Summary of Plastic-to-Oil Plants Recent Years

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1 Introduction to Representative Plastic-to-Oil Plants

1.1. Renewlogy & Sustane Technologies - Full-scale plant (Nova Scotia, Canada, 2019 and Phoenix, Arizona, 2020/2021) [1]

Renewlogy & Sustane Technologies, located about 25 kilometers north of Chester, plans to establish a plastic pyrolysis plant with a capacity of 40,000 to 50,000 tonnes of waste plastics per year (110-140 t/d). Synthetic oil and synthetic kerosene are the main products of this technology. The yield of the former will be 9,000 litres of synthetic diesel per day (56 barrels/d), and some of it will be used on-site in the pyrolysis processe. The total conversion rate can be up to 70-80%. The acceptable plastic feedstocks include high-density polyethylene (HDPE, #2), low-density polyethylene (LDPE, #4), and polypropylene (PP, #5), polystyrene (PS, #6).

Fig. 1 Full-scale plant of Renewlogy & Sustane Technologies.

See: 1. https://renewlogy.com/project/nova-scotia-canada/

2. Attachment 1: the environmental assessment approval and process details

1.2 RES Polyflow - Full-scale plant (Demonstration: Perry, Ohio, 2013/Commercial-scale: Ashley, Indiana, 2020) [2]

In April 2019, Brightmark Energy announced the construction of a commercial-scale plastics-to-fuel plant in Ashley, Indiana using a $260 million financing package. The scale will be 100,000 t/y;

the oil yield will be 430,000 barrels/yr (4.3 barrels/t) of diesel and naptha, and 120,000 barrels/yr (1.2 barrels/t) of wax. The site is expected to open in 2020.

Fig. 2 Pyrolysis unit of RES Polyflow.

The feedstock are waste plastics that would be sent to landfill, usually polymers like No. 2, 4, 5, 6, and 7, postindustrial streams and streams that included more than 85 percent polymer in its mix. Before pyrolysis, the plastics need to be sorted, shredded to ½-inch to ¾-inch sized pellets ,and dried.

See: 1. https://www.brightmarkenergy.com/ashley-indiana-project (an introduction video)

2. Attachment 2: Investment banking update.

1.3 New Hope Energy – Plastic-to-Fuel facility (Tyler, Texas, 2020) [3]

The commercial-scale Plastic to Fuel facility established by New Hope Energy (NHE) in Tyler, Texas is now operational. In Phase one NHE Phase will build a facility with a capacity of around 150 t/d of plastic**.** The Trinity Oaks, Tyler plant will be capable of processing 960 tons/day or 340,000 tons/yr. the yield of renewable synthetic fuels will be over 4,500 BBL/day (4.7 barrels/t). The facility is expected to reach full capacity by 2020.


Fig. 3 Schematic diagram inside and outside the facility of New Hope Energy.

See: 1. https://newhopeenergy.com/news/f/trinity-oaks-tyler-plant-operational

2. https://twitter.com/NewHopeEnergy/status/1152785253871902720 (an introduction video)

1.4 Recycling Technologies – RT7000 commercial-scale unit (Binn Eco Park, Scotland, 2019) [4]

Recycling Technologies prepares to build its commercial-scale unit using its proprietary technology "RT7000" at Binn Eco Park, Perthshire, Scotland in 2019, and plans to launch its first commercial unit in Q4, 2019. The technical parameters are shown in Table 1. The capacity of the unit is around **60t/d**, and the oil yield is around **58%**. The main product of its technology is called "Plaxx", which is an oil used to make new polymers. Multiple RT7000 units can be installed in parallel to directly increase the capacity.

Table 1 technical parameters of RT7000 commercial-scale unit.

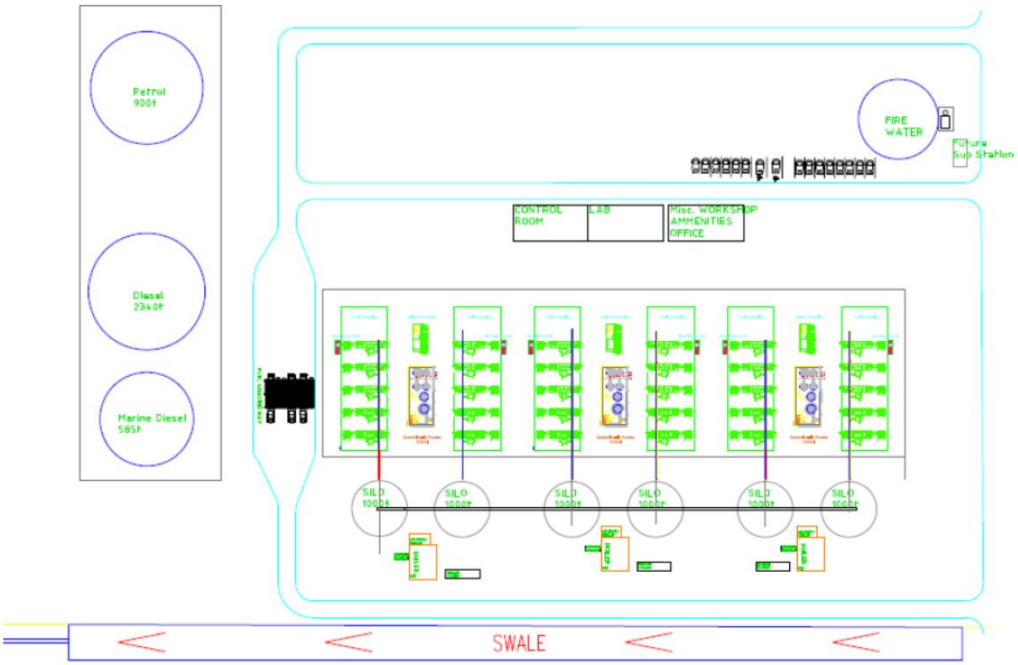
Parameters	Value
Annual capacity (wet weight)	9000 t
Annual capacity (dry weight)	7000 t
Throughput	1 t/h
Annual Plaxx production	5200 t
Technology	Thermal cracking
Yield	75%
Energy efficiency	85%
Overall equipment effect	80%

Fig. 4 Schematic diagram of the technical process and the commercial-scale unit of Recycling Technologies

See: https://recyclingtechnologies.co.uk/technology/the-rt7000/

1.5 GEP Fuel & Energy Indiana - Scrap-plastics-to-fuel facility (Camden, Indiana, 2019) [5]

GEP Fuel & Energy Indiana planned to build a 450,000 square-foot plastic-to-fuel facility in Camden, Indiana, which could convert recyclable and nonrecyclable plastics into commercially viable end products. Besides, they also planned to build an adjacent facility to realize the conversion of non-recyclable plastics to transportation fuels.



Design drawings of the WPTF facility, showing 30 modules each capable of producing over 500 million litres of road ready fuel per year

Fig. 5 Design drawings of the WPTF facility, showing 30 modules each capable over 500 million liters of road ready fuel per year.

The capacity was reported to be 1500 tonnes a day of end-of-life waste plastics, and the yield of fuel was around 5.7 barrels/t. Construction is expected to begin in the second quarter of 2019, and then 14 months was expected to be taken to produce fuel.

See: Attachment 3: Construction announcement of Scrap-plastics-to-fuel facility.

1.6. Quantafuel - Plastic-to-fuel plants (Skive, Denmark, 2019; Norway, ???; Antwerp, ???) [6]

Norwegian Quantafuel's convert plastic waste to fuel using a three-stage process: (1) Pyrolysis, (2) catalytic reforming to increase the alkane content, and (3) distillation into product oil, in which diesel is the dominating by-weight output. They claim that the fuel products can be used without further processing in a refinery.

Quantafuel's first commercial plastic-to-fuel plant planned to be built in Skive, Denmark (60 t/d) in 2019. This plant will have an oil yield of around 5.2 barrels/t. Besides, the company has announced specific plans for at least two additional plants: one similarly sized plant in Norway and a larger one (80 million litres) in Antwerp.

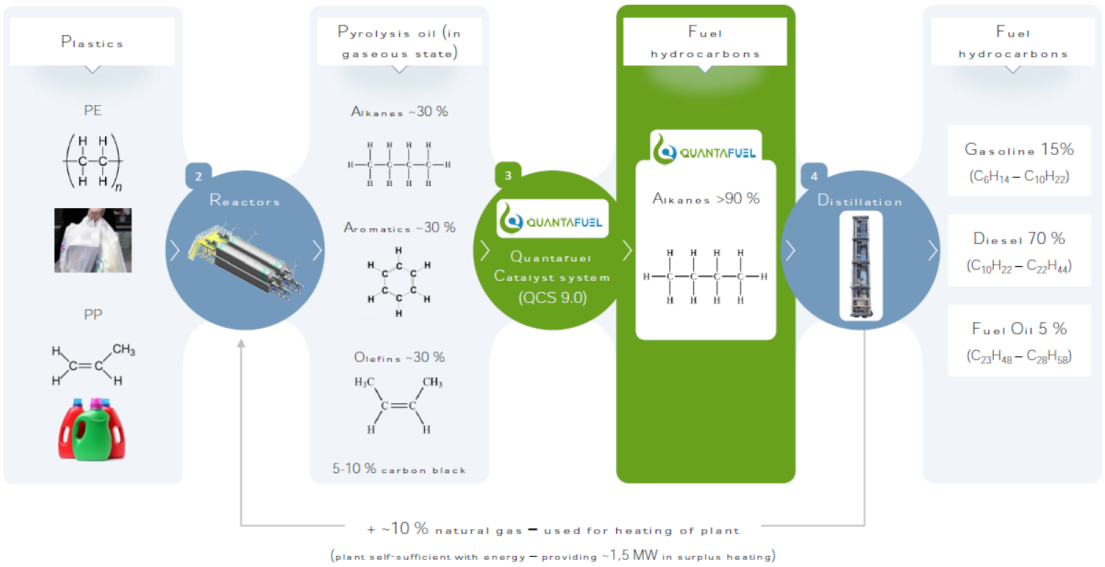


Fig. 6 The main technical route of Quantafuel's plastic-to-oil technology.

See: 1. https://quantafuel.com/background-of-technology/

2. Attachment 4: Quantafuel introduction.

1.7 Vadxx Energy - Plastic to EcoFuel™ (Akron, Ohio, 2017) [7]

Fig. 7 Plastic to EcoFuel™ facility of Vadxx Energy.

Vadxx Energy has developed a technology named “EcoFuel™” which converts waste plastics to diesel and naphtha. This technology can recycle most kinds of waste plastics, including those not typically accepted by other facilities, such as #6 polystyrene and #7 polycarbonates. Its scale is up to 23,000 t/yr. The oil (including diesel and naphtha) yield is around 115,000 barrels/yr (5 barrels/t).

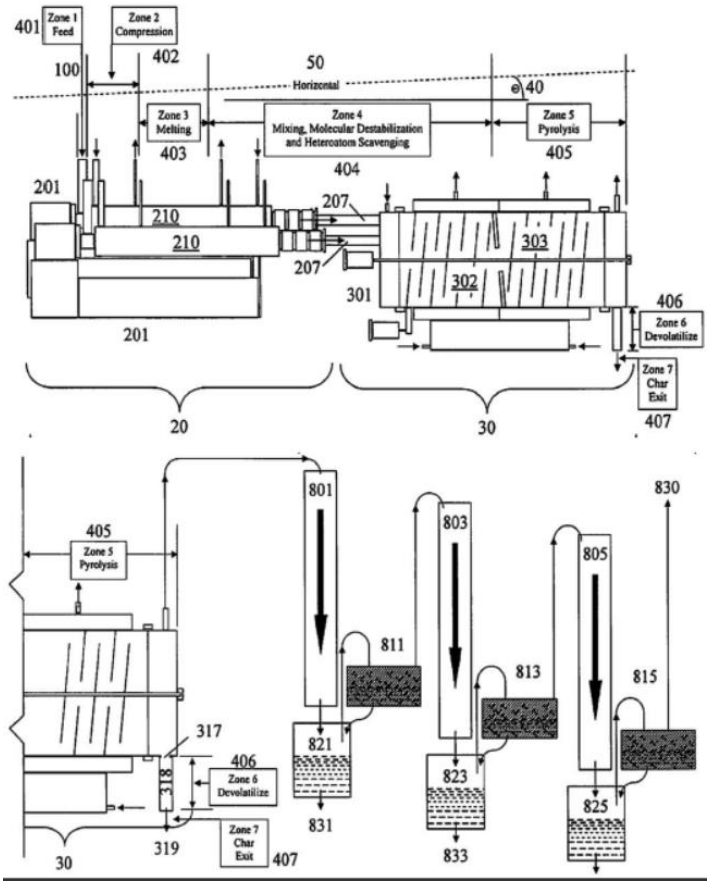


Fig. 8 EcoFuel ™ plastics recycling process flow.

Vadxx Energy defines the produucts into 4 different catagories:

1) EcoFuel-I™: A diesel stock for use as a blending agent to improve the overall quality of ultra-low sulfur diesel, as well as distillate fuels blended with diesel for on-road use.

2) EcoFuel-II™: A naphtha that can be used as a gasoline additive to increase octane.

3) EcoFuel-SNG™: A synthetic natural gas produced for the exclusive use by the Vadxx process.

4) EcoFuel-S™: A carbon powder that can be used as a low-grade fuel source.

The facility expected to reach its full capacity (about 10-15 million litres/yr) in 2018. However, no further publicly available production data could be found.

See: 1. https://polymerohio.org/vadxx-energy-establishes-waste-plastic-ecofuel-facility-akron/

2. https://vadxx.com/ (an introduction video)

3. Attachment 5: Introduction of plastic to EcoFuel™.

1.8 Cynar PLC - Plastic-to-fuel plants (Almeria, Spain, 2014; Seville, Spain, 2015; Bristol, UK, ???; Portlaoise, UK, ???) [8, 9]

UK based company Cynar PLC has established several plastic-to-fuel plants during the past

decades. Two of these are located in Spain and are owned by Plastic Energy and the third is located in Avonmouth, UK and owned by SITA (UK subsidiary of recycling company Suez). The facilities have a capacity of 20 t/d and an annual production capacity of 5.7 million litres per year (4.9 barrels/t) each.

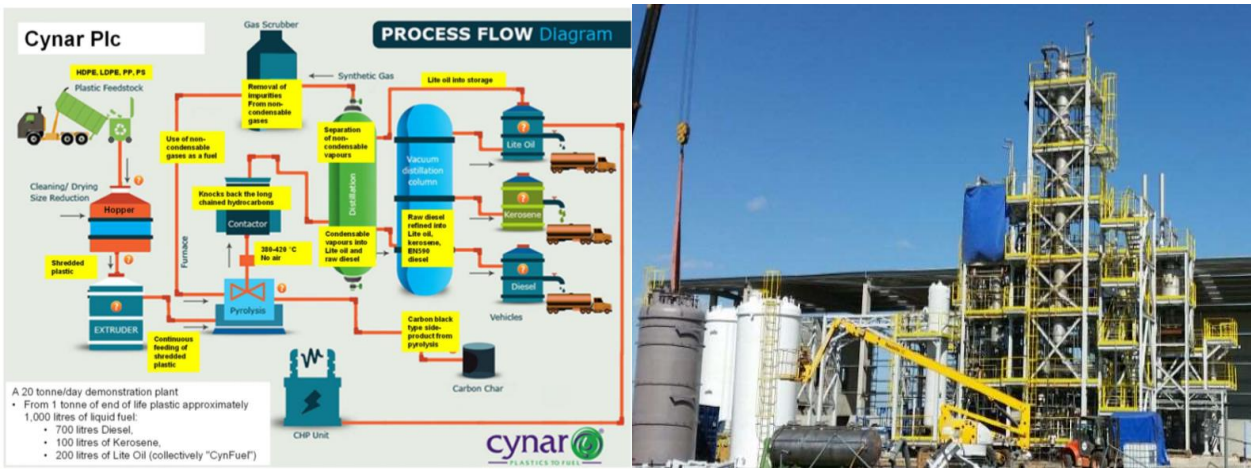


Fig. 9 Schematic diagram of the technical process flow and the plastic-to-fuel plant of Cynar PLC.

The technology accepts almost all classes of plastics but No. 2, 4, 5, and 6 are preferable. The main feedstocks of this plant will be post-consumer and post-industrial rigid and film plastic, and the products will be a middle distillate diesel fuel blendstock meeting ASTM D975 and EN590 (CynDieselTM), light oil (CynLiteTM) and kerosene (CynKeroTM).

The demonstration plant (2.9 million litres per year capacity) in Portlaoise, Ireland is thought to be shut down (idled). Also, no publicly available production data from the two facilities in Spain could be found.

1.9 Plastic Advanced Recycling Corporation (PARC) - Plastic-to-fuel plants (Jiangsu, China, 2009) [10]

For PARC's plastic-to-oil technology, the treatment capacity of the basic unit is 20 tons/day or 30 tons/day. The treatment capacity can be increased by adding more unit(s). Fuel oil yield is highly dependent on the plastic feedstock content. The oil yield is dependent on the plastic components and varies from 50 to 70%. The lifespan of the system is 80,000 hours (10 years).

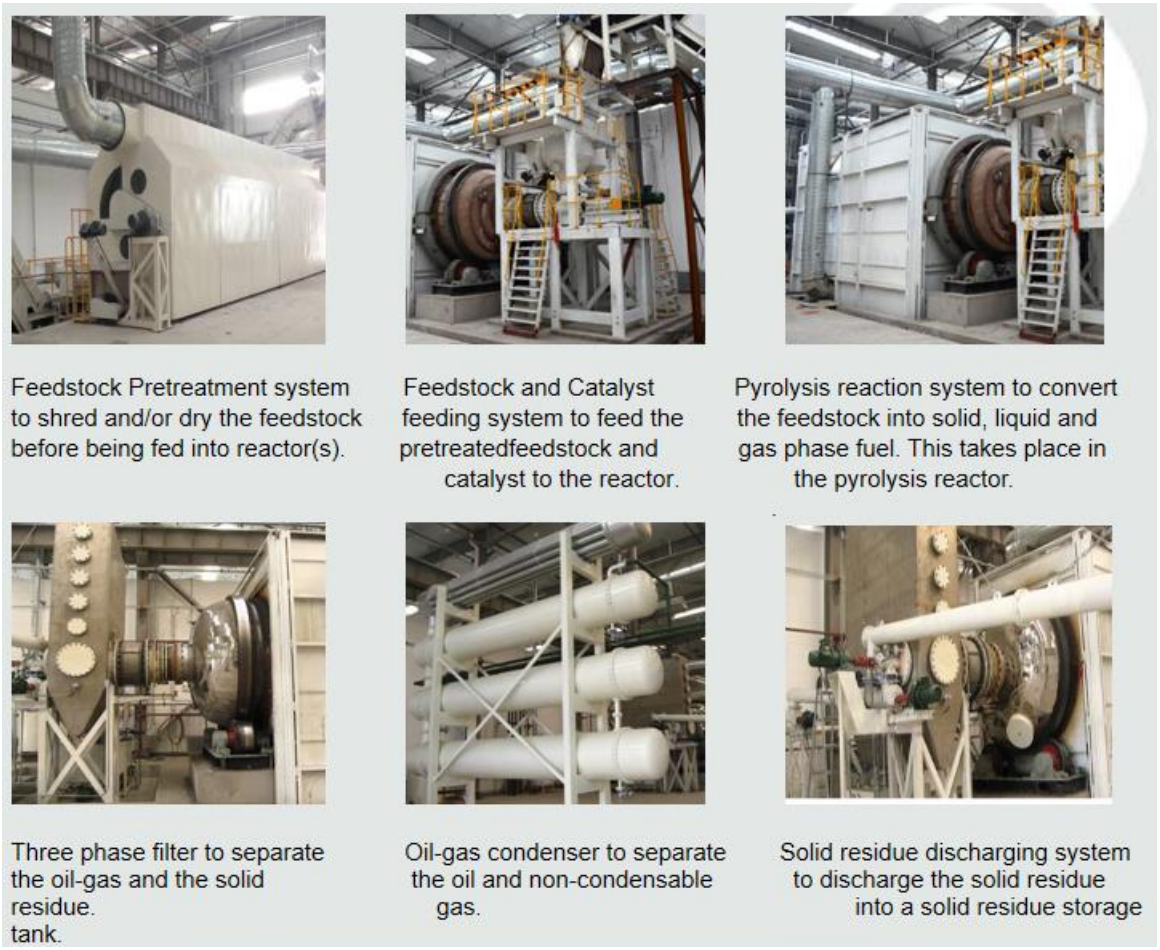


Fig. 10 The main functional units of the plastic-to-oil plant of PARC.

The capacities of the plants in Jiangsu, China are reported to be 15 t/d and 20 t/d. The oil yield of these two plants is 3290 and 4400 m^3/yr (around 3.8 barrels/yr). While the content of PVC in feedstocks should be < 5% and PET should be sorted out. Catalysts are used in the pyrolysis process while the details are unknown. The yield of this process is: char yield is 10-15%, syngas yield is 15-20%, and wax yield is around 10%.

However, no further information can be found about these two plants these years.

See: 1. http://www.plastic2x.com/parcproducts/ for technical details.

2. http://www.plastic2x.com/video/ a video introduces the currant plant in China.

1.10 Quantafuel and BASF - ChemCycling (Skive, Denmark, ???) [11]

In the Q4 of 2019, Quantafuel plans to establish a plant for pyrolysis of mixed plastic scrap and purification of pyrolysis oil with a capacity of approximately 44 t/d in Skive, Denmark. Germany-based BASF has invested 20million euros and would have the right of first refusal to all pyrolysis oil

and purified hydrocarbons in at least the first four years.

See: https://www.recyclingtoday.com/article/basf-quantafuel-investment-chemical-recycling/

1.11 Bin2Barrel (IGE Solutions Amsterdam BV) - Plastics-to-Oil Plant (Amsterdam, Netherland, ???) [12]

This plastic to fuel plant in Amsterdam has a design capacity of 33,000 tonnes per year and will yield 35 million litres of fuel per year. Its output will be marketed to marine users. On January 22, 2019, the plastic to fuel modules were completed and loaded for shipment to Amsterdam.

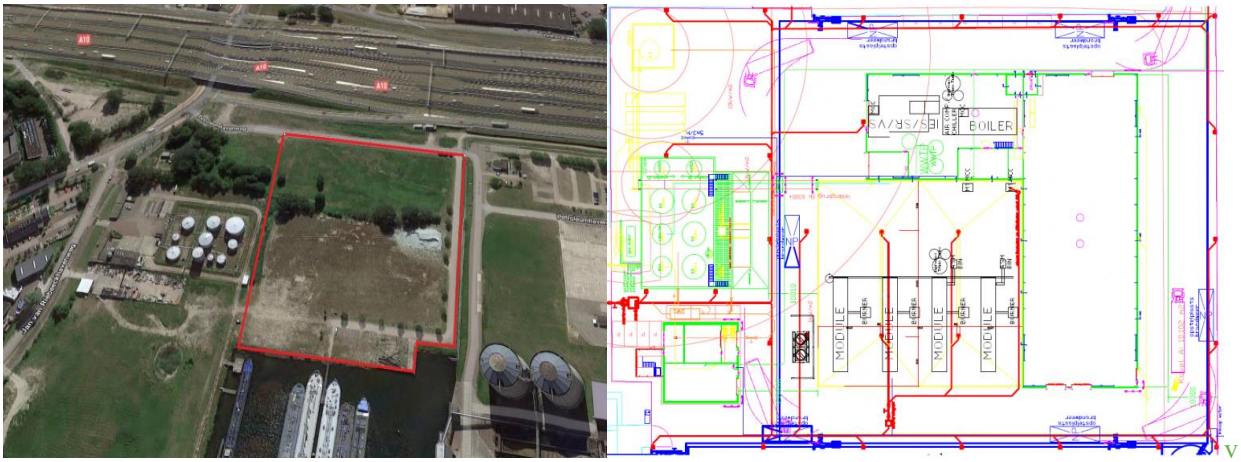


Fig. 11 Site selection and construction planning of Bin2Barrel's plastic-to-oil plant

See: 1. https://www.igesolutions.org/amsterdam/

1.12 Cassandra Oil - Syncrude plant (Jerez, Spain, ???) [13]

Cassandra Oil's partner in Spain, Valoriza, plans to build a syncrude plant with a capacity of 56,000 tonnes of waste plastic per year (150 t/d), and the products will be 48,000 tonnes/yr of oil (oil yield: 86%) and 2,800 tonnes/yr of carbon black. The released pyrolysis gas would be used in the pyrolysis process.

Fig. 11 Site selection of Cassandra Oil's syncrude plant.

This plant will house: four CASO 600E machines, pre-treatment equipment for drying; waste conversion system (10 tons/h of plastics), and two 4MW gas turbines for electricity generation. The information comes from reports in November 2016, with no updates so far.

See: http://cassandraoil.com/en/Press/Press-releases/Press-release/?releaseid=2364596

Others

- Globalgreen International Investments (GGII) has built several pyrolysis plants for MSW treatment. But these plants were not built specifically for waste plastic disposal. See: http://www.ggienergy.com/projects
- Global Renewable Energy (GRE) invented a pyrolysis machine for waste plastic disposal, which has been used in Zebulon, NC since 2019. However, detailed information about this plant could not be found. See: https://gontramarchitecture.com/portfolio_item/global-renewable-energy/
- EcoFuel Technologies, Inc. has developed Plastics to Fuel (PTF) units range in sizes capable of handling 200 pounds of plastics per day to 10,000 pounds of plastics a day (around 5 t/d) to multiples of 10,000 pounds per day. See: https://www.ecofueltechnology.com/home/products/
- Agilyx launched a depolymerization plant in 2020 that processes polystyrene into monomer oil. However, they didn't focus on mixed waste plastics.
- Pyrocrat has established several small plants. Over 18 plastic to oil projects established by Pyrocrat converts about 100MT of waste plastic daily into pyrolysis oil. From there brochure, the

largest one is 10.2 t/d. See: https://www.pyrocratsystems.com/projects-technologies.html and also Attachment 6: Pyrocrat Systems Introduction.

- Plastic Energy planned to establish 10 plants in Asia and Europe by 2023, including one at Sabic's chemical complex in the Netherlands. The capacity will be 20 t/d. However, no further information is available. See: https://cen.acs.org/environment/recycling/Plastic-problem-chemical-recycling-solution/97/i39.
- Golden Renewable Energy put the shred waste plastics through its depolymerization process at temperatures that vary between 700 and 1300 degrees Fahrenheit. The capacity was around 20 to 24 t/d (7,500 tons per year), the oil yield of which was around 4.8-5.7 barrels/t. The renewable diesel meets ASTM D396 specifications and can be distributed according to New York Mercantile Exchange (NYMEX) fuel pricing. See: Attachment 7: Patent and technical details.

2 Summary

This report presented a brief overview of (mixed) plastic-to-fuel plants with relatively large scales (usually > 10 t/d) in recent years. In around ten years since 2009, nearly twenty plastic-to-fuel plants have been completed and put into production, or are under construction, or planned. These plants with a maximum capacity of around 1500 t/d (reported) are mainly distributed in Europe and the US. While the scale of mainstream plastic-to-fuel plants is about 10-150 t/d with a oil yield of around 4.5-5 barrel/t at present.

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