



| Turning Trash into Treasure

Chemical Recycling References

TECHNOLOGY PARTNERSHIP WITH PLASTIC ENERGY



Challenge

Establish a circular economy for plastic scrap by implementing patented chemical recycling technology



Solution

Plastic Energy developed a patented chemical recycling technology using a thermal anaerobic-conversion (TAC) process

- Thermal decomposition in an inert atmosphere
- Output is feedstock for new plastics, even suitable for food packaging
- Trusted partnership and joint application development for DCS, instrumentation and Analytics solution while securing Intellectual property



Benefits

Supporting Plastic Energy's worldwide technology rollout

- One supplier for the entire control and instrumentation solution
- Reliable modular solution that can be replicated globally
- Global frame contract



PYRUM INNOVATIONS

Intelligent automation to support a revolutionary recycling process



Challenge

Resolving the problem of the enormous amounts of waste generated by scrap tires and reuse the valuable raw materials



Solution

With Pyrum Innovations, important primary materials can be extracted from the scrap tires, which in turn can be reused in industry

- Reduction of the need for conventionally mined fossil raw materials
- Great potential for the decarbonization of industry
- Pyrum Innovations' plant is energy self-sufficient and CO₂-neutral



Benefits

- Supporting with the Siemens automation portfolio, from the state-of-the-art Simatic PCS Neo process control system to our intelligent measuring instruments
- Contribution to establish a new type of raw material that can be used as a substitute for fossil fuels



SCANDINAVIAN ENVIRO SYSTEMS

Digitalization technology to maintain circular resources



Challenge

Recover valuable materials as carbon black, steel, oil from scrap tires to achieve environmental and economic sustainability.



Solution

Scandinavian Enviro Systems developed a patented pyrolysis process gaining ISCC-certified materials from end-of-life tires

- Driving the resource transformation that is costly, but indispensable
- Retrieve materials that were originally produced from crude oil and gas
- Process control implementation using Siemens' advanced digitalization, automation, electrification, and information technology



Benefits

- Seamless integration of tools into Enviro's platform to efficiently roll-out multiple plants simultaneously
- Using AI capabilities for continuous improvements
- Holistic information integration to reliably control and optimize new processes to turn scrap tires into treasure



ADURO CLEAN TECHNOLOGIES

Technology cooperation for recycling pilot plant and scale-up



Challenge

Develop, validate and scale up innovative chemical recycling technology for plastic waste towards industrial readiness



Solution

Aduro Clean Technology has developed a patented hydrochemolytic™ Technology to transform plastic waste into valuable materials

- Modular, flexible technology to handle various feedstock compositions
- Limited pre- and post treatment required
- Output is feedstock for new plastics, even suitable for food packaging
- Pilot plant being commissioned with Siemens process automation, instrumentation and digitalization technology



Benefits

Supporting Aduro in scaling up their process technology

- One supplier for the entire control and instrumentation solution for the pilot plant
- Simatic PCS Neo web-based DCS platform as core of the solution
- Siemens process consulting expertise engagement for further process scale-up



<https://investors.adurocleantech.com/press-releases/press-releases-details/2025/Aduro-Engages-Siemens-to-Deliver-Advanced-Automation-for-Hydrochemolytic-Pilot-Plant/default.aspx>

EUREX OIL

Scalable and modularized solutions for waste plastic conversion



Challenge

Design highly efficient and continuous chemical recycling units for industry & municipalities to treat waste plastic decentrally.



Solution

Process unit that is best-in-class in case of environmentally friendliness and efficiency

- Elimination of residues and heavy hydrocarbons
- Continuous process to turn post-industrial waste plastics into fuel to generate electricity
- highly automated plant for almost autonomous operation



Benefits

- Digitalization and automation solution including guaranteed long service life and long-term support
- Several tools for process data management and analysis determine correlations and dependencies easily.
- Comprehensive analytic capabilities provide information e.g. to optimize operation procedures and to streamline energy consumption.



UNIVERSITY OF LEOBEN (PILOT PLANT)

Industrial Edge and AI in Recycling



Challenge

Classification of plastic flow according to plastic types on a conveyor belt; Sensor technology in the form of bridge superstructures.



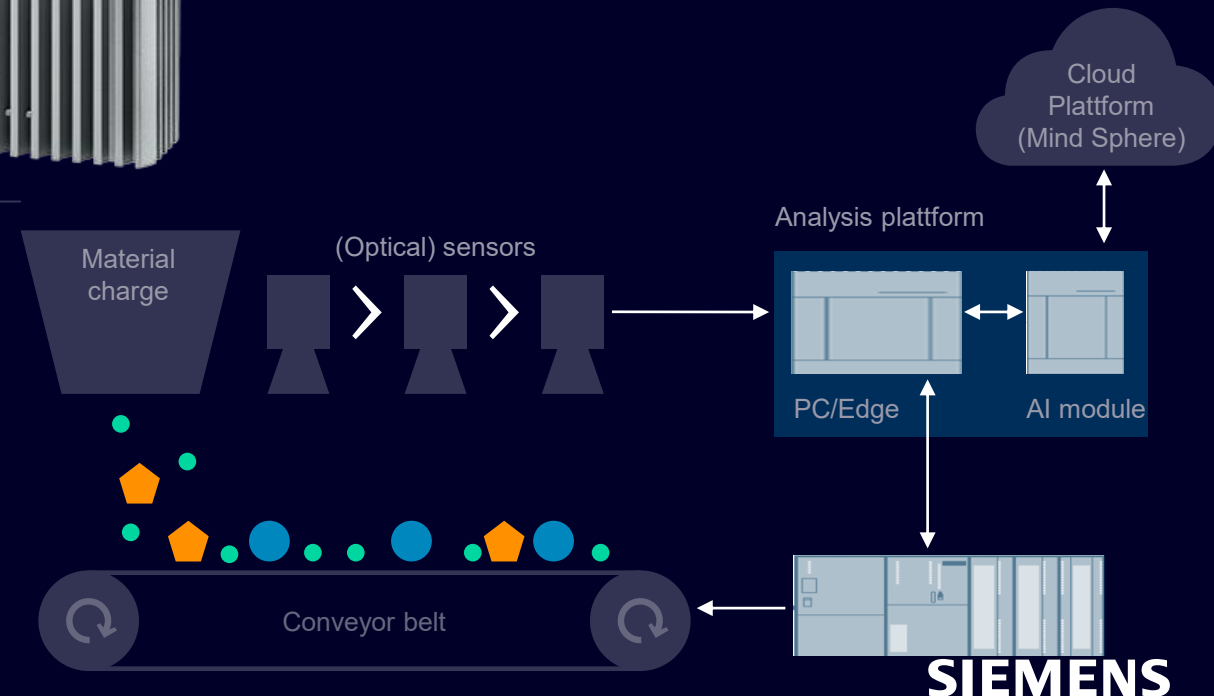
Solution

- Recycling-Analysis-Software platform to create material statistics, data for optimal use of devices (shredder, sorter,...)
- AI use case using Siemens Industrial Edge
- Device integration using MTP standard
- Multisensor connection (open interface)
- Sensor fusion
- Live view with false color image



Benefits

- Identify multi-layer plastics to create homogenous fractions from mixed plastics
- Increase quality of input material for the recycling process
- Integrated portfolio from sensor technology to cloud computing
- Increased calculation performance using condensed information



Client profile

eeden GmbH, founded in 2019, is developing an efficient upcycling technology to reuse end-of-life textiles. With this eeden enables fashion companies to turn upcoming regulations into opportunities by offering circular garments with as-good-as-new quality. The process is based on PET depolymerization and adaption of the cotton's degree of polymerization for reuse as Viscose or Lyocell.



Location: Münster, Nordrhein-Westfalen



Industry: Textile Recycling



Employees: 13, support from 4 industry experts

Customer challenge

- Parallel development of different process routes
- Decision based on rough estimations and lab trials not sufficient
- Need for calculation of whole process taking into account implications on downstream process
- Need for first energy and cost estimation based on simulation of whole process rather than on lab trials
- Need for increasing certainty to build pilot and demo plant with chosen process route

Project approach

- Workshop to support progressing in scaling up lab results to pilot scale
- Process Simulation as decision base for process decision with gPROMS
 - Heat and mass balance as base for pilot plant plannings
 - Identification of levers for energy saving measures

Results

- **Pros and Cons of the different process routes were discussed and also details, e.g. the challenging process conditions, transportation and treatment of textile slurries**
- **A result was to initiate a simplified process simulation as it seems helpful regarding:**
 - ✓ Heat and mass balance (HMB)
 - ✓ Energy Savings potential identification
 - ✓ Pros/Cons of process routes
 - ✓ Rough equipment design/dimensions
 - ✓ Infrastructural requirements
 - ✓ Authority HMBs
 - ✓ Cost estimation
 - ✓ Process Optimization
 - ✓ Validation of process changes
 - ✓ Component accumulation due to recirculation
 - ✓ Promotion of process know-how

Customer benefits

- The combination of experienced process consulting and simulation enables eeden to quickly decide on which process route a pilot plant will be based.
- Discussions with investors will be more straight forward as pros and cons can clearly be addressed and cost estimates are based on facts
- The simulation file can be used by eeden for own process development if license packages will be purchased
- As outlook an owner's engineering package is suggested to align activities, to check the necessary documentation as needed by EPCs and authorities.

ARCUS GREENCYCLING

Holistic recycling process of plastic waste



Challenge

Convert untapped waste-streams to plastic raw materials with food grade quality.



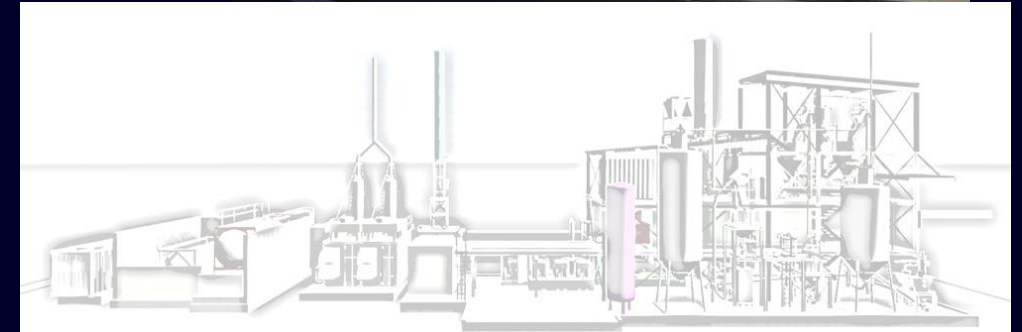
Solution

Arcus pyrolysis technology transforms complex plastic waste streams into raw materials for the petrochemical industry.

- Robust waste treatment process using a special reactor type / and furnace combination
- Energy autonomous process while using high-quality gas from pyrolysis process in a combined heat and power plant (CHP)
- ★ Entirely electrical operation prepared for net-zero

Benefits

- Redundant design of critical components for maximum availability
- Robust technology ensures failure-free operation
- Enabling fully certified plant, process and product meeting highest standards (REACH 'end-of-waste status', EfB, ISCC+, RedCert2, BimSch),



APPLICATION EXAMPLE UNISENSOR POWERSORT

Sorting of waste plastic using laser spectroscopy

Customer

Unisensor Sensorsysteme GmbH, Karlsruhe (Germany)

- OEM specialized in sensor systems for the recycling, beverage and gas industries

Application/ challenge

- Sorting of waste plastic streams using laser spectroscopy
- Different materials are detected and separated into mono-fractions based on their spectra
- Even black plastics can be detected
- High computing power required for analysis and separation in real-time

Siemens solution

- Siemens Industrial PCs SIMATIC IPC as the “brain” for the separation process
- Providing computing power with highest reliability in an industrial environment

UNIsensor



SIEMENS

CARBOLIQ

Automation technology for catalytic liquefaction process



Challenge

Control and hold a single-step process steady to convert mixed plastic fractions into a crude-oil substitute with virgin-grade properties.



Solution

The Carboliq process recovers monomers from mixed and contaminated plastics into oils and gases at low reaction temperatures

- Direct liquefaction in a single-stage process, characterized by the high liquid portion using frictional heat
- Output suitable for high-performance films, e.g. for the packing industry
- Process runs without using chemicals, only using silicate as catalyst



Benefits

- Modular design maintains flexibility
- Enabling evidence of the output's yield and quality
- Steady-state process conditions significantly contribute to reduce green-house gases



CARBON2CHEM

CO₂ emissions as raw material for the chemical industry



Challenge

Reduce the release of carbon-rich gases into the atmosphere and substitute fossil raw materials as carbon source.



Solution

Digitalized plant, a system that calculates temperature profiles and provides values for evaluation in the control system, forming the basis for implementation and optimization of the processes control as well as for management of the installed assets.

- SIMATIC PCS 7 for visualization and process control
- Sitrans TO500 to determine the temperature profiles in a reactor








Benefits

- Recycling of harmful CO₂ emission
- New feedstock, foster defossilization
- Scalable and adjustable solution
- Meet the goals of the EU Commission's Green Deal without jeopardizing competitiveness



Chemical Recycling – Project Successes, References

	Plastic Energy, UK Plastic recycling OEM	Pyrum Innovations AG, DE Process OEM Tire Recycling	Blue Alp, NL Plastic Recycling OEM	ADURO CLEAN TECHNOLOGIES Plastic Recycling OEM	Scandinavian Enviro Systems Process OEM Tire Recycling
About	<ul style="list-style-type: none">• Technology leader in plastic recycling (Pyrolysis)• Several projects in execution in Europe, global expansion with JV partners	<ul style="list-style-type: none">• Emerging technology driver in tire recycling business• PCS Neo project in commissioning at Dillingen site• Several projects planned	<ul style="list-style-type: none">• Emerging Process OEM for plastic recycling• First commercial scale project with Renasci in BE• Selected as global partner by Shell	<ul style="list-style-type: none">• Innovative Process OEM with hydrochemolytic plastic recycling• Upcycling plastics to handle various feedstock compositions• Limited pre- and post treatment required	<ul style="list-style-type: none">• patented pyrolysis process for ISCC-certified materials recovery• Process control Implementation with advanced digitalization, automation, electrification, and information technology
Involved Parties	<ul style="list-style-type: none">• Plastic Energy, Sabic, Total, Exxon, Petronas, SK Geocentric	<ul style="list-style-type: none">• Pyrum Innovations AG, BASF, Schwalbe, Conti	<ul style="list-style-type: none">• Blue Alp, Renasci, Shell• Currently projects in execution with Shell	<ul style="list-style-type: none">• Aduro Clean Technology,• Siemens Canada• Siemens Process Design Engineers	<ul style="list-style-type: none">• Partnership with Michelin• JV Antin
Success factors	<ul style="list-style-type: none">• Standardized automation and instrumentation package• Global frame agreement and account management• Executive relation	<ul style="list-style-type: none">• Automation portfolio, Simatic PCS Neo, analytics, simulation, training systems• Modularization & flexibility• Financial services, Partnership agreement	<ul style="list-style-type: none">• Modular automation concept that can be replicated globally• Close Cooperation with Shell CAM	<ul style="list-style-type: none">• One supplier for the entire Control and Instrumentation Solution• Intensive process consulting and process engineering support	<ul style="list-style-type: none">• Seamless integration of tools into Enviros platform• AI capabilities for continuous improvements• Holistic information integration for reliable control and optimization
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Chemical Recycling – References cont.

	Eurex Oil, SK Process OEM Plastic recycling	Arcus Greencycling, DE Process OEM Plastic recycling	University of Leoben Research Plastic recycling	Unisensor, DE OEM Plastic recycling	Eeden Technology provider for textile recycling
About	<ul style="list-style-type: none">Design highly efficient and continuous chemical recycling units for waste plasticsRollout of recycling skids	<ul style="list-style-type: none">Transform complex waste streams to petrochemical inputEntirely electrical operation prepared for net-zero	<ul style="list-style-type: none">Classification of plastic types incl. multilayer plastics on a conveyor beltSensor technology connected to cloud using edge devices	<ul style="list-style-type: none">Sorting of waste plastic streams using laser spectroscopyHigh computing power required for analysis and separation in real-time	<ul style="list-style-type: none">environmentally friendly process to extract cellulose from cotton textiles or other fibersProcess simulation (gProms) to minimize carbon food print and energy consumption
Involved Parties	<ul style="list-style-type: none">Eurex Oil, Chemosvit Strojchem, Chemosvit	<ul style="list-style-type: none">Arcus Greencycling	<ul style="list-style-type: none">University of Leoben (Austria)	<ul style="list-style-type: none">Unisensor Machine Builder	
Success factors	<ul style="list-style-type: none">Automation portfolioSinamics drivesInstrumentation and analyticsSwitches & Sinema RC for remote control & maintenance	<ul style="list-style-type: none">Redundant design of critical components for maximum availabilityEnabling fully certified plant, process and product meeting highest standards (REACH, EfB, ISCC+, RedCert2, BimSch),	<ul style="list-style-type: none">AI Use Case using Siemens Industrial EdgeDevice integration using MTP standardMultisensor connection (open interface)	<ul style="list-style-type: none">Providing computing power with highest reliability in an industrial environmentSiemens Industrial PC's SIMATIC IPC as the "brain" for the separation process	<ul style="list-style-type: none">Deep process understanding, Process Consulting WorkshopsProcess Simulation with gPROMSOwners engineering + Process engineering



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