of the ISO 9001 and IATF 16949 certified company are known for their high measurement accuracy and reliability. Typical applications in the plastics industry are, for example: • Humidity and temperature measurement in drying processes • Gas flow and consumption metering in blow moulding processes • Dew point monitoring of compressed air systems E+E Elektronik has a worldwide dealer- ship network and is represented by its own subsidiaries in Germany, France, Italy, Korea, China and the United States.
EBP Schweiz AG	Switzerland	Mühlebachstrasse 11 8032 Zurich Switzerland	www.ebp.ch	info@ebp.ch			+41 4439 5161 6	
Eco Special Waste Management Pte Ltd	Singapore	21/23 Tuas View Circuit Singapore 637358 / 637768	www.eco.com.sg	sales@eco.com.sg				

ECON GmbH	Austria	Biergasse 9 4616 Weißkirchen/Traun Austria	www.econ.eu		Mr Uwe NEUMANN	u.neumann@econ.eu	+43 7243 565 60 - 20	For almost 20 years, ECON has been THE specialist for underwater pelletizing systems. The continuous development of their technology has made ECON the innovation leader in underwater pelletizing, especially with their patented thermal insulation technology. The simple operation guarantees ideal process reliability and the user benefits from the high level of productivity. For ECON it is important to find the right solution for every customer. The international ECON team ensures that a tailor-made solution is implemented to meet the individual requirements of the customer. Standardised, but also individualised systems ensure maximum success.
Ecoplast Kunststoffrecycling GmbH	Austria	Untere Aue 21 8410 Wildon Austria	www.ecoplast.com	info@ecoplast.com			+43 3182 33 55 - 0	With more than 25 years of experience, Ecoplast Kunststoffrecycling GmbH is one of the largest recyclers of plastics in Europe. In August 2018 Ecoplast became a member of the Borealis Group and will focus even more on both the production and research and development of high quality polyethylene (PE) recyclates. The customers of Ecoplast are mainly manufacturers in the field of PE film production who produce carrier bags, bin liners and similar thin wall packaging from Ecoplast recyclates.
Eggersmann	Germany	Carl-Zeiss-Straße 6-8 32549 Bad Oeynhausen Germany	www.eggersmann-recyclingtechnology.com	sales@f-e.de				

EICON GmbH	Austria	Hausleitner Straße 16 4400 Steyr Austria	www.eicon- gmbh.at		Mr Sebastian EIGRUBER	s.eigruber@eico n-gmbh.at	+43 664 586 13 21	At the beginning of 2017 EICON developed from a trading company to a manufacturer of machines and equipment for the production of plastic pipes. EICON's core competence lies in the development, design and production of highly productive downstream equipment, as well as the realisation of complete production lines. In addition to standard machines, EICON also offers special machines, which provide the perfect solutions for their customers' requirements. Customer satisfaction is always of the utmost priority. Through the focus on constant new and further developments, tailor-made solutions are created for plastic pipe manufacturers.
Eisbär Trockentechnik GmbH	Austria	Wuhrmühle 22 6840 Götzis Austria	www.eisbaer.at	cool@eisbaer.at	Ms Elfi BREUSS		+43 5523 555 58 - 0	Eisbär develops and manufactures high- quality systems for drying, dehumidification and cooling for the plastics industry. In close cooperation with the customers, individual and energy-saving solutions are developed and realised to meet their special requirements. The Eisbär product range: • DAS – Dry Air System to avoid condensation on cooled moulds • GDS/DP – Granule Drying System • CR- Crystallizer • MU - Mixing and dosing systems • LC – Cap cooling • BACS – Blow Air Cooling System
ELM Recycling GmbH & Co. KG	Germany	Fabrikstraße 29 73266 Bissingen Germany	www.elm- recycling.de	info@elm- recycling.de			+49 7023 9008 120	

ELMET Elastomere GmbH	Austria	Tulpenstrasse 21 4064 Oftring Austria	www.elmet.com	m.ostermann@elmet.com	Mr Mrk OSTERMANN		+43 7221 745 77 - 160	“ELASTOMER IS OUR BUSINESS” - Since the company was founded in 1996, ELMET stands for products at the highest technological level. As a globally active company, ELMET is known for the development and manufacturing of high-quality equipment for the production of silicone and rubber parts. Constant development of the product range and technologies means that today ELMET is a FULL SYSTEM SUPPLIER with a focus on the following areas: • Product development • LSR dosing system • Cold decks • LSR and 2K moulds • Turnkey solutions • Serial production At its headquarters in Oftring (Linz), ELMET now employs a committed, ambitious and experienced team with more than 200 highly qualified employees.
Energenta Südwest GmbH	Germany	Junkers-Str. 9, 67681 Sembach Germany	www.energenta-suedwest.de	info@energenta.de				
ENGEL AUSTRIA GmbH	Austria	Ludwig-Engel-Straße 1 4311 Schwertberg Austria	www.engelglobal.com		Ms Ute PANZER	ute.panzer@engel.at		As one of the world's leading companies in the field of plastics machinery construction, ENGEL sees its task not only in the production of injection moulding machines and robots, but also in the supply of integrated turnkey solutions. At ENGEL, injection moulding machines and automation, process technology and mould project development, training and service are all perfectly interlinked. Innovation and technology leadership provide ENGEL's customers with a decisive competitive advantage. Since it was founded in 1945, ENGEL has been 100 percent family-owned. ENGEL currently employs around 6,900 people worldwide.

Entsorgungsfachbetrieb Plömacher GmbH & Co. KG	Germany	Metjendorfer Landstraße 10b 26215 Wiefelstede Germany	www.ploemacher-entsorgung.de	info@ploemacher-entsorgung.de			+49 4416 1849	
Entsorgungstechnik Bavaria GmbH	Germany	Siemensstrasse 14 85716 Unterschleißheim Germany	www.et-bavaria.eu	info@et-bavaria.eu				
ERE Kunststoff RAM-Extrusion GmbH & Co. KG	Germany	Auf der Steinrausch 10, 53539 Kelberg Germany	www.ere-kunststoff.de	info@ere-kunststoff.de				
EREMA Engineering Recycling Maschinen und Anlagen GmbH	Austria	Unterfeldstrasse 3 4052 Ansfelden Austria	www.erima.com	erima@erima.at			+43 732 31 90	Since 1983 EREMA Engineering Recycling Maschinen und Anlagen GmbH has been specialised in the development and production of plastics recycling systems and technologies for the plastics processing industry. The company is regarded as the global market and innovation leader in these fields. Product portfolio: • Plastics recycling systems for standard applications and production waste and for heavily printed/contaminated post-consumer waste • FDA-approved PET recycling systems, VACUREMAR, VACUNITER, efsa approval requested via customers • Inline PET applications • COREMAR plastic recycling system for the production of highly filled and customised compounds • Fully automatic, self-cleaning melt filters • Pelletizing systems
Erich Rada GmbH	Germany	Südtiroler Straße 22 86165 Augsburg Germany	www.rada-recycling.de	info@rada-recycling.de			+49 8217 2079 0	

Erkis Plast	Germany	Alte Heerstraße 76, 47652 Weeze Germany	www.erkis- plast.de	service@erkis- plast.de				
Eu-Rec GmbH	Germany	Unter dem Dostler 2 54293 Trier Germany	www.eu-rec.de	info@eu-rec.de			+49 6519 9551 60	
Euro Kunststoffpro- dukte Yavuz	Germany	Münsterknapp 5- 11, 45721 Haltern am See Germany	www.ekp- yavuz.de	office@ekp- yavuz.de				
Eurofol Kunststoffe GmbH	Germany	Obere Industriestrasse 31, 57250 Netphen Germany	www.eurofol- kunststoffe.com	info@eurofol- kunststoffe.de				
EVO-tech GmbH	Austria	Gahberggasse 9a 4861 Schörfling Austria	www.evo- tech.eu		Ms Julia BRAND	julia.brand@ev- o-tech.eu	+43 7662 384 00	Since it was founded by managing director Markus Kaltenbrunner, the Austrian company EVO-tech GmbH sees itself as a complete supplier in the field of additive manufacturing and professional 3D printing with a distinct consulting and service component. As such, EVO-tech develops and produces FFF printers for additive manufacturing. A further focus is on the development and adaptation of filaments and technical plastics.
Exel Composites GmbH	Austria	Industriestraße West 8 8605 Kapfenberg Austria	www.exelcomp- osites.com		Mr Milan STANAREVIC	milan.stanarevi- c@exelcomposi- tes.com	+43 3862 331 80 26	Exel Composites is the largest producer of glass-fibre reinforced plastic profiles in the world. The Exel Group incorporates 8 production sites worldwide. The extensive product range includes not only standard forms but also special designs, as well as cost-efficient solutions for customer- specific products and problems. As a global supplier of composite mate- rials, the company has developed thousands of carbon- and glass- fibre profiles for its customers, based on many years of experience and international expertise.

extrunet gmbh	Austria	Bad Haller Str. 40 4550 Kremsmünster Austria	www.extrunet.com	office@extrunet.com	Mr Dietmar GRUBER		+43 570 580 - 2	For many years extrunet has successfully met the challenges facing a complete supplier of extrusion lines and tools for profile extrusion. As a pioneer in the development of self-learning and self-controlling profile extrusion lines, the focus in further development is not only on energy efficiency, but also on increasing production reliability. The current extrunet developments concerning the digitalisation of extrusion processes in profile extrusion mark the opening of a new era and indicate the future of the industry. extrunet product portfolio: • DIGI-DAT overall control • CO-Extruder I Extruder • Calibration table I Haul off I Saw/cutter unit I Tilting table • Extrusion tooling • Project management
F. Ehrich GmbH & Co. KG	Germany	Kieler Straße 171 24768 Rendsburg Germany	www.ehrich.de	info@ehrich.de			+49 4331 1402 0	
Farrag Tech GmbH	Austria	Dammstraße 61 6922 Wolfurt Austria	www.farragtech.com	info@farragtech.com			+43 5574 838 00	Farrag Tech GmbH is proud to look back on over 25 years of experience in plastics periphery. As the inventor of the Compressed Air Resin Dryer and the Internal Air Cooling System for blow moulding processes, the company has always remained at the forefront of these technical possibilities through the continual development and improvement of its products. Thanks to Farrag Tech's innovation, mould area protection of chilled tool moulds has become more energy-efficient and economical. Currently thirteen people are employed at the company headquarters in Wolfurt, Austria, who take care of the processing of orders and technical development of the machines and solutions for Farrag Techs' customers worldwide.

Felder Group	Austria	KR-Felder-Str. 1 6060 Hall in Tirol Austria	www.felder-group.com	info@felder-group.com			+43 5223 58 50 - 0	Since 1956 the family-owned Felder Group, with its pioneering machine concepts and high-quality products, has been one of the world's leading mechanical engineering and technology companies in the wood and composite processing industry. Development and production of a model range comprising more than 180 machines, from combined standard woodworking machines to the high-end 5-axis CNC machining centre, takes place at the plant in Hall in Tyrol. The brands Felder, Format-4, and Hammer meet all the requirements of business, trade and industry. With the "c-tech" product line, the Felder Group offers a specially designed machine programme for processing plastics and composite materials.
FHF Anlagentechnik GmbH	Germany	Loher Busch 43 D-32545 Bad Oeynhausen Germany	www.fhf.global	info@horstmann-anlagentechnik.de				
FISCHER Cyclepor Deutschland GmbH	Germany	Am Waldeck 6 77855 Achern Germany	www.fischergruppe.eu	info@fischergruppe.eu			+49 7843 9943 0	
Fischer Recycling Lindau GmbH	Germany	Spitalmühlweg 16-18 88131 Lindau Germany	www.fischer-recycling.com	fischer_lindau@t-online.de			+49 8382 9332 0	
Fluid Solids AG	Switzerland	Hohlstrasse 408 8048 Zürich Switzerland	www.fluidsolids.com			info@fluidsolids.com	+41 4440 0550 0	
Foundation myclimate	Switzerland	Pfingstweidstrasse 10 8005 Zurich Switzerland	www.myclimate.org				+41 4450 0435 0	
Frank Strobel	Germany	Martin-Luther-King-Straße 10 58638 Iserlohn Germany	www.wertstoffballenpressen.de	frank.strobel@bramin.de				

Fraser and Neave Singapore Ltd	Singapore	438 Alexandra Rd, #20-00 Alexandra Point, 119958 Singapore	www.fraserandneave.com	ir@fraserandneave.com				
Friedel Kunststoffrecycling GmbH	Germany	Werkstraße 1+5, 89558 Böhmenkirch Germany	www.friedel-gmbh.de	info@friedel-gmbh.de				
Friedola Tech GmbH	Germany	Ershäuser Str. 4, 37308 Geismar Germany	www.con-pearl.de	info@con-pearl.de				
FWT Composites & Rolls GmbH	Austria	Werner von Siemens Straße 7 2620 Neunkirchen Austria	www.fwt.at	office@fwat			+43 2635 710 17 - 0	The product range includes the production of rollers, pipes, drive shafts and special components made of fibre composite, as well as roller coating (rubber and composites), contract work and rolling service. Application areas of the products: • Paper- and printing machines • Film producing machines • Production of non-woven materials • Marine application The manufacturing of the metal parts, the production of the CFRP pipes, the final assembly of the rollers and the rubber coating takes places at the company head-quarters in Neunkirchen. Currently the company has a production area of 8,000 m². The export rate is more than 90%, the goods are delivered within Europe, as well as to Asia and the USA.
Gabriel-Chemie GmbH	Austria	Industriestraße 1 2352 Gumpoldskirchen n Austria	www.gabriel-chemie.com		Mr Marko BESENLEHNER	m.besenlehner@gabriel-chemie.com	+43 2252 636 30 - 1425	Now in its 2nd generation as an owner- managed family business, Gabriel-Chemie is today, after almost 70 years, one of the leading masterbatch producers in Europe. A long-term and above all sustainable strategy is therefore of top priority for the company and is the guarantee for the innovation-driven and quality assurance level.

								For many years Gabriel-Chemie has placed a strong focus on sustainability. Responsibility and awareness of resource-saving processes pave the way for the group into the future. The upcoming generations in the family business also contribute to the pursuit of sustainability.
Gaintech Industries Pte Ltd	Singapore	No. 55 Serangoon North Ave 4, #03-06/07, S9 Singapore 555859	www.gaintech.com.sg	enquiry@gaintech.com.sg				
Gantzkow Rohstoff GmbH	Germany	Im Rollfeld 2 76532 Baden-Baden Germany	www.gantzkow-rohstoff.de	info@gantzkow-rohstoff.de			+49 7221 9963 913	
GAR Gesellschaft für Abfall und Recycling mbH & Co. KG	Germany	Carl-Zeiss-Str. 6 28816 Stuhr Germany	www.gar-gmbh.de	info@gar-gmbh.de			+49 4218 7716 0	
GASSNER RecTec Maschinenhandel	Germany	Schusterstrasse 15 85653 Aying OT Göggenhofen Germany	www.gassner-rectec.de	info@gassner-rectec.de				
Gebrüder Lödige Maschinenbau GmbH	Germany	Elsener Str. 7 - 9 33102 Paderborn Germany	www.loedige.de	info@loedige.de				
Gebrüder Stueve GmbH	Germany	Peutestrasse 43-45 20539 Hamburg Germany	www.maxipress.de	info@maxipress.de				
Gee Hoe Seng Pte Ltd	Singapore	53 Ubi Avenue 1, #01-38, Paya Ubi Industrial Park,	www.ghs.sg	sales@ghs.sg				

		Singapore 408934						
General-Industries Polymere GmbH	Germany	Heinrich-Hertz-Straße 99, 34123 Kassel Germany	www.gi-polymere.de	info@gi-polymere.de				
GFR - Gesellschaft für Recycling mbH	Germany	Siebenstücken 10 24558 Henstedt-Ulzburg Germany	www.gfr-recycling.de	info@gfr-recycling.de			+49 4193 8820 910	
Global Solutions GmbH	Germany	Schoßbachstraße 24, 07552 Gera Germany	www.repoly.de	sales@repoly.de				
GOR GmbH	Germany	Hauptstraße 35 67297 Marnheim Germany	www.gor-gmbh.de	info@gor-gmbh.de			+49 6352 7500 0	
GPN GmbH	Austria	Greinerstrasse 18 4542 Nussbach Austria	www.gpn.at	office@gpn.at			+43 / 505 41 - 45 0	GPN GMBH - Excellence in Manufacturing GPN stands for the Greiner Production Network with around 400 employees and locations in Austria and the Czech Republic. It's core competence is the precise mechanical production of tooling, machines and components for the extrusion of plastics on the basis of customer designs. More than 40 years of experience and one of the largest manufacturing capacities in the market make GPN unique in the industry.
Grannex Recycling-Technik GmbH & Co. KG	Germany	Dornierstraße 11, 49090 Osnabrück Germany	www.grannex.de	info@grannex.de				
Greenway Environmental Waste	Singapore	6 Tuas South Street 8 Singapore 637003	www.greenwayenv.com.sg	steven@greenwayenv.com.sg				

Management Pte Ltd								
Greiner Extrusion GmbH	Austria	Friedrich-Schiedel-Strasse 1 4542 Nussbach Austria	www.greinerextrusion.com	office.at@greinerextrusion.com			+43 505 41 - 410	Greiner Extrusion is the world's leading supplier of extrusion lines, tooling and turnkey plants for profile extrusion. The core competence is process expertise in profile extrusion: the development, design, production and process optimisation of tooling and extrusion lines. The service portfolio ranges from formulation development to extrusion lines, tooling and the engineering of complete production plants. Complete solutions for all the requirements of profile manufacturers are provided at thirteen locations. With one of the largest development centres in the entire industry, Greiner provides complete tailor-made solutions for a greater competitive advantage in profile extrusion.
Greiner Packaging International GmbH	Austria	Greinerstraße 70 4550 Kremsmünster Austria	www.greiner-gpi.com	office@greiner-gpi.com			+43 7583 72 51 - 0	As a division of the Greiner Group, Greiner Packaging International can look back on a long history dating back almost sixty years as one of Europe's leading manufacturers of plastic packaging in both the food and non- food sector. The company faces the challenges of the market with its two business units: Packaging and Assistec. The product range of the former comprises cups, as well as packaging solutions such as bottles, containers and buckets made from plastic and cardboard-plastic combinations. Assistec focuses on the production of customised plastic components and products, as well their assembling and individual refinement.
H&S Scheuten GmbH	Germany	Lindchenspfad 7a 52391 Vettweiß Germany	www.zerkleinerer.de	info@zerkleinerer.de				

Habold GmbH	Germany	Leimberg 24 52222 Stolberg Germany	www.habold.de	mail@habold.de			+49 2402 2901 9	
HAGEMANN RECYCLING GmbH	Germany	Stellwerksweg 5 38304 Wolfenbütte Germany	www.hagemann-recycling.de	info@hagemann-recycling.de			+49 5331 9009 00	
Hahn Kunststoffe GmbH	Germany	Gebäude 1027 55483 Hahn- Flughafen Germany	www.hahnkunststoffe.de	ns@hahnkunststoffe.de			+49 6543 9886 0	
HAIDLMAIR GmbH	Austria	Haidlmairstraße 1 4542 Nußbach Austria	www.haidlmair.com	office@haidlmair.at			+43 7587 60 01 - 0	For more than 35 years HAIDLMAIR has stood for high performance injection moulding tools. Thanks to the backing of the HAIDLMAIR GROUP corporate network both at home and abroad, large orders can be fulfilled very quickly. In recent years the company has specialised in making moulds for bottle crates (global market leader), containers for warehouse and logistics applications, pallets, pallet boxes and recycling containers. Injection moulds for the production of electrical and electronic components, irrigation systems, parts for the automobile industry etc. complete the range. HAIDLMAIR acts as the "one stop for higher productivity": from mould design, production and sampling to perfectly tailor-made, customer-specific automation solutions.
Hamos GmbH	Germany	Im Thal 17 82377 Penzberg Germany	www.hamos.com	info@hamos.com			+49 8856 9261 0	
Hans Trautwein SB Technik GmbH	Germany	Hagäckerstr. 20 D-73760 Ostfildern Germany	www.trautwein-sb.de	info@trautwein-sb.de				
Hansa-Kunststoff-Recycling	Germany	Blocksbarg 7, 25563 Wrist Germany	www.hansa-kunststoff.de	info@hansa-kunststoff.de				

HAROC Rohstoff GmbH	Germany	Brüderstr. 14 20355 Hamburg Germany	www.haroc.de	info@haroc.de			+49 4063 6078 30	
Haweku GmbH	Germany	Bovenplaatzen 2, 26909 Neulehe Germany	www.haweku.de	info@haweku.de				
HCG Environment Pte Ltd	Singapore	8 Tuas View Circuit Singapore 637777	www.hcgenviro.com	info@hcgenviro.com				
HeiTec Rohstoffe GmbH	Germany	Untere Hilsstraße 23b 31073 Grünenplan Germany	www.heitec-recycling.de	info@heitec-recycling.de			+49 5187 3005 28	
Herbold Meckesheim GmbH	Germany	Industriestraße 33 74909 Meckesheim Germany	www.herbold.com	herbold@herbold.com				
Herding GmbH Filtertechnik	Germany	August-Borsig- Str. 3 92224 Amberg Germany	www.herding.de	info@herding.de				
Herta Görgens GmbH Kunststoffrecycling	Germany	Im Rohnweiher 45, 53797 Lohmar Germany	www.hertagoergens.de	info@mkk-recycling.de				
Hirsch Maschinenbau GmbH	Austria	Glanegg 58 9555 Glanegg Austria	www.hirsch-technology.com	office.maschinenbau@hirsch-gruppe.com			+43 4277 22 11	HIRSCH Maschinenbau is the technology leader in the manufacturing of high-quality, flexible and cost-effective plants and machinery for the processing of EPS and EPP. HIRSCH Maschinenbau is one of the world's top suppliers of innovative mechanical engineering and mould construction technology for the production of shaped-moulded parts and insulation, that at the same time has also acquired the necessary expertise through its own in-house processing. This ensures that all the machines and systems are coordinated with each other for reliable processes.

Hitachi Zosen Innova	Switzerland	Hardturmstrasse 127 8005 Zurich Switzerland	www.hz-innova.com	info@hz-innova.com			+41 4427 7111 1	
Horsch GmbH & Co. KG	Germany	Weißwasserstr. 27 52068 Aachen Germany	www.horsch.de	service@horsch.de			+49 2419 5895 0	
HOS-Technik GmbH	Austria	Obersteigerweg 4 9431 St. Stefan Austria	www.hos-tec.com	hos@hos-technik.at			+43 / 4352 / 525 87	HOS-Technik GmbH is a chemical company operating in the international composite materials and rubber sector and proves that a small company can also offer high-priced niche products, such as mono- and bismaleimides, worldwide. The product portfolio ranges from maleimides and their derivatives to thermoset and thermoplastic resins, organometallic catalysts to microspheres based on polyurethane (PU) and polyacrylate (PA). Research and development as well as quality control are carried out in a well-equipped, modern laboratory. The company has many years of experience in the development of high-performance polymers, is ISO 9001: 2015 and ISO 14001: 2015 certified and also offers contract manufacturing.
HP-T Höglmeier	Germany	Ziegelweg 15, 91792 Ellingen Germany	www.hp-t.de	info@hp-t.de				

HTP High Tech Plastics GmbH	Austria	Eumigstraße 6 8753 Fohnsdorf Austria	www.htp.at		Mr Ronald PRETTNER	ronald.prettner@htp.at	+43 664 514 31 81	HTP is a manufacturer of functional and decorative plastic parts by injection moulding. Together with the customer, high-quality refined surfaces and assembled component groups are developed, optimised and brought to series production. The combination of technologies such as multi-component injection moulding and back injection moulding of films (IML, IMD) with coating (e.g. high-gloss painting) and joining processes is one of the strengths of HTP. Expertise in the injection moulding of high- performance thermoplastics and parts with fine, functional structures, such as loud- speaker grilles, complements the technology spectrum for a wide variety of applications.
htw formen und fertigungstechnik gmbh htw molds	Austria	Zementwerkstrasse 26 6713 Ludesch Austria	www.htw-werkzeugbau.com	sales@htw-werkzeugbau.com	Mr Kevin MATHIS		+43 699 181 006 71	htw molds is a constantly growing moulding company based in Ludesch, Austria. Design, development and construction represent an essential part of htw. The company offers a whole range of prefabricated cap designs as well as individual product designs. These are produced either under licence or through the use of specially manufactured moulds. The required tools for the production of plastic products are manufactured in the company's own plant. In answer to the customer's demands, mould sizes of up to 96 cavities are produced. htw mold's own toolstar hotrunner system or a customer preferred system can be implemented for the operation of these tools. A high process security is ensured, which is of great importance in the field of injection moulding.
Hubert Eing Kunststoffverwertung GmbH	Germany	Stadtlohner Straße 71 48712 Gescher Germany	www.eing-kunststoffverwertung.de	info@eing.info			+49 2542 9174 0	

Hündgen Entsorgungs GmbH & Co KG	Germany	Peterstraße 70 53913 Swisttal Germany	www.huendgen-entsorgung.de	info@huendgen-entsorgung.de			+49 2255 9430 0	
Hunkeler Systeme AG	Switzerland	Industriestrasse 2 4806 Wikon Switzerland	www.hunkeler-systems.com	info@hunkeler-systems.com			+41 6274 5777 7	
Husmann Umwelt-Technik GmbH	Germany	Gewerbegebiet Nord 2 26892 Dörpen Germany	www.husmann-umwelt-technik.de	info@Husmann.com				
I.C.E AG	Switzerland	Hubstrasse 64 P.O. Box 547 9501 Wil Switzerland	www.iceag.com	info@iceag.com			+41 7191 4802 0	
ifw mould tec GmbH	Austria	Pyhrnstraße 73 4563 Micheldorf Austria	www.ifw.at	office@ifw.at			+43 7582 625 56	ifw - the quality and technology leader - specialises in the development and construction of high-tech moulds for plastic pipe connectors. The range comprises injection moulds for plastic devices and fittings up to more than ø 1,200 mm in PVC, PP, PE, PVDF, PPSU, etc. for: • Wastewater Systems • Water supply • Exhaust systems • Gas supply • Customised mould specialties ifw offers the best service and provides production-ready moulds with the shortest set-up and production times. One special area of expertise of this Austrian company is the construction of large moulds (up to 60 t mould weight).
IKV - Innovative Kunststoff-veredelung GmbH	Germany	Grisutenstraße 13, 14727 Premnitz Germany	www.ikv-kunststoffe.de	info@pet-innovation.com				
Impetus Conceptus Pte Ltd	Singapore	19 Sungei Kadut Loop Singapore 729462	www.impetuscconceptus.com	enquiries@impetusconceptus.com				

INAST Abfallbeseitigungs GmbH	Germany	Luttenbachtalstraße 30 74821 Mosbach Germany	www.inast.de	info@inast.de			+49 6261 9244 0	
Indus GmbH	Germany	Gewerbepark Birkenhain 10, 63579 Freigericht Germany	www.indus- deutschland.de	info@indus- deutschland.de				
Inkurec Ilka Holsten e. K.	Germany	Anne-Frank-Weg 20, 28790 Schwanewede Germany	www.inkurec.d e	holsten.inkurec @t-online.de				
InnoPlastics SA	Switzerla nd	Hörnlistrasse 1 8360 Eschlikon TG Switzerland	www.innoplasti cs.ch	info@innoplasti cs.ch			+41 7197 3709 0	
Inoplast Kunststoff GmbH	Germany	Winterling- Porzellan-Straße 24, 92670 Windischeschen bach Germany	www.inoplast.d e	info@inoplast.d e				
INTEC Micro Powder AG	Germany	Kaiserin- Augusta-Allee 14 10553 Berlin Germany	www.intec- micro- powder.de	info@intec- micro- powder.com				
Interseroh Dienstleistun gs GmbH	Germany	Stollwerckstr. 9a, 51149 Köln Germany	www.interseroh .de	info@interseroh .com				
Jäckering Gruppe	Germany	Vorsterhauser Weg 46 59067 Hamm Germany	www.jaeckering .de	jaeckering@jae ckering.de			+49 2381 4220	

JOHANNES KEPLER UNIVERSITY LINZ JKU LINZ INSTITUTE OF TECHNOLOGY	Austria	Altenberger Strasse 69 4040 Linz Austria	www.jku.at/polymertechnology	polymertechnology@jku.at	Mr Reinhold W. LANG		+43 732 24 68 - 6610	Polymer Engineering & Science - the comprehensive study programme incorporating sustainable development and circular economy Polymeric materials include a wide variety of thermoplastics, thermosets, elastomers, composites and hybrid materials. Steady growth and innovation have contributed to the advancement of polymer technologies and polymer products are now an indispensable part of the economy and our everyday lives. With regard to future prospects, polymers can help us manage some of human civilization's greatest challenges as we try to supply a growing global population with energy, water and other goods and services while adhering to the principles of a 'circular and sustainable economy'. The JKU is one of only a handful of universities in the world to offer comprehensive academic degree programmes in polymer technologies and science.
JOMA Kunststofftechnik GmbH	Austria	Wolfholzgasse 14-16 2345 Brunn am Gebirge Austria	www.jomapackaging.com	customerservice@jomapackaging.com			+43 2236 336 33	JOMA develops and produces highly functional plastic primary packaging of the highest quality for the foodstuffs, pharmaceutical and chemical technology industries. The product range consists of an ever- increasing variety of perfectly coordinated products: the spice mills come in various designs with grinding geometry specifically designed for particular spices to bring out the best inherent aromas and so to ensure maximum customer satisfaction. The Securibox is an absolutely tight container system, available in 21 different sizes and can be perfectly combined with the cream dispenser and pill dispenser. A selected assortment of spice mills and also the Securibox are available in the environ- mentally

								conscious Joma Nature range – sustainable and CO2 efficient!
JÖST GmbH + Co. KG	Germany	Gewerbestr. 28 - 32 48249 Dülmen Germany	www.joest.com	info@joest.com				
JP Industrieanlagen GmbH	Germany	Schlesische Straße 249 94315 Straubing Deutschland	www.jp-industrieanlagen.de	anfrage@jp-industrieanlagen.de	Ms Melissa BRANDNER	melissa.jpmachinery@sgc.org.sg	+65 6433 5340	
JR Environmental Pte Ltd	Singapore	153 Bukit Batok Street 11 #02-292 Singapore 650153	www.jr.com.sg	jrecyclenet@gmail.com				
K INDUSTRIES GMBH	Austria	Krestastrasse 1 9433 St. Andrä Austria	www.k-industries.at	biach@k-industries.at	Mr Philipp KREUZER		+43 4358 38 11 - 0	K industries GmbH is a family business headquartered in Carinthia/Austria and specialising in industrial plant construction. Core areas of expertise are engineering, production, installation, insulation, tank and apparatus construction, pipeline construction, welding and steel construction, mechanical engineering and assembly manufacturing as well as environmental engineering. The production site is located in Sankt Andrä im Lavanttal in Carinthia. GloBra FZ-LLC and K industries GmbH developed a new system in the TDO of biaxial film stretching lines. This rope stretch technology (RST) replaces the massive chain-track system by using guided ropes to hold the film. The use of the RST substantially reduces investment, operation, and energy costs.
K K Asia (HK) Ltd.	Singapore	46, East Coast Road, #04-04, East Gate Singapore 428766	www.kkasiacorp.com	robinloh@kkasiacorp.com				
K.-H. Backmeyer GmbH & Co. KG	Germany	Königinhofstraße 97 34123 Kassel Germany	www.backmeyer.de	info@backmeyer.de			+49 5615 0714 0	

Kärntner Montanindustrie GmbH	Austria	Schloss 1 9400 Wolfsberg Austria	www.kmi.at	miox.technik@kmi.at			+43 4352 545 35 - 0	Kärntner Montanindustrie is one of the leading suppliers of lamellar iron oxide, Wollastonite, Muscovite, Phlogopite and Talc. These functional mineral products are used in the plastics, paint & coatings and the ceramic industries, as well as in foundry and building materials. MIOX®: lamellar iron oxide, micronised and sub-micronised, as a new functional product for plastics WOLLASTONITE: needle-shaped mineral product with a high aspect ratio, micronised and sub-micronised for reinforcing plastics MICA: Muscovite mica and Phlogopite mica with a high aspect ratio, micronised for the specific modification of plastic compounds TALC: lamellar micronised mineral product for specific modification of polymer compounds The company is EN ISO 9001 and 14001 certified.
Kastrup Recycling GmbH & Co KG	Germany	Gewerbegebiet 2 49152 Bad Essen / Wehrendorf Germany	www.kastrup-recycling.de	info@kastrup-recycling.de			+49 5472 9543 010	
KEBA AG	Austria	Gewerbepark Urfahr 4041 Linz Austria	www.keba.com	keba@keba.com			+43 732 70 90 - 0	Founded in 1968, KEBA AG is an internationally successful electronics company based in Linz/Austria with subsidiaries around the world. In line with its credo, "Automation by innovation", KEBA has been developing and producing inventive, top-quality automation solutions for 50 years for industrial, banking, services and energy automation branches. With over 30 years of branch experience in the plastics industry, KEBA offers the latest technologies for controlling injection moulding machines – from individualized and customer-specific solutions up to the ready-to-use turnkey KePlast i-series with a scalable hardware and modular software platform for any industry 4.0 requirements.
KINGYEAR Trade & Business	Germany	Thymianweg 8 04158 Leipzig Germany	www.kingyear.de	kingyeargmbh@hotmail.de			+49 3416 0037 66	

Consulting GmbH								
KL-Entsorgung GmbH	Germany	Carl-Leverkus-Str. 20, 40764 Langenfeld Germany	www.kl-entsorgung.de	info@kl-entsorgung.de				
Klever Kunststoff Recycling GmbH	Germany	Höhenweg 16, 47533 Kleve Germany	www.kkr-kunststoffe.de	info@kkr-kunststoffe.de				
Kohl Waste Trade GmbH	Germany	Am Flugplatz 26 49565 Bramsche Germany	www.kohl-wastetrade.de	info@kohl-wastetrade.de			+49 5461 9336 885	
Kolthoff GmbH	Germany	Industriestraße 1, 26849 Filsum Germany	www.kolthoff-kunststoffe.de	info@kolthoff-kunststoffe.de				

KomRec-ReCond GmbH	Germany	Hofer Str. 61, 95632 Wunsiedel Germany	www.komrec-recond.de	info@komrec-recond.de	Mr Olaf THANNHEISER	ot@komrec.com	+49 1754 1467 71	KomRec-ReCond GmbH - Our Strength is Diversity Beginning in year 2003 with two several companies, one as recycler for plastic - ReCond - and one as trader with AQSIQ - KomRec – decided the owner of ReCond and KomRec in the year 2015 to merge together. KomRec - ReCond is an industrial plastic scrap recycler and exporter with the Headquarters in South Germany and some stores in Europe. Our facilities consist of two large plastic recycling plants in Wunsiedel, Bavaria and utilize 22 plastic grinding lines, washing line for regrind and two high-compression balers. We mainly purchase rigid plastic scrap from waste collectors and from manufacturing plants in Europe with a quantity up to 3,200 tons in the month. We have experience in all marketable plastic materials like: buckets, bumpers, car parts, cd and dvd scrap, coextruded foils pe/pp, pe/pa, pp/pa from production on rolls, color concentrates (master batches), computer housings, floorsweeps, glas fleece, glas rovings, LCD plates, metalized and printed film on rolls, etc. We are already in active business relationships in many Asian countries and only know Singapore in the position of a trader. We would be glad to help promote the trade with secondary raw materials. Furthermore, we are interested to supply recycled recyclate to the producing industry in Singapore and foster relationships with other plastic recycling companies in Singapore.
KRAIBURG WALZENFERTIGUNG GMBH	Austria	Webersdorf 11 5132 Geretsberg Austria	www.kraiburg-walzen.at	info@kraiburg-walzen.at	Mr Ralf METZGER		+43 7748 72 41 – 0	KRAIBURG Walzenfertigung GmbH produces rollers, roller coatings, rolls and sleeves for all industrial sectors and all kinds of applications. KRAIBURG processes a multitude of caoutchouc types from its own rubber compound production, as well as polyurethane coatings in all hardness ranges. Due to its most advanced production lines and extensive caoutchouc know-how, KRAIBURG Walzenfertigung is able to deliver tailor-made solutions to meet even the most demanding customer requirements. The company's roller surface finishing programme

								ranges from normal grinding, polish grinding and superfinishing to crowning and grooving, depending on the customer's requirements. Perfection and precision are the driving forces behind the high standards set by KRAIBURG roller production!
Krall Kunststoff-Recycling GmbH	Germany	Glanzstoffstraße 21, 63820 Elsenfeld a. Main Germany	www.kunststoff-recycling.de	info@krall.de	Mr Wilhelm KRAFT	QM@krall.de	+49 6022 7099 18	Krall Kunststoff-Recycling GmbH is specialized in technical plastics materials, we sort and grind production waste from the industry for the compounders and producers. We are a long-standing partner of the plastics industry. Over five hundred production, trading, and processing companies in Europe trust in us. We constantly improve our process and combine years of experience with innovative technologies such as the analysis of plastics during the sorting process via spectral cameras or infrared devices.
Kreislaufwirtschaft Grübler GmbH & Co. KG	Germany	Gewerbepark 1 - 5 09488 Wiesa Germany	www.kw-gruebler.de	kwg@kw-gruebler.de			+49 3733 5030	
KRS Kunststoff Recycling & Service GmbH	Germany	Industriezentrum 9-11, 32139 Spenge Germany	www.krs-kunststoff.de	info@krs-kunststoff.de				
Kruschitz GmbH	Austria	Werner-Heisenberg-Straße 5 9100 Völkermarkt Austria	www.kruschitz-plastic.com	office@kruschitz-plastic.com	Mr Werner KRUSCHITZ		+43 4232 512 20	Since 1999 Kruschitz GmbH has been running the only PET-bottle recycling plant in Austria and is therefore one of the leading companies in PET recycling technology. The flakes are used in the plastics industry for fibres, sheets, bottles and so on. With its technical equipment Kruschitz is able to produce PET sheets for the food industry from 100% recycled post-consumer material. The company operates the first PET-BOTTLE to BOTTLE plant for food-approved reprocessed pellets. Furthermore, Kruschitz is a plastic recycling company for all kind of thermoplastic material like PP, PE, PS, ABS, PA and since 2008 has been converting various plastics

								and scraps to a high-quality grinding material in the new factory. Kruschitz processes reprocessed pellets, grinded material, off grades and prime material.
Kunststoff Recycling Bartl	Germany	Robert-Bosch-Straße 24 - 26, 74632 Neuenstein Germany	www.krb-neuenstein.com	info@krb-neuenstein.de				
Kunststoff- und Farben-GmbH	Germany	An der Flurscheide 7, 64584 Biebesheim Germany	www.kfg-biebesheim.eu	info@kfg-biebesheim.de				
Kunststoff Veredelung Gronau GmbH	Germany	Röntgenstraße 12 48599 Gronau Germany	www.kvgronau.de	info@kvgronau.de			+49 2562 8198 574	
Kunststoff-Börse Nord GmbH	Germany	Am Friesenpark 28a, 27751 Delmenhorst Germany	www.kbn-gmbh.de	info@kbn-gmbh.de				
Kunststoff-Cluster, Business Upper Austria - OÖ Wirtschaftsagentur GmbH	Austria	Hafenstraße 47 - 51 4020 Linz Austria	www.kunststoff-cluster.at	kunststoff-cluster@biz-up.at	Mr Wolfgang BOHMAYR		+43 732 798 10 - 5115	As a cross-industry network for the plastics sector, the Plastics Cluster (KC) promotes the cooperation between companies. The KC has nearly 400 companies, 54 % of which are SME: from raw and recycled materials to plastics processing, mechanical engineering, mould and tool making and R&D institutions. Topic areas: circular economy, material development with lightweight construction, 3D printing, manufacturing technologies, improvement and increase of production flexibility. The Smart Plastics Initiative provides a professional company network for the development and/or production of functional plastic components. The

								electronic functionalities are carried out using innovative coating and/or assembly technologies.
Kunststoffereignisse Occhipinti GmbH & Co. KG	Germany	Jüngerstr. 17, 58515 Lüdenscheid Germany	www.occhipinti.de	info@occhipinti.de				
Kunststoffrecycling CKT GmbH & Co. KG	Germany	Klausbergstraße 32, 99947 Bad Langensalza Germany	www.kurec- ckt.de	info@kurec- ckt.de				
Kunststoffrecycling mit System	Germany	Felix-Rütten-Str. 10, 53474 Bad Neuenahr Germany	www.kunststoff recycling-mit- system.de	furmanek- kunststoffrecycling@t-online.de				
Kunststoffverarbeitung Potsdam	Germany	Ketziner Str. 32D, 14476 Potsdam Germany	www.kv- potsdam.de	info@kv- potsdam.de				
Kunststoffwerk Bremen GmbH & Co. KG	Germany	Ferdinand- Porsche-Str. 18 28237 Bremen Germany	www.kunststoff werk- bremen.de	info@kwb- bremen.de				
KVB-Gardelegen	Germany	Ackendorfer Landstr. 13, 39638 Gardelegen Germany	www.kvb- gardelegen.de	kvb- gardelegen@t- online.de				
KVS Plastics GmbH	Germany	Niederwaldstr. 5, 79336 Herbolzheim Germany	www.kvs- plastics.de	info@kvs- plastics.de				
Laabs GmbH	Germany	Lüchtringer Weg 30-32, 37603 Holzminden Germany	www.laabs- kunststoffe.com	laabs@laabs- gmbh.de				
Landbell AG für Rückhol-Systeme	Germany	Rheinstraße 4 L 55116 Mainz Germany	www.landbell.de	info@landbell.de				

Langzauner GmbH	Austria	Lambrecht 52 4772 Lambrecht Austria	www.Langzauner.at	Office@Langzauner.at	Mr Thomas WITZMANN		+43 7765 231	Langzauner develops and produces presses for the composite industry. From the development and production of individual parts to their assembly, every manufacturing stage bears the Langzauner signature. This is the only way Langzauner can guarantee high quality and durability. The automotive, aerospace and sports industries have been relying on the quality, know-how and reliability of Langzauner for decades. From the 5-ton laboratory press to the 5000-ton press for fully automated batch production – Langzauner offers the perfect solution for the customer's process. Thermo-plastic composites are also processed on the company's presses. Fast transfer systems ensure processing within seconds.
Leistritz SEA Pte Ltd	Germany/ Singapore	25 International Business Park, #04-53/54 German Centre, 609916	extruders.leistritz.com		Mr Alf HOFSTETTER	ahofstetter@leistritz.com	+65 99618 2961	Extensive knowledge in the field of machine and process design, new technologies and a consistent quality-oriented policy are the key factors in the success of Leistritz. For more than 80 years Leistritz has been committed to plastics extrusion. Headquartered in Nuremberg/Germany, Leistritz designs and manufactures customized co-rotating twin screw extruders as well as turnkey extrusion and recycling lines for the plastics industry as well as for life science and pharma applications.
Lenzing Plastics GmbH & Co KG	Austria	Werkstraße 2 4860 Lenzing Austria	www.lenzing-plastics.com	plastics@lenzing-plastics.com	Ms Bettina KRALLINGER		+43 7672 330 00	Efficient, reliable, and innovative - Lenzing Plastics Lenzing Plastics is one of the world's leading manufacturers of polyolefin and fluoropolymer products. As a manufacturer of thermoplastic and PTFE products, the company is always looking for new challenges. The core competencies lie in the monoaxial stretching of films and filaments and in laminating different substrates.

								Lenzing Plastics is as versatile as the material they work with. The plastics experts offer special solutions in the fields of construction and insulation, medicine and hygiene, pack-aging, cable industry, automotive and technical textiles.
LH-Plastics GmbH	Germany	Crimmitschauer Straße 282, 08412 Werdau Germany	www.lh-plastics.de	info@lh-plastics.de				
Lian Gim (S) Trading	Singapore	172 Pandan Loop, 128366 Singapore	www.liangim.com					
Lindner-Recyclingtech GmbH	Austria	Villacher Strasse 48 9800 Spittal an der Drau Austria	www.lindner.com	office@lindner.com			+43 4762 2742 - 0	The Lindner family-run business has been offering innovative, tried-and-tested shredding solutions for decades. In addition to stationary and mobile shredders for waste processing, the portfolio also includes complete systems for plastics recycling, SRF and waste wood processing. Lindner's multi-stage processing facility for post-consumer plastic is in a class of its own. Perfectly matched components guarantee high output quality. Robust high-end shredding, washing and drying components ensure smooth 24/7 operation with low maintenance and consistently high throughput. The ideal input material for the subsequent processes is provided.
LITHOS Industrial Minerals GmbH	Austria	Wirtschaftspark ecoplus Straße 2/8 4482 Ennsdorf bei Enns Austria	www.lithos-minerals.at	office@lithos-minerals.at	Ms Anna-Maria RACHLINGER		+43 699 100395 42	LITHOS Industrial Minerals GmbH develops and produces innovative applications from natural minerals in the field of TALC, ZEOLITE and MASTERBATCHES for the plastic, paint, coating and paper industry. LITHOS has developed its own methods and processes, which release the specifically valuable elements in the minerals and prepare them for further processing. No matter whether these are special grinding processes, cost and time advantages in logistics, adaptive

								developments to attain a certain quality or special services – LITHOS transforms raw materials into valuable products and additives into innovations.
LKR Recyclate Lohner Kunststoffrecycling GmbH	Germany	Buchholzstraße 42-46 49377 Vechta Germany	www.recyclate.de	info@recyclate.de			+49 4441 9780 00	
LM Holding	Germany	Essener Str. 13 49716 Meppen Germany	www.ludden.de	info@ludden.de				
Loetec Elektronische Fertigungssysteme GmbH	Germany	Dresdener Straße 28 06886 Lutherstadt Wittenberg Germany	www.loetec.com	kontakt@loetec.com				
LÖMI GmbH	Germany	Baumschulweg 1 63762 Grossostheim Germany	www.loemi.com	sales@loemi.com				
Lubey AG	Germany	Marktplatz 18 06108 Halle (Saale) Germany	www.lubey.de	office@lubey.ag			+49 3459 7724 960	
Malz Polytec GmbH & Co. KG	Germany	Thüringer Strasse 4, 49356 Diepholz Germany	www.malz-polytec.de	info@malz-polytec.de				
Mao Feng Recycle Trading Pte Ltd	Singapore	Blk 6 Marsiling Industrial Estate Road 1 #01-06 Singapore 739275	www.maofengrecycle.com	sales@maofengrecycle.com				
MAPLAN GmbH	Austria	Maplan-Straße 1 2542 Kottlingbrunn Austria	www.maplan.at		Mr Paul-David BETEA	paul-david.betea@maplan.at	+43 2252 790 909 - 244	MAPLAN's rubber and silicone injection moulding machines are known throughout the world for their accuracy, performance, and efficiency. INNOVATIVE. MAPLAN's FIFO injection technology incurs minimum pressure loss with negligible residual rubber. The CoolDrive II servo-hydraulic technology saves up to 50 % of energy.

								COMPETENT. MAPLAN is the global leader in horizontal injection moulding machines (20-650 t clamping force) and offers a wide range of solutions for semi- and fully-automated production. CUSTOMER-ORIENTED. MAPLAN helps to increase OEE and the service lifetime of machines: • Machine refurbishment • Machine and process training • Preventive maintenance contracts
Marco Arand Innovaplast® Kunststoffe & Compounds	Germany	Flinsberger Strasse 4, 37308 Heilbad Heiligenstadt Germany	www.innovaplast-kunststoffe.de	info@innovaplast-kunststoffe.de				
Mercodor GmbH	Germany	Bonameser Str. 44 60433 Frankfurt am Main Germany	www.mercodor.de	info@mercodor.de				
Mertl Kunststoffe GmbH Comco EPP	Austria	Neualmerstrasse 33 5400 Hallein Austria	www.comco-epp.com	info@mertl-kunststoff.com			+43 6245 700 00	Mertl Kunststoffe / Comco EPP Engineering Plastic Products supplies finished parts according to drawings in quantities ranging from samples to entire production runs. Highly trained technicians operate CNC turning and milling machines for production, ensuring the highest level of quality. Comco EPP machine all types of engineering plastics on a regular basis. Comco EPP offers complete system solutions: insertion of ball-bearings into cable pulleys or the installation of threaded bushings. Finished parts made by Comco are especially suited to the fields of machine construction, conveyor plants, crane systems and packaging, as well as within facilities of the electric and textile industries.

Meusburger Group	Austria	Kesselstraße 42 6922 Wolfurt Austria	www.meusburger.com	office@meusburger.com			+43 5574 67 06 - 0	The Meusburger Group is the leading international manufacturer of high-quality products for die, mould, jigs and fixtures construction. Constant availability of all products makes the Meusburger Group a high-performing and reliable partner in the industry. The group of companies helps its customers achieve sustainable success along the entire value chain. The product portfolio ranges from high-precision standard parts and selected work-shop equipment to hot runner and control systems, the knowledge-oriented management method WBI and solutions for efficient corporate management in the ERP/PPS software area.
MGG Polymers GmbH	Austria	Wipark, 12. Straße 8 3331 Kematen/Ybbs Austria	www.mgg-polymers.com	office@mgg-polymers.com	Mr Wolfgang GANSER		+43 7476 774 88 - 0	MGG Polymers operates a highly automated plastics recycling plant that is unique in Europe, specialised in the recovery of different plastic types (PP, PS, ABS and PC/ABS) from the mixed WEEE plastic fraction. Manufacturers all over the world trust in the reliable raw materials for various applications, whether consumer goods or business applications. With the clean raw materials and the constant level of quality, the use of resource-intensive new plastics can be reduced and 80% of primary energy saved. The recycled plastic granules are used in the automotive industry, appliances, construction, office supplies, telecommunications and IT hardware.
Michael Girstenbrei Recycling GmbH	Germany	Petersruhstraße 10 89434 Blindheim Germany	www.girstenbrei-recycling.de	info@girstenbrei-recycling.de			+49 9074 2231	
Mirau Kunststoff-Recycling GmbH	Germany	Heuserweg 4, 53842 Troisdorf Germany	www.kunststoff-e-mirau.de	info@kunststoff-e-mirau.de				

MKV GmbH Kunststoffgru- nulate	Germany	Siemensstrasse 5, 65779 Kelkheim/Ts. Germany	www.mkv- kunststoff.com	kontakt@mkv- kunststoff.com				
MOCO Maschinen- und Apparatebau GmbH / Co. KG	Germany	Großer Stellweg 19 68519 Viernheim Germany	www.moco- shredder.de	info@moco- shredder.de				
Möller- Micheel GmbH	Germany	Sandkampstraße 219 48432 Rheine Germany	www.2m- entsorgung.de	2m- entsorgung@pr oximedia.de			+49 5971 64478	
Montanuniversität Leoben - Department Kunststoff- technik Department Polymer Engineering and Science	Austria	Otto Glöckel- Straße 2 8700 Leoben Austria	www.kunststoff technik.at	kunststofftechn ik@unileoben.a c.at			+43 3842 402 - 2701	For almost 50 years, the Department of Polymer Engineering in Leoben has been an internationally recognised centre for applied and basic research, a cooperation partner for industry and science, as well as a training centre for aspiring polymer engineers. From the development of innovative polymer and composite materials, to the evolution of new manufacturing technologies such as additive manufacturing and the optimisation of existing processes for the manufacture of components and components made of high-performance polymers, to a variety of testing and stress tests, the centre's portfolio covers all areas from the raw material to the finished product.
Motan Holding GmbH	Germany	Stromeyersdorfs tr. 12 78467 Constance Germany	www.motan- colortronic.com	info@motan- colortronic.com				
mtm plastics GmbH	Germany	Bahnhofstraße 106 99759 Niedergebra Germany	www.mtm- plastics.eu	info@mtm- plastics.eu			+49 3633 8325 0	
Müller + Weber GmbH	Germany	Am Wasserwerk 3+5,	www.m-w- kunststoffe.de	mueller_weber @t-online.de				

		58840 Plettenberg Germany						
MultiPet GmbH	Germany	Parkstraße 17, 06406 Bernburg Germany	www.mp- bbg.eu	info@mp- bbg.eu				
mx.flow GmbH	Austria	Pirath 12 4952 Weng im Innkreis Austria	www.mx- flow.com		Mr Martin HERMANDINGE R	m.hermandinge r@mx-flow.com	+43 7723 427 86 - 800	Fresh air is just as important for machines as for us humans. With mx.flow your filters are reliably cleaned and your machines can breathe again! mx.flow offers a machine that cleans dust- laden filters fully automatically. Costly procurement of new filters is no longer an issue. Your advantages: • Reduced costs for new filters • Employees and the environment are protected from dust • The conserving of resources by recycling the filters • Longer service life thanks to professional cleaning • Differential pressure measurement documents the condition of filters Manual cleaning is not necessary - this innovative machine provides you with an economic solution.
Naftex GmbH	Germany	Illexstraße 12, 26639 Wiesmoor Germany	www.naftex.de	info@naftex.de				
Nagel-Recycling	Germany	Benzstr. 11, 73660 Urbach Germany	www.nagel- recycling.de	nagel- recycling@t- online.de				
NBG Neustädter Baustoffhandels-gesellschaft mbH	Germany	Siebenhitzer Str. 8, 08223 Neustadt Germany	www.nbg- recycling.de	info@nbg- recycling.de				
Neidhardt Rohstoff GmbH	Germany	Alpenstr. 64, 87700 Memmingen Germany	www.neidhardt- rohstoff.de	info@neidhardt- rohstoff.de				

NEUE HERBOLD Maschinen- und Anlagenbau GmbH	Germany	Wiesenstr. 44 74889 Sinsheim Germany	www.neue-herbold.com	info@neue-herbold.de				
Next Generation Recyclingmaschinen GmbH	Austria	Gewerbepark 22 4101 Feldkirchen Austria	www.ngr-world.com	info@ngr-world.com			+43 7233 701 07 - 0	NGR develops, manufactures, and distributes intelligent and future-oriented plastic recycling technologies. These technologies enable “zero-waste” production in the plastic processing industry and turn waste into high-quality pellets. With its innovative PET recycling solution “Liquid State Polycondensation (LSP)” the PET-material which leaves the recycling process is of higher quality than the raw material and is 100% safe for food contact (= upcycling). As its most important task for the future NGR is enforcing the change to a circular economy. As technological leader in the plastics industry, NGR wants to further the goal of preserving plastics as a valuable raw material for future generations.
NEXUS Elastomer Systems GmbH	Austria	Solarstraße 10 4653 Eberstallzell Austria	www.nexus-elastomer.com	office@nexus-elast.com			+43 50 12 15 - 200	NEXUS is an international manufacturer of tools and dosing systems specializing in the elastomer sector (LSR, HCR, rubber). NEXUS designs and manufactures fully automatic injection moulding tools with needle closure technology and electrical balancer systems (TIMESHOT & FLOWSET & FLOWSET E with iPad). The patented dosing system SERVOMIX is based on the SPLITNEX technology, a unique conveyor technology with fully automatic venting.
Ng Wah Hong Enterprises Pte Ltd	Singapore	52 Defu Lane 9, Singapore 539292	www.nwh.com.sg	sales@nwh.com.sg				
Nico Kunststoffe GmbH	Germany	Gewerbegebiet Süd 17, 90587	www.nico-kunststoffe.de	kontakt@nico-kunststoffe.de				

		Obermichelbach Germany						
Noventiz Dual GmbH	Germany	Dürener Straße 350 50935 Köln Germany	www.noventiz.de	info@noventiz-dual.de				
NTUC Fairprice Co-operative Ltd	Singapore	1 Joo Koon Circle 13-01, FairPrice Hub, 629117 Singapore	www.fairprice.com.sg	fpb2b@fairprice.com.sg				
omnicycle GmbH & Co. KG	Germany	Lise-Meitner-Straße 27 a 48691 Vreden Germany	www.omnicycle.de	info@omnicycle.de			+49 2564 3955 05	
Opack (S) Pte Ltd	Singapore	No. 11 Kranji Crescent Singapore 728656	www.opack.com.sg	sales@opack.com.sg				

Orchard Hotel Singapore	Singapore		www.millenniumhotels.com		Mr NG Hoe Guan	marcom.ohs@millenniumhotels.com	+65 91996489	As a 5 star hotel with 656 rooms and multiple F&B outlets, we try to minimise waste and recycle whenever possible in our daily operations. For instance, we are committed to stop the usage of single use plastic. Hence, we no longer deliver laundry into guest rooms with any plastic cover. We have also switched over from plastic laundry bags to non-woven bags in all our guest rooms to minimise the use of plastic. For leftover toiletries like shampoo and conditioner in guest rooms, we re-purpose them for usage in staff toilets. Excess Soap are also collected by our contractors on a monthly basis for further processing and recycling. We have also reduced the amount of paper we utilise across our administrative departments and check in counters whenever possible by digitalising our processes which reduced the number of printed forms and invoices. In line with our recycling measure, our restaurants- Hua Ting Restaurant and The Orchard Cafe, uses biodegradable bags, containers and straws for customers who wish to take away their food and drinks. Cutlery are recyclable as well. Last but not least, our engineering department works with an appointed NEA waste vendor to collect any general waste that can be recycled including paper, cardboard, and metal tin cans on regular basis.
Otto-Rüdiger Schulze Holz- und Baustoffrecycling GmbH & Co. KG	Germany	Schleuener Weg 1, 16775 Löwenberger Land Germany	www.ors-recycling.de	info@ors-recycling.de				
P&M Plastics	Germany	Leitenstraße 65, 82538 Geretsried Germany	www.pmkplast.com	pmkplast@aol.com				

Pal Plast GmbH	Germany	Lämmerspieler Straße 8, 63165 Mühlheim am Main Germany	www.palplast.com	info@palplast.de				
Pallmann Maschinenfabrik GmbH & Co. KG	Germany	Wolfslochstraße 51 66482 Zweibrücken Germany	www.pallmann.eu	management@pallmann.eu				
PB Solutions GmbH	Germany	Talstraße 74, 75328 Schömburg Germany	www.pbs-worldwide.de	info@pbs-recycling.de				
pekutherm Kunststoffe GmbH	Germany	Chauvignystraße 19 65366 Geisenheim Germany	www.pekutherm.de	info@pekutherm.de			+49 6722 9377 030	
Petra Kithil Recycling-Systeme	Germany	Bahnhofstrasse 11 91126 Rednitzhembach Germany	www.kithil.de	kithil@kithil.de				
PFR Nord GmbH	Germany	Böternhöfen 13, 24594 Hohenwestedt Germany	www.pfr-nord.de	info@pfr-nord.de				
Piller SEA Pte Ltd	Germany/ Singapore	25 International Business Park, #03-56 German Centre, 609916	www.piller.de		Mr Dieter KNOBLICH	knoblich@piller.de	+65 8533 2086	Against the backdrop of rising energy prices, generating or recovering steam using a heat pump is an attractive option. The basic principle of the PILLER Industrial Heat Pump is to recover waste heat and provide it at a usable temperature level. The advantages: high primary energy savings, CO2 reduction and overall improved economic efficiency of the system. Here, PILLER benefits from the know-how gained over the years in mechanical vapor recompression and enables the high-performance blowers to be used as

								kind of industrial heat pump. These industrial heat pumps allow the use of the excess heat: To generate usable steam, PILLER works with existing fluids – vapor from the process or water
Plaspulp Union Company	Singapore	20 Tuas South Street 1 Singapore 637465	www.plaspulpunion.com	info@plaspulpunion.com				
POLIFILM EXTRUSION GmbH	Germany	Köthener Straße 11 06369 Südliches Anhalt Germany	www.polifilm.de	info-pfe@polifilm.de			+49 3497 8270	
Poly Recycling	Switzerland	Industrie Ost 8865 Bilten Switzerland	www.polyrecycling.com	plastic@polyrecycling.com			+41 5561 9340 0	
Polymer Competence Center Leoben GmbH	Austria	Roseggerstraße 12 8700 Leoben Austria	www.pccl.at	office@pccl.at			+43 3842 429 62 - 0	Polymer Competence Center Leoben GmbH (PCCL) is the leading Austrian centre for cooperative research in the field of plastics technology and polymer sciences. Together with companies from the plastics industry and universities (including the Montana University Leoben), the almost 100 highly qualified employees work on R&D projects for innovative plastic solutions in a wide range of applications (from automotive, aviation and packaging to solar and photovoltaic applications). This is complemented by the K-project "Polymer Composites for Thermally Demanding Applications (PolyTherm)" in the field of polymer-based composites for applications in electrical engineering and electronics.

Praher Plastics Austria GmbH	Austria	Poneggenstraße 5 4311 Schwertberg Austria	www.praher- plastics.com	office@praherpl- astics.com			+43 7262 61178 - 0	Praher Plastics Austria GmbH is a specialist in processing technical plastics and offers a comprehensive range of valves, fittings and pipes for industrial piping systems, especially in the water treatment industry. The company also looks back on many years of know-how in the realisation of customised functional plastic parts and assemblies in serial production. Standard range: • 2-way-, 3-way ball valves, butterfly valves, lug type version, manual, electric or pneumatic • Sampling/laboratory ball valves • Check valves, cone check valves • Aerating valves • 6-way valves • In PVC, PP and PVDF Praher Plastics Austria GmbH is a global acting, family-owned company with nearly 50 years of experience in processing plastics.
PreZero Dual GmbH	Germany	Stiftsbergstr. 1 74172 Neckarsulm Germany	www.prezerodu- al.com	info@prezerodu- al.com				
ProCycle Separations GmbH	Germany	Alte Heerstraße 6 38644 Goslar Germany	www.procycle- gmbh.de	info@procycle- gmbh.de			+49 5321 3899 041	
ProTec Polymer Processing GmbH Sales Center Germany	Germany	Stubenwald- Allee 9 64625 Bensheim Germany	www.sp- protec.com	info@sp- protec.com				

PureLoop GesmbH	Austria	Unterfeldstraße 3 4052 Ansfelden Austria	www.pureloop.at	office@pureloop.at			+43 732 301 316 - 0	PURE LOOP, a subsidiary of EREMA Group GmbH, stands for the highly efficient recycling of clean production waste using shredder-extruder technology. The company headquarters are in Ansfelden / Linz. Optimal adaptation to the existing scrap logistics as well as the largest possible return of recycled pellets to the production cycle characterise the recycling solutions from PURE LOOP. Additionally, customers benefit from the experience, the technological know-how and the innovative power of the entire EREMA Group. Product: High-performance shredder-extruder combination ISEC evo for the production of recycled plastic pellets with best quality characteristics.
PURPLAN GmbH	Germany	Penter Str. 28 49134 Wallenhorst Germany	www.purplan.com	info@purplan.de				
Purus Plastics GmbH	Germany	Am Blätterrangen 4, 95659 Arzberg Germany	www.purus-plastics.de	info@purus-plastics.de				
R.PLAST Kunststoffaufbereitungs- und Handels-GmbH	Germany	Rückertstraße 28, 97421 Schweinfurt Germany	www.rplast.de	info@rplast.de				
Rako Edelstahl Service GbR	Germany	Siemensring 114 47877 Willich Germany	www.rako-edelstahl.de	rabatsch@rako-edelstahl.de				
RCS Entsorgung GmbH	Germany	Capeller Straße 147 59368 Werne Germany	www.rcs-entsorgung.de	info@rcs-entsorgung.de			+49 2389 9826 0	
RDA RECYCLING MACHINERY GMBH	Germany	Gutenbergstraße 22 28816 Stuhr/Bremen Germany	www.rda-rema.de	info@rda-rema.de				

RDB plastics GmbH	Germany	Nortorfer Straße 2 24613 Aukrug Germany	www.rdb-plastics.com	info@rdb-plastics.com			+49 4873 2034 0	
RDG Kunststoffe GmbH	Germany	Mühlenstraße 10, 87647 Kraftisried im Allgäu Germany	www.rdg-kunststoffe.com	info@rdg-kunststoffe.com				
RE Plano GmbH	Germany	Brunnenstraße 138, 44536 Lünen Germany	www.replano.com	info@replano.com				
Reclay Systems GmbH	Germany	Im Zollhafen 2-4 50678 Köln Germany	www.reclay-group.com	t.pangaribuan@reclay.de				
Reconcept Peters GmbH & Co. KG	Germany	Borner Str. 28 42897 Remscheid Germany	www.reconcept-peters.de	info@reconcept-peters.de			+49 2191 6968 00	
Recotex Recycling GmbH	Germany	Schildarpstraße 12 48712 Gescher Germany	www.recotex.de	info@recotex.de			+49 2542 9334 0	
Reifenhäuser GmbH & Co. KG Maschinenfabrik	Germany	Spicher Straße 46 53844 Troisdorf Germany	www.reifenhauser.com	info@reifenhauser.com	Mr Daniel LAMERS	daniel.lamers@reifenhauser.com	+49 1719 3871 95	The German Reifenhäuser Group is the leading provider of innovative technologies and components for plastics extrusion. The majority of our machines is being used to produce single-use plastic applications. For us as a family-run company, sustainability and circular economy are important components of our corporate strategy. Therefore, we have developed machines that can incorporate recyclate and produce fully recyclable plastic packagings. To ensure that a fully recyclable packaging will indeed be recycled we have developed a tracking and tracing system for packagings.
Reiling Glas Recycling GmbH & Co. KG, Osterweddingen	Germany	Appendorfer Weg 4 39171 Sülzetal-Osterweddingen Germany	www.reiling.de	osterweddingen@reiling.de			+49 3920 5450 910	

Reinbold Entsorgungstechnik GmbH	Germany	Robert-Mayer-Straße 5 74360 Ilsfeld (Germany) Germany	www.reinbold-entsorgungstechnik.com	info@reinbold.de				
Relux Kunststofftechnik GmbH & Co. KG	Germany	Sülzborn 4 39128 Magdeburg Germany	www.relux-umwelt.de	info@relux-umwelt.de			+49 5731 4800 61	
Remondis Recycling GmbH & Co. KG	Germany	Ostufersstraße 21, 45356 Essen Germany	www.remondis-recycling.de	info-recycling@remondis.de				
RENO Kunststoffprodukte GmbH	Germany	Interpark 3, 76877 Offenbach/Queich Germany	www.reno-plastic.de	info@reno-plastic.de				
Re-Plast GmbH	Germany	Am Hameckerbach 1, 58566 Kierspe Germany	www.re-plast-gmbh.de	alexander.justus@re-plast-gmbh.de				
RE-PLAST-Kunststoff GmbH	Germany	Warendorfer Straße 48, 59302 Oelde Germany	www.im-export.de	info@re-plast-kunststoff.de				
RetoPlast GmbH	Germany	Röher Straße 81-87, 52249 Eschweiler Germany	www.retoplast.de	office@retoplast.de				

RETRALOG® GmbH	Germany	Julius-Leber-Weg 9 21684 Stade Germany	www.retralog.com	echtstark@retralog.com			+49 4141 7889 20	
RetroTec Kunststoff und Recycling GmbH	Germany	Alter Postweg 28, 32469 Petershagen Germany	www.retrotec-gmbh.de	info@retrotec-gmbh.de				
RICO Elastomere Projecting GmbH	Austria	Am Thalbach 8 4600 Thalheim bei Wels Austria	www.rico.at	office@rico.at			+43 7242 764 60	RICO is a solution provider in the fields of development, tool making, prototypes, zero series, automation and serial production for components/product lines made from LSR, HTV and multi-component material combinations, for example hard/soft compounds (e.g. thermoplastic with LSR), LSR with LSR or coating of inserts. As one of the technological leaders in tool making for LSR and 2K products, RICO offers the possibility of acquiring the technology for the tools, as well as the efficient production of components/product lines. RICO is certified to comply with ISO 14001:2004, ISO 9001:2008, IATF16949.
Rim Polymers Singapore	Singapore	209 Henderson Road #03-08 Henderson Industrial Park Singapore 159551	www.rimpolymers.com	rim_polymers@cehgroup.com				
Rissland Kunststoffe GmbH	Germany	Bahnhofstraße 100, 98746 Katzhütte Germany	www.rissland-kunststoffe.de	rissland@rissland-kunststoffe.de				
RKB Handelskontor GmbH	Germany	Bismarckstr. 29 28203 Bremen Germany	www.rkb-handelskontor.de	info@rkb-handelskontor.de			+49 4217 0190 0	
Robert Bosch (SEA) Pte Ltd	Germany/ Singapore	11, Bishan Street 21 Singapore, 573943	www.bosch.com.sg		Mr Steffen HESSEL	steffen.hessel@sg.bosch.com	+65 9630 0264	Bosch research team in Singapore is investigating a cost effective, autonomous sorting system, which is backed by AI technologies. The system can extract and recover recyclable materials including glass, metal, plastics (PE, PP, PCV, PS, PET, and black

								plastics) from a conveyor belt carrying a continuous stream of municipal waste material. The solution helps to address the growing plastic pollution in the ocean and thereby making the society sustainable in living.
Rohstoffverwertung und Container-Service GmbH	Germany	Capeller Str. 147, 59368 Werne Germany	www.rcs-entsorgung.de	info@rcs-entsorgung.de				
Rolbatch GmbH	Germany	Angermünderstrasse 101 16227 Eberswalde (bei Berlin) Germany	www.rolbatch.de	info.de@rolbatch.com				
Romplast PE-Regenerat GmbH	Germany	Philipp-Reis-Str. 25, 63477 Maintal Germany	www.romplast.de	info@romplast.de				
RSG Plastic Recycling GmbH	Germany	Gutenbergstr. 33, 72555 Metzingen Germany	www.rsg-recycling.de	info@rsg-recycling.de				
RSH Polymere	Germany	Großmooring 16, 21079 Hamburg Germany	www.rsh-polymere.de	info@rshpolymere.de			+49 4076 7393 0	
Rüsing Kunststoffe GmbH	Germany	Industriestraße Möhnetal 2, 59602 Rülthen Germany	www.ruesing-kunststoffe.de	mail@ruesing-kunststoffe.de				
RW-Plast Kunststoffverarbeitung	Germany	Am Teichrasen 10, 07381 Pößneck Germany	www.rw-plast.de	info@rw-plast.de				
Rytec AG	Switzerland	Alte Bahnhofstr. 5 3110 Münsingen Switzerland	www.rytec.ch	mail@rytec.ch			+41 3172 4333 3	
S & B Kunststoffrecycling GmbH	Germany	Industriestr. 9/1, 72585 Riederich Germany	www.sundb-kunststoffrecycling.de	info@sundb-kunststoffrecycling.de				

S + D Polymer GmbH	Germany	Blankenhainer Str. 25, 99441 Magdala Germany	www.sud-kunststoffgranulate.de	info@sud-kunststoffgranulate.de				
S.D.F. GmbH	Germany	Hansator 5a, 28217 Bremen Germany	www.sdf-environment.de	info@sdf-environment.de				
S+D Kunststoffrecycling GmbH	Germany	Im Grund 5 21435 Stelle Germany	www.s-d-kunststoffrecycling.de	info@s-d-kunststoffrecycling.de			+49 4174 6694 0	
Saneo Plastic GmbH	Germany	Industriestrasse 40, 47652 Weeze Germany	www.saneo-plastic.de	info@saneo-plastic.de				
saperatec GmbH	Germany	Ernst-Graebe-Straße 10 33611 Bielefeld Germany	www.saperatec.de	info@saperatec.de			+49 5219 8623 50	
Sauer Kunststoffe GmbH	Germany	Schleifweg 7, 90562 Heroldsberg Germany	www.sauer-kunststoffe.de	info@sauer-kunststoffe.de				
SBI Produktion techn. Anlagen GmbH & Co KG	Austria	Kaplanstraße 12 2020 Hollabrunn Austria	www.sbi.at	office@sbi.at			+43 2952 341 39-0	SBI is an Austrian firm and high-tech leader in gauging systems for film and sheet extrusion, metal welding and additive manufacturing for metals. In the area of plastics extrusion, SBI specialises in developing, building, and distributing high-quality inline thickness gauges and thickness control for film and sheet extrusion. SBI also offers customised components of automation systems for extrusion-dies and extruder control. SBI's latest development is the detection of the thickness profile of barrier-layer such as EVOH in PP sheet through the help of an additional measuring process. SBI can look back on many years of proven applications in products (thermoforming sheet from PP, PS; PET), ski-layers, refrigerator inner liners, sheets for automotive industry etc.

Schatz Umwelt GmbH	Germany	Hohlstedter Weg 1, 06528 Brücken Germany	www.schatz- umwelt.de	info@schatz- umwelt.de				
Schenck Process Holding GmbH	Germany	Pallaswiesenstr. 100 64293 Darmstadt Germany	www.schenckpr ocess.com	info@schenckpr ocess.com				
ScheZe GmbH	Germany	Kißlingweg 62 75417 Mühlacker Germany	www.scheze.de	info@scheze.de				
Schmaus Kunststoffaufbereitung	Germany	Am Galgenfeld 1, 86554 Pöttmes Germany	www.schmaus- kunststoffaufbe reitung.de	info@schmaus- kunststoffaufbe reitung.de				
Schwarz Produktion GmbH & Co. KG	Germany	Gewerbegebiet Plauen- Neuensalz Nord, Zum Plom 35, 08541 Neuensalz Germany	www.schwarz- produktion.com	info@meg- gruppe.com				
Senoplast Klepsch & Co. GmbH	Austria	Wilhelm- Klepsch-Straße 1 5721 Piesendorf Austria	www.senoplast. com		Ms Claudia PICHLER	pichler_c@seno plast.com	+43 6549 74 44 - 10250	Senoplast, established in 1956, extrudes plastic sheets and films for thermoforming and has developed into a technological leader in the field of coextrusion of multi-layer composite sheets. From its headquarters in Austria (Piesendorf), the company supplies customers worldwide with senosan® products for a wide range of applications. The senosan® brand not only stands for the excellent quality of its sheets and films but also above all for environmentally-friendly and virtually waste- free production methods. senosan® plastic sheets and films are in use in many different industries e.g. automobile, commercial vehicle and caravan manufacturers and are used in furniture fronts, bath- room fittings, refrigerators and suitcases.
Sesotec GmbH	Germany	Regener Str. 130 94513 Schönberg Germany	www.sesotec.c om	info@sesotec.c om				

SID SA	Switzerland	Zone Industrielle 2123 Saint-Sulpice Switzerland	www.sidsa.ch	info@sidsa.ch			+41 3286 2650 0	
Sielaff GmbH & Co. KG	Germany	Münchener Straße 20 91567 Herrieden Germany	www.sielaff.de	info@sielaff.de				
SIGMATEK GmbH & Co KG	Austria	Sigmathekstrasse 1 5112 Lamprechtshaus en Austria	www.sigmathek- automation.co m	office@sigmate k.at			+43 6274 43 21 - 0	SIGMATEK has over 30 years of experience in the automation of plastics machinery, from extrusion and blow moulding technology to injection moulding. Machine builders will find tailor-made control systems, operator panels, drive- and safety-solutions as well as an all-in-one software. SIGMATEK's comprehensive know-how in the industry also includes downstream machines, handling tasks, finishing processes and peripheral devices. Series machine builders appreciate the high-performance and modular complete automation systems in combination with long-term availability of the components used. Comprehensive on-site support from experienced application engineers with in-depth industry expertise shortens time-to-market.
Sikoplast Maschinenbau Heinrich Koch GmbH	Germany	Aulgasse 176 53721 Siegburg Germany	www.sikoplast. de	info@sikoplast. de				
Silver Dragon Resources Singapore Pte Ltd	Singapore	21 Woodlands Close #04-34, Primz Bizhub Singapore 737854	www.sdrsg.com	enquiries@sdrs g.com				

Sky Plastic Recycling and Commerce GmbH	Austria	Industriezone Ost 5 9111 Haimburg Austria	www.skyplastic.com	info@skyplastic.com			+43 4232 39 30	Sky Plastic Recycling and Commerce GmbH is one of the leading recycling compounders of post-consumer waste and post-industrial scraps in Europe. Years of experience in the market and the continuous technological development enable the prompt processing and implementation of individual customer demands. The core business consists in the processing of PP, PP with fillers, PS, HDPE and LDPE in all variants. The concept of environmental sustainability and the therefore necessary certifications stand in the foreground, as well as the project 'Il Po d'AMare', sponsored by the Foundation for Sustainable Development, the Corepla and Castalia consortia with the collaboration of Skymax, the Italian sister company of Sky Plastic.
SML Maschinengesellschaft mbH	Austria	Gewerbepark Ost 32 4846 Redlham Austria	www.sml.at	sml@sml.at			+43 7673 909 99 - 0	SML, located in Upper Austria's Salzkammergut region, manufactures high-end extrusion lines for the production of film, sheet, coating and laminating as well as for multifilaments. SML develops both pre-fabricated and custom-made extrusion solutions which are exactly tailored to meet the customer's needs – both in terms of quality and overall performance. SML's global leadership in extrusion technology is based on customer orientation, strong R&D and several decades of experience. Machinery designed and constructed by SML is in operation in more than 100 different countries – a substantial part of their customers are major companies in the global plastics, packaging, and technical textile industries.
SM-Polymer	Germany	Am Fliegerhorst 31, 99947 Bad Langensalza Germany	www.sm-metalle.de	info@sm-metalle.de				

SMS Sondermaschinen GmbH	Germany	Werkstraße 1 89290 Buch Germany	www.sms-sondermaschinen-buch.de	sms_info@t-online.de				
Sobernheimer Rohstoff-Kontor GmbH	Germany	Industriepark Pferdsfeld, Gebäude 234, 55566 Bad Sobernheim Germany	www.srk-rohstoffe.de	info@srk-rohstoffe.de	Mr Moritz KRÖNIG	m.kroenig@srk-rohstoffe.de	+49 1776 5562 96	We recycle plastics since 1998 with focus on production scrap. We have two shredding - grinding lines and one agglomeration line. In addition, we have a winnowing line to separate light and heavy material. We currently recycle about 13.000 tons of plastic scrap. We are expanding in the field of post-consumer or post-commercial plastics starting with a demetallizing line which will be completed by a dry-cleaning line. We also recycle plastics as a contract work for other companies.
SOLA-Messwerkzeuge GmbH	Austria	Lastenstraße 41 6840 Götzis Austria	www.sola-kunststoffe.com	info@sola-kunststoffe.com			+43 5523 533 80 - 936	SOLA-Kunststoffe, a division of SOLA-Messwerkzeuge GmbH (SOLA Measuring Tools), has been producing injection-moulded parts of highest precision at its location in Götzis, Austria for more than 60 years. The company has more than 40 injection moulding machines, which are mainly used for processing technical plastics, such as polyamides, polyacetal or acrylic glass. SOLA has special expertise in processing PMMA, in multi-component injection moulding and in the post-processing and finishing of plastic components. These include machining as well as laser and ultra-sonic welding. To ensure a smooth workflow, SOLA undertakes the procurement and maintenance of tools.
SPM Refinery Pte Ltd	Singapore	15 Tuas South Street 3 Singapore 638020	www.spmrefinery.com.sg	enquiry@spmrefinery.com.sg				
SRE GmbH	Germany	Mönchenbusch 15 52382 Niederzier Germany	www.sre-recycling.de	info@sre-recycling.de			+49 2428 9099 712	
STADLER Anlagenbau GmbH	Germany	Max-Planck-Str. 21 88361 Altshausen Germany	www.w-stadler.de	info@w-stadler.de				

Starlinger & Co. Gesellschaft m.b.H.	Austria	Sonnenuhrgasse 4 1060 Wien Austria	www.starlinger.com	sales@starlinger.com			+43 1 599 55 - 0	Starlinger is world market leader in the field of machinery and process technology for woven plastic bags – from tape extrusion lines and circular looms to lines for coating, printing, and sack conversion. On these lines, customers worldwide produce innovative packaging such as AD*STAR®, PP*STAR®, or (recycled) PET tape fabric. The portfolio of the recycling technology and viscotec divisions comprises machinery solutions for the recycling and refinement of a wide range of plastics (e.g. PE, PP and PET). Starlinger viscotec supplies lines for the production of food-grade PET sheet made of up to 100 % recycled PET. Sales and service centres in Brazil, China, India, Indonesia, Mexico, Russia, South Africa, Thailand, the USA and Uzbekistan, as well as numerous local agents, ensure quick customer service.
Starlinger recycling technology	Austria	Furtherstrasse 47 2564 Weissenbach Austria	www.recycling.starlinger.com	recycling@starlinger.com			+43 2674 808 31 01	For more than 30 years, Starlinger recycling technology has been providing machinery solutions for the recycling and refinement of a wide scope of plastics such as PE, PP, PA, PS, BOPP and PET. The recoSTAR lines produce high-quality pellets from scrap that accrues during the production of film, sheet, fibres, non-woven, raffia, tapes, bottles or preforms as well as from post-consumer plastics. Starlinger PET recycling systems supply food-safe rPET and are approved for use in food applications by many brand owners as well as various national and international authorities. The company's worldwide sales and service network supports customers in achieving optimum results in the manufacturing process.

Starlinger viscotec	Austria	Adsdorf 38 4113 St. Martin im Mühlkreis Austria	www.viscotec.at	viscotec.sales@starlinger.com			+43 7232 38 17 - 0	Starlinger viscotec offers technology for the decontamination of PET, PP and HDPE flakes as well as for the viscosity increase of PET flakes and pellets. viscotec stands for excellent cleaning efficiency and uncompromising food grade quality; the process exceeds the highest food grade standards such as FDA and EFSA. At viscotec, sustainability is more than just a buzzword: viscoSHEET PET sheet lines produce food grade PET sheet from up to 100% recycled PET. Starlinger viscotec is a business unit of Austrian Starlinger & Co. GmbH, world market leader in the field of machinery and process technology for woven plastic bags.
STEINERT GmbH	Germany	Widdersdorfer Str. 329-331 50933 Köln Germany	www.steinert.de	sales@steinert.de				
STF Recycling GmbH	Germany	Industriestr. 1, 94529 Aicha v. Wald Germany	www.stf-group.de	info@stf-group.de				
StM Stein-Moser GmbH	Austria	Gewerbegebiet Gasthof Süd 178 5531 Eben im Pongau Austria	www.stm.at	info@stm.at			+43 6458 200 14	Passion for Performance Passion for Waterjet cutting StM is a leading provider of waterjet cutting systems located in Eben (Austria) and Schweinfurt (Germany). For over 25 years the company has been enthusiastically developing sustainable production solutions, primarily for the steel, aluminium, metal, plastic, retained composite, stone and glass industries. StM stands for quality systems that have been developed as a modular system, unusually high customer orientation and an incomparable passion for the technology of waterjet cutting.

STÖFFL RUDOLF GMBH	Austria	Gewerbeparkstraße 8 4615 Holzhausen Austria	www.stoeffl.at	stoeffl@stoeffl.at	Mr Rudolf STÖFFL		+43 7243 500 20 - 12	Since it was founded in 1989, the Austrian company Rudolf Stöffl GmbH has constantly grown. To begin with Stöffl GmbH concentrated on the distribution and development of an extensive range of rubber to metal bonded products. As a result of its ever-increasing market presence and the extremely positive customer acceptance, the standard product range was systematically extended by the following further product groups: Rubber moulded parts in all qualities such as profiles in the form of PVC edge protection, sealing profiles, microcellular rubber plastic parts such as moulded stoppers or closure elements, standard parts such as handles, cable grommets as well as machine mounts and special components for conveyor systems. Special productions according to individual customer drawings complete the range.
Strautmann Umwelttechnik GmbH	Germany	Auf dem Haarkamp 22 49219 Glandorf Germany	www.strautmann-umwelt.de	info@straumann-umwelt.de				
SUNPOR Kunststoff GmbH	Austria	Tiroler Straße 14 3105 St. Pölten Austria	www.sunpor.at	office@sunpor.at			+43 2742 291 - 0	At two locations in St. Pölten, SUNPOR Kunststoff GmbH produces around 230,000 tonnes of EPS granules (expandable polystyrene) per year in keeping with the Responsible Care standard. The grey high-tech EPS Lambdapor® with improved insulation performance plays an important role in this. 90% of the production is exported. The main customers are the international construction industry (building insulation) as well as the packaging and helmet industry. The company is fully owned by the Norwegian O.N. Sunde A/S.

susGain Pte Ltd	Singapore	1 Coleman Street, #01-06 Singapore, 179803	www.susgain.com		Ms Carolin BARR	carolin@susgain.com	+65 9125 1401	SusGain is a free mobile app that incentivises people in Singapore to adopt more sustainable lifestyle choices. Users collect points for eco-friendly habits (eg. recycling, donations, BYO, volunteering...), earn cash back rewards at eco conscious businesses and automatically support initiatives for sustainable development with each spend. Our purpose is to drive the change towards a more sustainable Singapore by connecting Consumers, Businesses and Communities in Singapore in a way that creates mutual value. We believe that to drive real change and make an impact it requires a large number of players across all domains to come together and work on it collectively.
Sutco RecyclingTechnik GmbH	Germany	Britanniahütte 14 51469 Bergisch Gladbach Germany	www.sutco.de	info@sutco.de				
Switzerland Global Enterprise	Switzerland	Stampfenbachstrasse 85 8006 Zurich Switzerland	www.s-ge.com		Ms Angela DI ROSA Mr David AVERY	adirosa@s-ge.com davery@s-ge.com	+41 4436 5547 3 +41 7940 9387 8	Switzerland Global Enterprise (S-GE) is the first point of contact in Switzerland for all questions relating to internationalization and helps to strengthen Switzerland as an economic hub. Part of S-GE is the Cleantech Cube: a platform used as a directory for Swiss Cleantech companies and for foreign companies and authorities to find suppliers or business partners from Switzerland.
SYNCO Polymer Recycling GmbH	Germany	Königsfelder Straße 21, 49824 Ringe Germany	www.synco.de	info@synco.de				
Sysplast GmbH & Co. KG	Germany	Beuthener Str. 43, 90471 Nürnberg Germany	www.sysplast.eu	info@sysplast.eu				
Systalen	Germany	Frankfurter Strasse 720-726, 51145 Cologne/Porz-Eil Germany	www.systalen.de	info@systalen.de				

Systec Plastics Eisfeld GmbH	Germany	Am Eichgraben 10 Gewerbegebiet Süd 98673 Eisfeld Germany	www.gruener-punkt.de	info-eisfeld@gruener-punkt.de				
Taraph Technologies	Singapore	32 Carpenter Street Singapore 059911	www.taraph technologies.com	msliew@taraph technologies.com				
Technische Universität Wien – CURRATEC	Austria	Getreidemarkt 9/163/MC 1060 Wien Austria	www.curratec.com	office@curratec.com	Mr Christoph SCHÖLL		+43 1 588 01 – 163 725	"CURRATEC" stands for an efficient and innovative technology for the curing of epoxy resins, that has been developed at TU Wien: Frontal Polymerisation. The curing is initiated "on demand" by using a localised light or temperature stimulus and propagates through the workpiece without any additional energy input. Conventional energy-, time- and cost-intensive curing in large industrial ovens and autoclaves can therefore be avoided by the user. The ready-to-use one-component formulations show excellent storage stability and can also be employed for the fabrication of compo- site materials. Even curing underwater is now possible with this revolutionary technology.
Tee Infrastructure Pte Ltd	Singapore	25 Bukit Batok Street 22 Singapore 659591	www.teeinfra.com	environmental@teeinfra.com				
Tenne-Plastics GmbH	Germany	Schlesische Straße 3, 64521 Groß-Gerau Germany	www.tenne-plastics.de	info@tenne-plastics.de				
Texplast GmbH	Germany	Andresenstraße 5, 06766 Bitterfeld-Wolfen Germany	www.texplast.de	info@texplast.de				

TEXPLAST GmbH	Germany	Andresenstraße 5 06766 Bitterfeld-Wolfen Germany	www.texplast.de	info@texplast.de			+49 3494 6517 0	
The Cool Tool GmbH	Austria	Fabrikgasse 15 2340 Mödling Austria	www.thecooltool.com	info@thecooltool.com	Ms Heidemarie HEINDL		+43 2236 892 666	For more than 30 years the Austrian company The Cool Tool® has been specialised in the development, production, and distribution of innovative machines for prototyping, design, and training. The multifunctional UNIMAT 1 system is unique. This modular machine system enables the construction of a wide range of different machines, which have the same features as large industrial machines, the only difference being the small size (that of a DIN A4 sheet). Various machines can be assembled within seconds – from woodturning, milling, turning, sanding-/drilling machines to CNC machines. The simple usage and the minimal space requirement makes UNIMAT a system which should not be missing in any lab or prototype workshop. In addition, it is an ideal starting tool for CNC training.
The Global Serve Pte Ltd	Singapore	20 Bukit Batok Crescent, #09-07 Enterprise Centre Singapore 658080	www.theglobalserve.com	info@theglobalserve.com				
The SeaCleaners Suisse	Switzerland	Chemin des Novalles 9 1807 Blonay Switzerland	www.theseacleaners.org/ch		Mr M. Milan DESPOTOVIC	m.despotovic@theseacleaners.org	+41 7941 6421 1	

Theysohn Extrusionstechnik GmbH	Austria	Josef-Sandhofer-Straße 4 2000 Stockerau Austria	www.theysohn.com	office@theysohn.at			+43 2266 905 05 - 2201	The Theysohn XTS extruders are outstanding because of their further enhanced performance and improved energy efficiency. Four machine sizes with twin-screw diameters of 88 - 138 mm and lengths of 26 - 36D are suitable for PVC profile and pipe manufacturing. Theysohn developed special manufacturing processes to insert chromium-steel liners in all types of twin-screw barrels. The result is a higher resistance to abrasion and chemical corrosion. T5000 lined barrels have a longer service life because the useable layer is 4 times thicker than on a standard nitrided barrel. The liners are replaceable and reasonably priced. This solution is an economical wear protection for production with recycling or highly filled material.
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thyssenkrupp Industrial Solutions AG	Singapore /Germany	3 International Business Park, #06-01 Nordic European Centre Singapore 609927	www.thyssenkrupp-industrial-solutions.com		Mr Tobias SAUMWEBER	tobias.saumweber@thyssenkrupp.com	+41 81 632 6844	thyssenkrupp Industrial Solutions AG is a leading partner for the engineering, construction and service of industrial plants and systems. Based on more than 200 years of experience we supply tailored, turnkey plants and components for customers in the chemical, fertilizer, cement, mining, and steel industries. Around 11,500 employees worldwide form a global network with a technology portfolio that guarantees productivity and cost-efficiency to the highest extent possible. The Chemical & Process Technologies business unit combines decades of experience in the engineering, procurement, construction and service of chemical plants. Our product range includes leading technologies in the fields of fertilizers, electrolysis, polymers, base chemicals, high-pressure solutions, coke plants and refining as well as innovative storage solutions for the growing renewables sector. Based on a unique combination of engineering experience, project management expertise and leading, resource-friendly processes, we develop customized solutions that enable chemical manufacturers around the world to enhance their efficiency and competitiveness. Our operating unit for polymers, Uhde-Inventa-Fischer (UIF), has developed the flakes-to-resin FTR® process for chemical recycling which has been integrated into several PET polycondensation plants worldwide. The chemical recycling process allows all kind of food applications for the virgin like PET product. In cooperation with LOOP-industries UIF is developing the chemical PET recycling process waste-to-resin WtR® without the requirement for cleaning and sorting of the recycle PET flakes.
Tide Ocean SA	Switzerland	Maiengasse 30 4056 Basel Switzerland	www.tide.earth	hello@tide.earth			+41 3232 8303 0	
TL Import-Export Handelsgesellschaft mbH	Germany	Röntgenstr. 11-13 60388 Frankfurt	www.tl-import-export.de	info@tl-import-export.de			+49 6109 3098 80	

		am Main Germany						
Transfercenter für Kunststofftechnik GmbH	Austria	Franz-Fritsch-Straße 11 4600 Wels Austria	www.tckt.at	office@tckt.at			+43 7242 20 88 - 1000	The TCKT is the first address for application-oriented research and development in plastics engineering and technology. The company offers excellent know-how in the field of material- and compound development, material characterisation as well as polymer processing. One focus is on the processing of composites. The main task of the TCKT is also technology transfer, especially for SMEs in the above-mentioned areas. Since 2004 the TCKT has been an accredited lab for mechanical, thermal and rheologic material testing. The TCKT is an associated company of the Upper Austrian Research GmbH (www.uar.at)
Treibacher Industrie AG	Austria	Auer-von-Welsbach-Straße 1 9330 Althofen Austria	www.treibacher.com		Mr Erich RACK	erich.rack@treibacher.com	+43 664 605 056 06	Treibacher Industrie AG is a global manufacturer of chemical and metallurgical products for a range of industrial applications. With its headquarters and production facilities in Althofen (AT), subsidiaries in Germany and Austria, as well as office locations in Toronto (CAN), Shanghai (CN) and Tokyo (JP), Treibacher has a worldwide distribution network which also serves the global market needs of the plastics industry. Heat stabilisers based on rare earths are produced for the long-term stabilisation of polymers such as silicone rubber, polyamide and polyester and are tailor-made for customers in the automotive, electrical and electronics industries.
TÜV SÜD PSB Pte Ltd	Germany/ Singapore	1 Science Park Drive, Singapore 118221	www.tuvsud.com/en-sg		Ms Dr Natalia DUQUE CICERI	natalia.duqueceri@tuv-sued.de	+49 8936 1965 329	TÜV SÜD is a trusted partner of choice for safety, security and sustainability solutions. With global expertise and experience, TÜV SÜD can support you in making technical-informed decisions in choosing more sustainable materials through our services: • Raw material (plastics) recycled content verification • Packaging biodegradability certification

								• Full array of chemicals and quality testing services for plastic recyclates to phase-out substances of environmental concern and to have confidence in the quality of the product.
Tyre Recycling Solutions SA	Switzerland	Zone Industrielle (Z.I.), Le Trési 9A 1028 Préverenges Switzerland	www.trs-ch.com					
Umwelttechnologie-Cluster Bayern e. V.	Germany	Am Mittleren Moos 48 86167 Augsburg Germany	www.umweltcluster.net		Ms Laura JANTZ-KLINKNER	laura.jantz@umweltcluster.net	+49 8214 5579 824	Umweltcluster Bayern is a network of >220 companies, research institutions and public bodies in the field of environmental technologies. One of our key competencies is the prevention, substitution (through bio-based materials) and circular economy (e.g. through digital business models) of plastics and plastic waste. Our aim is to link the relevant stakeholders through projects, workshops and B2B meetings on regional, national and international level.
unoTech GmbH	Germany	Feldkoppel 17 49779 Niederlangen Germany	www.unotech.de	info@unotech.de				
UNTHA shredding technology GmbH	Austria	Kellau 141 5431 Kuchl Austria	www.untha.com	info@untha.com			+43 6244 70 16 - 0	UNTHA shredding technology develops and produces customised and reliable shredding systems. Applications covered range from the recovery of recyclable materials to the preparation of waste in order to produce alternative fuels. UNTHA plastic shredders were developed specifically for the processing of these components. They effortlessly process all kinds of plastics, ranging from foils, lumps, profiles, fibres, ribbons, PET bottles and hollow parts to post-consumer and production waste. Thanks to a range of different cutting systems, rotor diameters and shapes as well as different blade sizes, the shredders are suitable for thermoplastics, duroplastics and elastomers and may be tailored to suit the customers' individual requirements.
UPR Plastik-Recycling-	Germany	Am Willers Berg 232,	www.upr-kunststoffe.de	info@upr-kunststoffe.de				

Gesellschaft mbH		98663 Ummerstadt Germany						
Uralan Kunststoffverarbeitung GmbH	Germany	Hermann-Staudinger-Straße 1, 72525 Münsingen Germany	www.uralan.de	internet@uralan.de				
V1 Recycle Pte Ltd	Singapore	No. 15 Defu Lane 8, Singapore 539318	www.v1recycle.com	v1@v1recycle.com				
V8 Environmental Pte Ltd	Singapore	20 Jalan Samulun Singapore 629130	www.v8.com.sg	sales@v8.com.sg				
VDMA e. V. (Association)	Germany	Lyoner Str. 18 60528 Frankfurt Germany	www.vdma.org	info@vdma.org				
Vecoplan AG	Germany	Vor der Bitz 10 56470 Bad Marienberg Germany	www.vecoplan.de	welcome@vecoplan.de				
VEKA Umwelttechnik GmbH	Germany	Im Straßfeld 1, 99820 Hörselberg-Hainich, OT Behringen Germany	www.veka-ut.de	info@veka-ut.de				
Veolia ES Singapore Pte Ltd	Singapore	6 Joo Koon Road Singapore 628970	www.veolia.com.sg	customer.service@veolia-es.sg				
Veolia Umweltservice Dual GmbH	Germany	Hammerbrookstraße 69 20097 Hamburg Germany	www.veolia.de/dual	de-ves-info-dual@veolia.com				
VGS Vermarktungsgesellschaft für Sekundärrohstoffe	Germany	Burghof 3 51491 Overath Germany	www.vgsmarkt.de	gf@vgsmarkt.de			+49 2206 9530 0	

toffe mbH & Co. KG								
Villiger Entsorgungssysteme AG	Switzerland	Bahnhofstrasse 13 5647 Oberrüti Switzerland	www.villiger.com	info@villiger.com			+41 4178 4232 3	
voestalpine BÖHLER Edelstahl GmbH & Co KG	Austria	Mariazellerstrasse 25 8605 Kapfenberg Austria	www.voestalpine.com/bohler-edelstahl	info@bohler-edelstahl.at	Mr Manfred NOCKER		+43 3862 203 62 60	BÖHLER high performance mould steel for the injection of fibre-reinforced plastics Fibre-reinforced plastics tend to be much more abrasive than conventional plastics and thus may cause premature wear of an injection mould. In order to counteract excessive and early wear in moulds, voestalpine Böhler Edelstahl offers a wide variety of high-quality tooling steels that are setting new standards in the production of heavy-duty components made from reinforced plastics.
Vogt-Plastic GmbH	Germany	Bukheinstraße 4 79618 Rheinfelden Germany	www.vogt-plastic.de	info@vogt-plastic.de				
Volker Bülow & Partner GmbH	Germany	Pampower Straße 3 19075 Holthusen Germany	www.buelowundpartner.de	info@buelowundpartner.de			+49 3865 7804 0	
Wah & Hua Pte Ltd	Singapore	11 Kranji Crescent Singapore 728656	www.wahhua.com	info@wahhua.com				
Wandaa GmbH	Germany	Am alten Kraftwerk 1, 71672 Marbach am Neckar Germany	www.wandaa.com	info@wandaa.com				
Wee Tee Tong Chemicals Pte Ltd	Singapore	No. 18, Sungei Kadut Street 3 Singapore 729149	www.weeteetong.com	info@weeteetong.com				

WEIMA Maschinenbau GmbH	Germany	Bustadt 6-10 74360 Ilsfeld Germany	www.weima.com	info@weima.com				
WELA-Plast GmbH	Germany	Westerriede 11, 49424 Goldenstedt Germany	www.wela-plast.de	info@wela-plast.de				
Wertstoffaufbereitung GmbH Edersleben	Germany	Der Hutdeckel 06528 Edersleben Germany	www.wertstoffaufbereitung-gmbh.de	WAE@wertstoffaufbereitung-gmbh.de			+49 3464 6712 13	
Weser Kunststofftechnik GmbH & Co. KG	Germany	Braunschweiger Str. 82, 37671 Hörter Germany	www.weser-kunststofftechnik.de	info@weser-kunststofftechnik.de				
WEWATEC GmbH	Germany	Industriestr. 6 92442 Wackersdorf Germany	www.wewatec.de	info@wewatec.de			+49 9431 7480 0	
Wilken Plastics Energy GmbH & Co. KG	Germany	Hasenstraße 9 49733 Haren Germany	www.wilken-gruppe.de	info@wilken-gruppe.de			+49 5935 7055 50	
Wipag Süd GmbH & Co. KG	Germany	Nördliche Grünauer Str. 31, 86633 Neuburg Germany	www.wipag.com	info@wipag.de				
WIS Kunststoffe GmbH	Germany	Lange Sömme 25, 98597 Breitungen Germany	www.wiskunststoffe.de	info@wiskunststoffe.de				

Wittmann Battenfeld GmbH	Austria	Wiener Neustädter Straße 81 2542 Kottingbrunn Austria	www.wittmann-group.com	info@wittmann-group.com			+43 2252 404 - 0	WITTMANN BATTENFELD offers its customers worldwide a broad product range encompassing the PowerSeries with EcoPower for all-electric machines, MicroPower for micro-injection moulding, MacroPower for large machines and the servo-hydraulic SmartPower, as well as vertical machines, including the new VPower which is also a machine of the PowerSeries. All machines can be supplied with integrated WITTMANN robots and peripheral equipment. Data exchange and visualisation can be realised via WITTMANN 4.0. Additional strengths lie in the fields of automation technology and special techniques such as the gas injection process AIRMOULD®, COMBIMOULD, PIM, LIM, IML, the VARIOMOULD® variotherm process or the CELLMOULD® structural foam process.
WITTMANN Kunststoffgeräte GmbH	Austria	Lichtblaustraße 10 1060 Wien Austria	www.wittmann-group.com	info.at@wittmann-group.com			+43 1 250 39 - 0	WITTMANN can provide processors of plastics with complete solutions which cover all of their requirements: robots and automation, automatic material supply and drying, including plastic recycling, temperature controllers and chillers for machine tools and volumetric and gravimetric blenders. In 2008, WITTMANN took over the BATTENFELD GmbH in Kottingbrunn (Lower Austria). This merger led to the seamless expansion of the respective product lines – to the advantage of the plastics industry, where there is a demand for a smooth integration of processing machines, automation and auxiliary equipment. The worldwide presence of the WITTMANN Group guarantees a perfect service everywhere.
WMK Plastics GmbH	Germany	Lüneschloßstr. 42, 42657 Solingen Germany	www.wmk-plastics.lehmannundvoss.de	info@wmk-plastics.de				

Wohlfahrt GmbH	Germany	Hauptstraße 18 b 21465 Wentorf Germany	www.wohlfahrt-gmbh.de	info@wohlfahrt-gmbh.de			+49 4072 1050 50	
Yin-Shan Engineering Private Limited	Singapore	Blk 1004 Toa Payoh North #02-05/07 Singapore 318995	www.yinshan.com.sg	info@yinshan.com.sg				
Zell-Metall GmbH Engineering Plastics (Klepsch Group member)	Austria	Schulstrasse 16 5710 Kaprun Austria	www.ZELLAMID.com	zell-metall@zmk.at	Mr Hans WINTERLEITNER		+43 6547 84 17	Zell-Metall Engineering Plastics has been producing extruded ZELLAMID® rods, plates and tubular bars in PA 6, PA 6.6, POM, PET, PEI, PEEK and cast polyamide since 1955. New products, also with nanotechnology, are created through permanent optimisation and further development. Zell-Metall Engineering Plastics is expanding worldwide (member of the Klepsch Group, with more than 57,000 tons of semi-finished plastic products/annum). ZELLAMID® products are substitutes for conventional materials such as metals, non-ferrous metals, glass and wood. Finished parts made of ZELLAMID® have excellent mechanical (high degree of impact resistance, abrasion resistance, self-lubricating, dimensional stability, long lifecycle), electrical (isolating, anti-static and conductive), chemical and tribological properties.
ZENO - Zerkleinerungsmaschinenbau Norken GmbH	Germany	ZENO-Platz 1 57629 Norken Germany	www.zeno.de	info@zeno.de				
Zentek GmbH & Co. KG	Germany	Ettore-Bugatti-Straße 6-14 51149 Köln Germany	www.zentek.de	dualessystem@zentek.de				
ZINK Kunststoffe	Germany	Scheppacher Mühle 2, 89343 Jettingen-	www.zink-kunststoffe.de	info@zink-kunststoffe.de				

		Scheppach Germany						
ZME Elektronik Recycling GmbH	Germany	Industriepark Nord, Auf dem Langen Furt 17, 35452 Heuchelheim Germany	www.zme- recycling.de	<a href="mailto:info@zme-
recycling.de">info@zme- recycling.de				
z- werkzeugbau -gmbh z- moulds®	Austria	Dr.-Walter- Zumbobel-Straße 9 6850 Dornbirn Austria	<a href="http://www.z-
moulds.com">www.z- moulds.com	<a href="mailto:sales@z-
moulds.com">sales@z- moulds.com	Mr Michael FINK		+43 5572 72 72	z-moulds® is the market leader in mould performance and stands for high cavity injection moulds especially for closure production systems. With the patented z-slides® technology z-moulds® offers the highest return per investment compared to conventional injection and compression moulds. This technology enables the most efficient production of lightweight caps. z-slides® technology is a compact, fully modular system, that above all operates with less energy and guarantees a longer product life cycle. z-moulds® also offers multiple solutions for multi-component injection moulds (plastic parts with varying materials or colours).
ZWS Recycling GmbH	Germany	Donaustauer Str. 199, 93055 Regensburg Germany	<a href="http://www.zws-
recycling.de">www.zws- recycling.de	<a href="mailto:zfeher@zws-
recycling.de">zfeher@zws- recycling.de				

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DPG, www.dpg-pfandsystem.de

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Environmental Protection Act, EPA
(www.admin.ch/opc/en/classified-compilation/19830267/index.html)

European Association of Plastics Recycling
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List of Abbreviations

A

ADF = advance disposal fees
ARF = advance recycling fees
ASEAN = Association of Southeast Asian Nations

B

BYO = Bring Your Own

C

CET = Continuing Education and Training
CPA = Carbon Pricing Act
CRC = Central Refuse Chute
CTWL = Closing the Waste Loop

D

DPWCS = district-level pneumatic waste conveyance system
DRS = Deposit Refund Scheme
DU = dwelling unit

E

EEE = electrical and electronic waste
EMAS = Environmental Management Association of Singapore
EPR = Extended Producer Responsibility
ES = Environmental Services
EWTCOI = Environmental & Water Technology Centre of Innovation

F

G

GHG = Greenhouse Gas

H

HDB = Housing Development Board

I

IBA = incineration bottom ash
ICT = Information and Communication Technology
INCUBATE = Innovating curating better automation and technologies for environmental services
ISO = International Organisation for Standardisation
ITM = Industry Transformation Map
IWMF = Integrated Waste Management Facility

J

K

KSTP = Keppel Seghers Tuas Waste-to-energy Plant

L

LEAD = Local Enterprise and Association Development
LEDS = Long-term low-emissions development strategy

M

MBT = mechanical and biological treatment
 MoU = Memorandum of Understanding
 MSE = Ministry of Sustainability and the Environment
 MSRF = Multi-story recycling facility

N

NDC = Nationally Determined Contribution
 NEA = National Environmental Agency
 NEWRI = Nanyang Environment and Water Research Institute
 NTU = Nanyang Technological University

O**P**

PCD = Pollution Control Department
 PET 1 = Polyethylene terephthalate
 PET 2 = Pre-Employment Training
 PRS = Producer Responsibility Scheme
 PSTLES = Public Sector Taking the Lead in the Environmental Sustainability
 PUB = Public Utilities Board
 PWC = Public Waste Collector
 PWCS = pneumatic waste conveyance system

Q**R**

RSA = Resource Sustainability Act
 RVM = reverse vending machines

S

SCARCE = Singapore-CEA Alliance for Research in Circular Economy
 SEC = Singapore Environment Council
 SIWW = Singapore Water Week
 SMC = Sustainable Manufacturing Centre
 SPA = Singapore Packaging Agreement
 SRF = solid recovered fuel
 SSTECH = Sino-Singapore Tianjin Eco-city
 SRP = Sarimbun Recycling Park
 SSG = SkillsFuture Singapore

T**U**

UNEP = UN Environment Programme

V**W**

WMRAS = Waste Management and Recycling Association of Singapore
 WSG = Workforce Singapore
 WSQ = Singapore Workforce Skills Qualifications
 WTE = Waste-to-energy
 WTERF = Waste-to-energy Research Facility

X**Y****Z**

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