

Scrap tire recycling – The next generation!



Scrap tire recycling



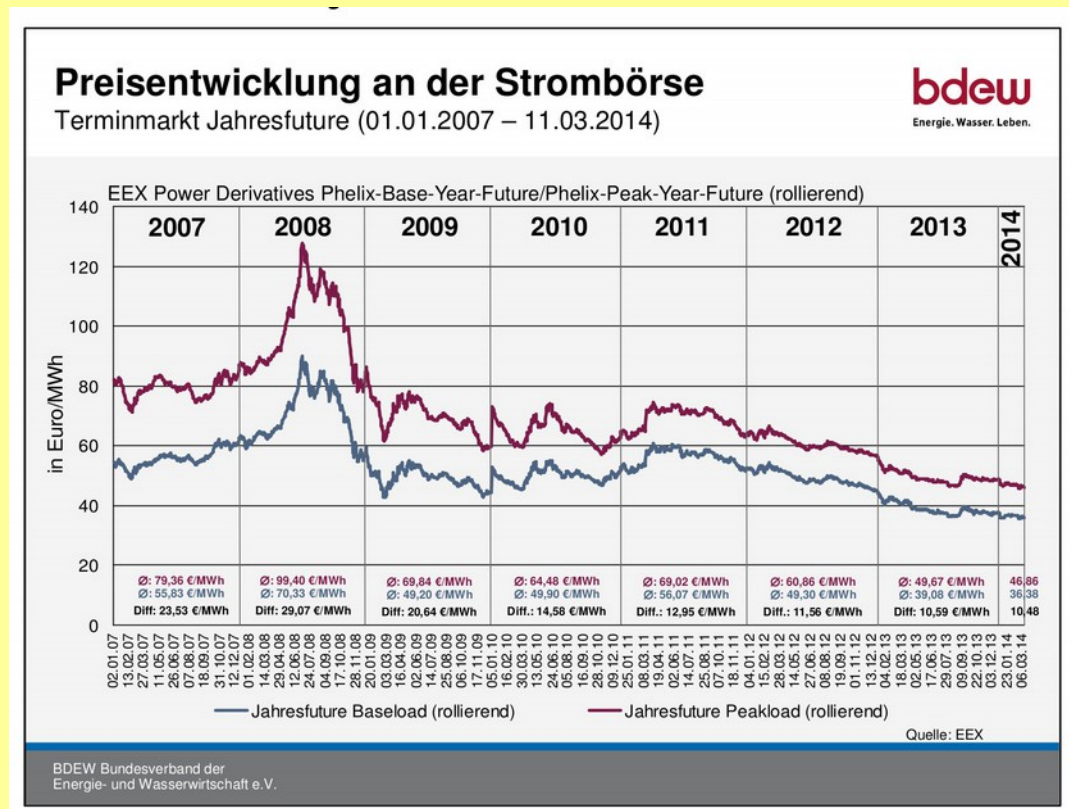
Current market situation

Actually there are different ways for scrap tire recycling:

- Production of rubber granulates
- Energy recovery by production of diesel-like condensates for electric power production
- Thermolysis for production of secondary raw materials

Due to emission regulations and economic reasons a granulation nor simply energy recovery will be more and more uneconomic.

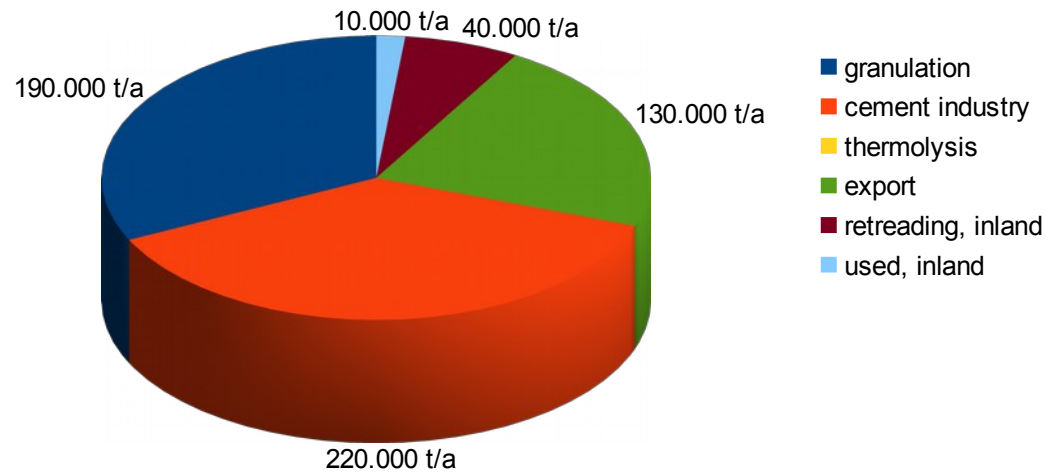
The data sheet shows the prices for electric power in Germany.



Changing of market situation

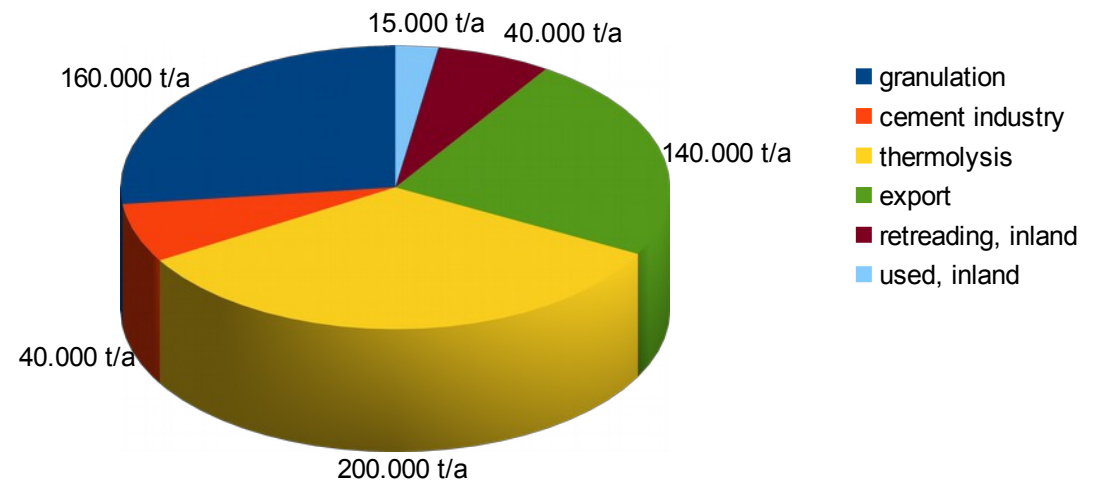
usage of scrap tires

Germany 1st 2012 (source: wdk 2013)



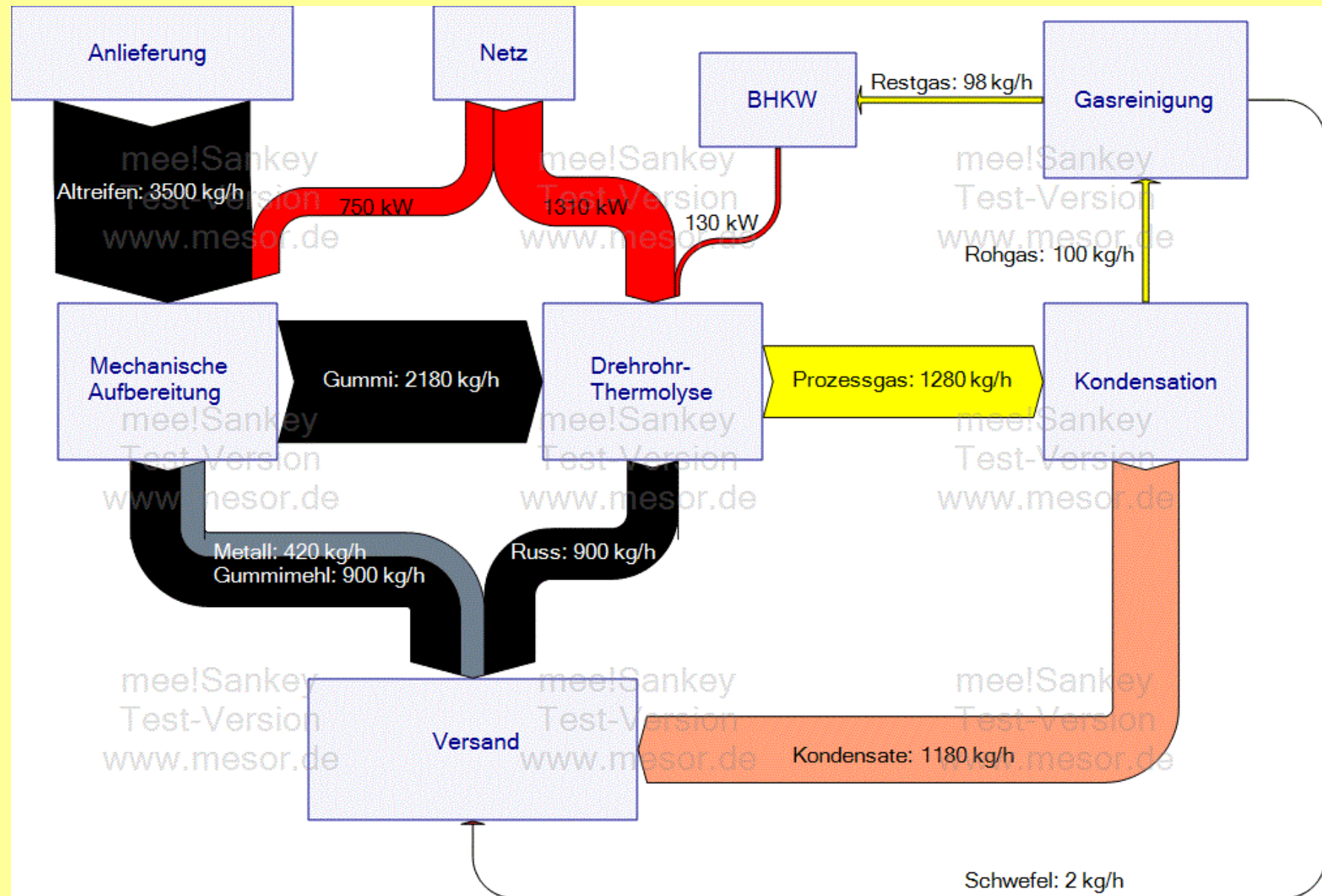
usage of scrap tires

Germany forecast

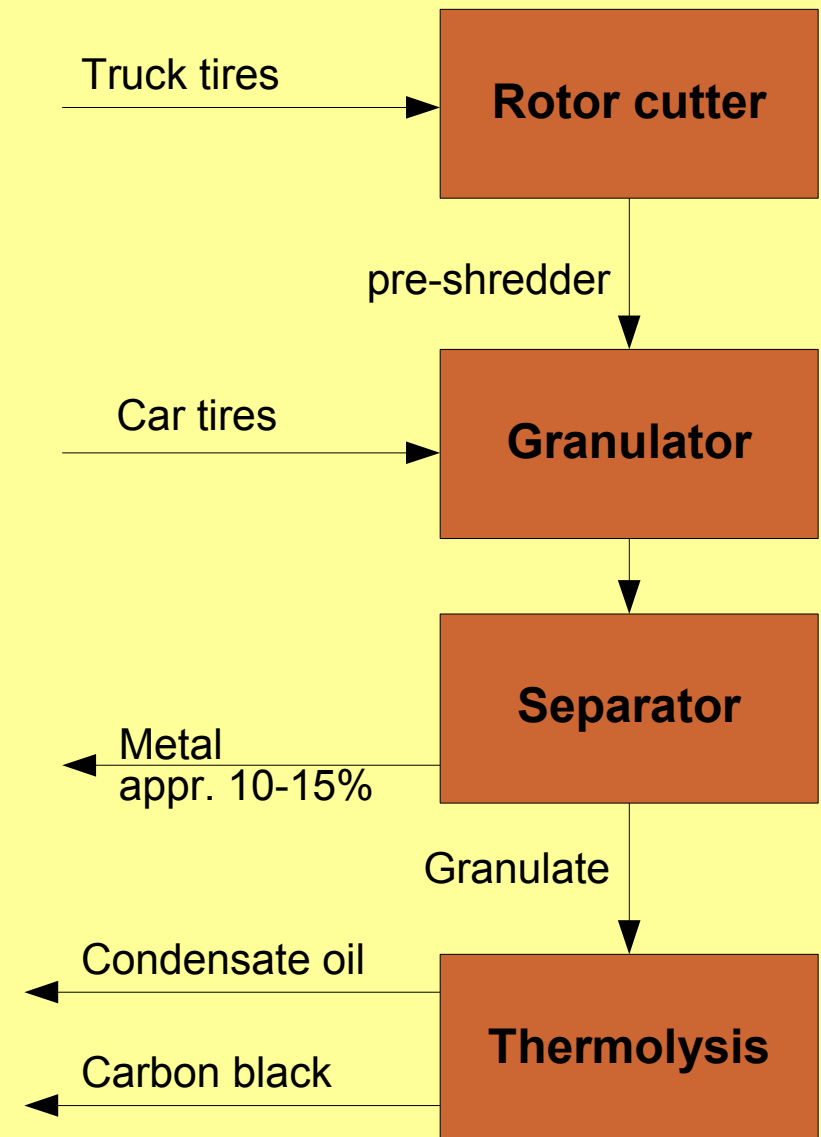


The scrap tire market in Europe changes dramatically
It is calculated with prime costs for scrap tires!

Sample mass balance



Preparation - overview



Preparation – truck tires



Preparation

- Rotor cutter
- Screen
- Refeeding
- Granulator
- Metal separator

Appropriate for
truck tires up to 1,6m

Throughput 2 -3 t/h

Energy demand
(actual)

< 800 kW_{el.} For

2 – 3 t/h

< 0,40 kWh/kg

Preparation – pre shred

Specification for the granulator:

→ car tires (quartered)

or

→ pre-shreddered to 250 x 250 mm



Preparation - granulation



Energy demand

330 kWel. for

3 – 5 t/h

< 0,10 kWh/kg



Preparation - granulate



Specification:

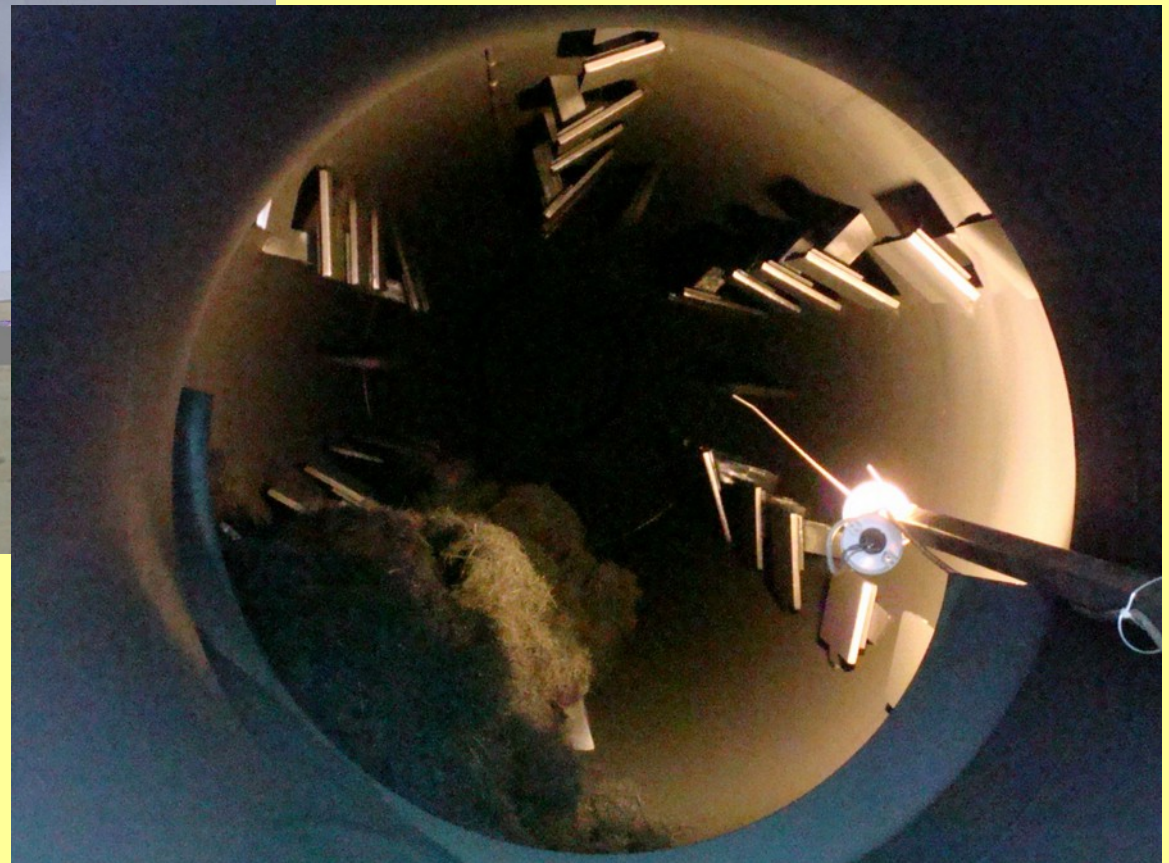
→ Metal-free

→ <20 mm

Must have: metall-free !



Due to the kiln rotation
Wire balls will be built...



Rotary kiln thermolysis plants



Energy demand

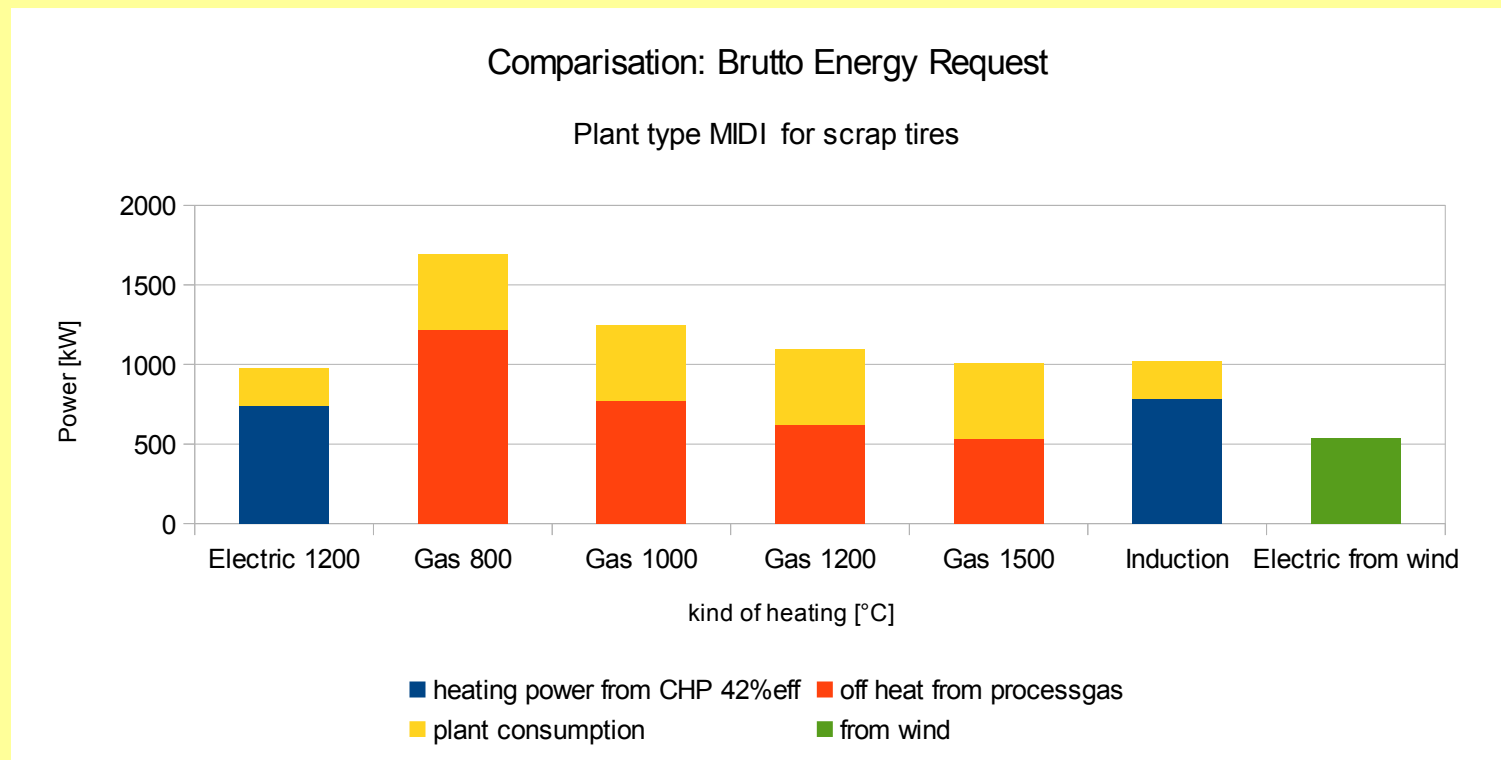
< 210 kWel. for

600 kg/h

< 0,35 kWh/kg

Please note: The needed proces heat will be produced by a burning chamber.

Efficiency



Pyrolysis - Thermolysis

Pyrolysis

Complete thermal decomposition of educt with target of destruction of educt.

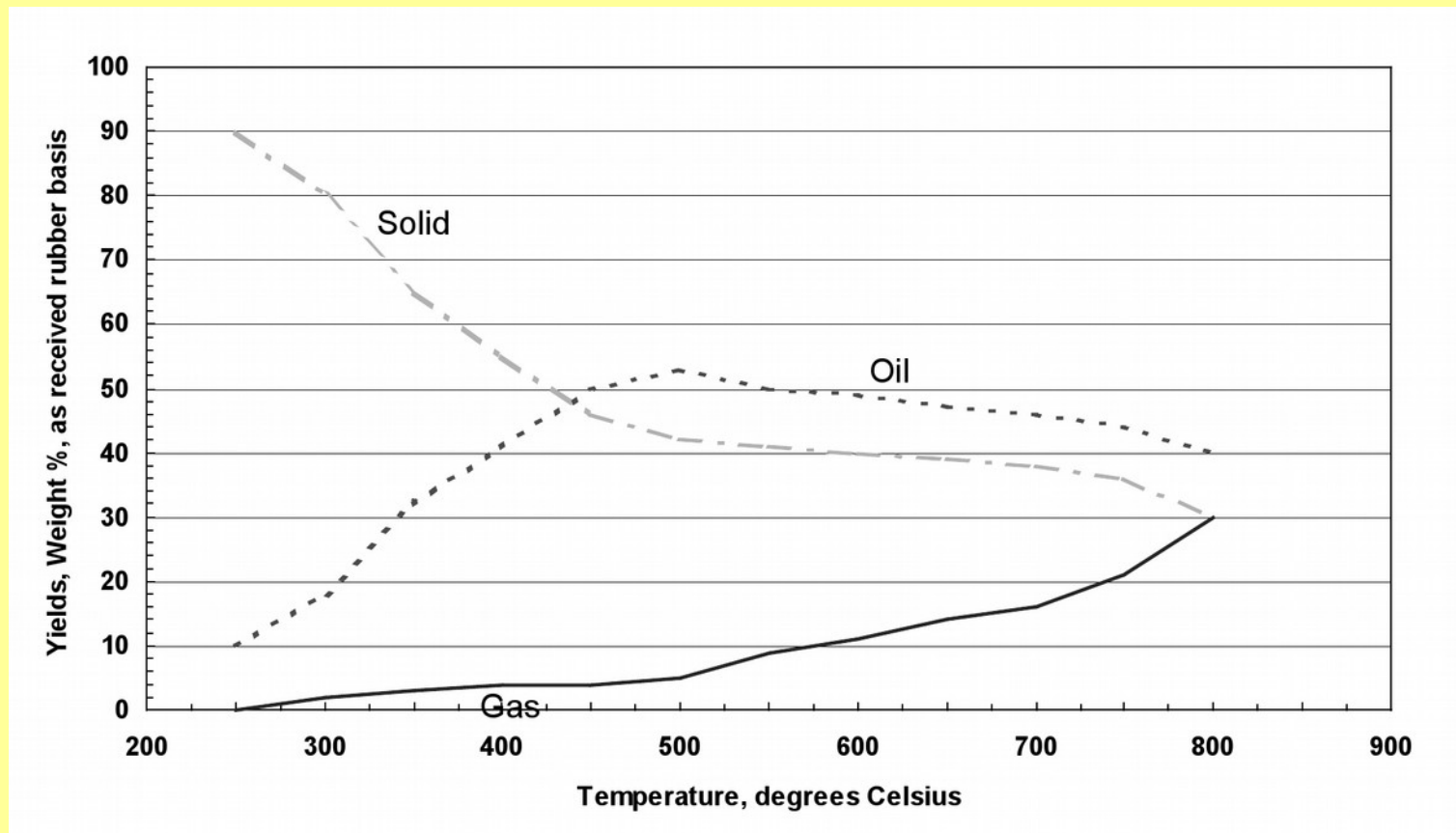
Thermal decomposition in oxygen-poor / (nearly) oxygen-free atmosphere.

Thermolysis

Thermal decomposition with selective and controlled generating of new products.

Thermal decomposition in a definitely oxygen-free atmosphere.

Thermolysis – balance variation



Source: CalRecovery-Report Nr. 1364 Kalifornien 1995

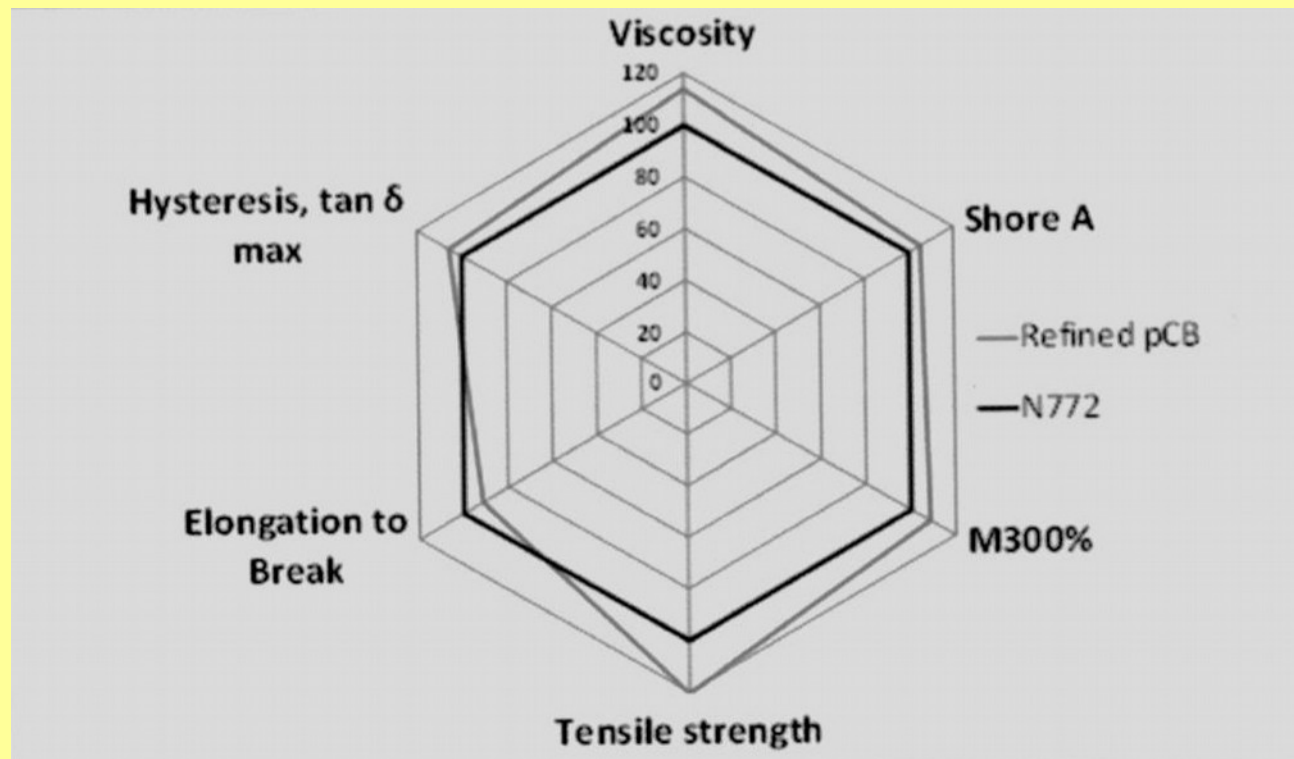
Product carbon black

	Unit	CBp	N330	N375	N550	N660	Comment
CTAB surface area	m ² /g	58,2	82	96	42	36	Our CBp has a higher surface area than that of N500 or N600 series, but not reach N300 series.
BET surface area	m ² /g	67,8	76				
Oil absorption number (OAN)	ml/100g	95,9	102	114	121	90	Indication of carbon structure (high value, high structure-> high viscosity)
Iodine absorption number	mg/g	154	82	90	43	36	A measure of surface area and micropore content.
Sieve Residue (45 µm)	%	82	100ppm	100ppm	50ppm	100ppm	Aggregate/agglomerate size as well as metal impurities
Ash content	%	11,7	0,3	0,3	0,4	0,4	Inorganic impurities (not dispose at 550°C)
Water content/ Heating loss at packing	%	1,8	0,4	0,4	0,3	0,3	Important factor for packing and storage.

CBp = Carbon Black pyrolyzed

Please note: The Carbon black quality depends highly due to the kind of process and its parameters!

Product carbon black



Please note: The Carbon black quality depends highly due to the kind of process and its parameters!

Product condensate oil



The raw condensate oil can be used in multifuel diesel engines or heating oil burners.
But: An application as a chemical raw material is economically even more interesting!

Remarks:

The condensate oil is already filtered and distilled during process to clean the oil from larger particles.

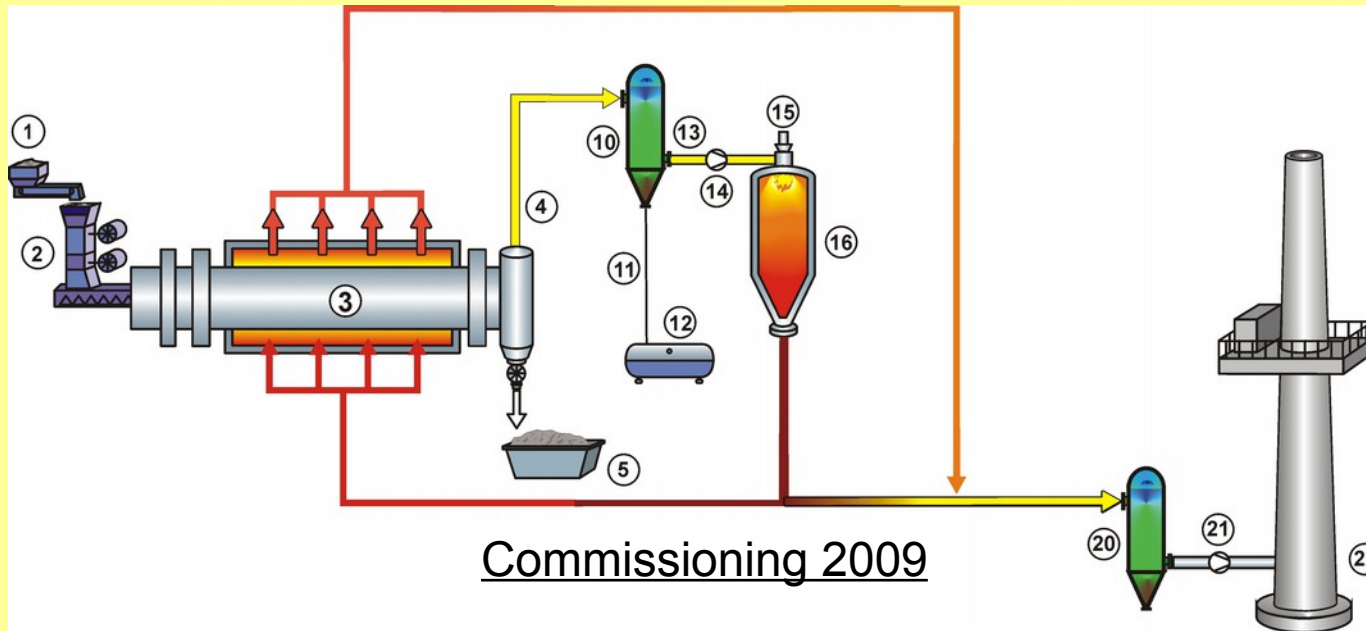
Product condensate oil

Analysis of scrap tire condensate oil

Hydrogen	Weight %	9,6	9 – 12
Nitrogen	Weight %	0,7	0,5 - 0,9
Ash	Weight %	<0,01	<0,01
Sulphur	Weight %	0,74	0,5 – 1,0
PCB	mg/kg	< 5	1 – 8
Water content	Weight %	0,06	0,05 – 0,09
Chlorine	Weight %	0,08	0,06 – 0,1
Burning point	° C	< 21	19 – 25
Viscosity at 40° C	mm²/s	2,81	2,6 – 3,1
Calorific value	MJ/kg	39,72	37 – 41
Silicium	mg/kg	36,7	32 - 42
Carbon	Gew. %	87,7	82 – 91
Zinc	mg/kg	7,1	6 – 8,5
Acid content	mg KOH/g	0,81	0,4 – 0,9
Density at 15° C	kg/m³	946	880 – 970

Please note: The Carbon black quality depends highly due to the kind of process and its parameters!

Process 2008



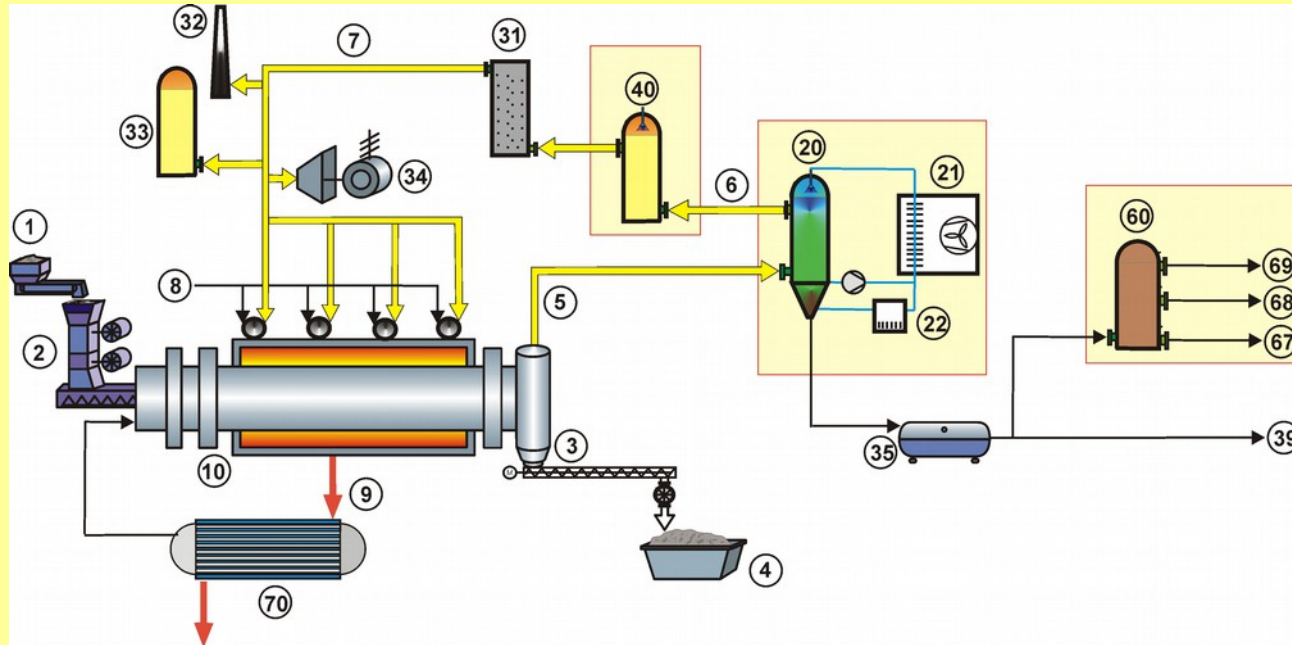
Advantages:

- Automatic operation
- Production of carbon black and oil
- Product result ok
- Condensation ok
- Autothermic operation
- Remote Control used

Potential for development:

- Long warm-up time (8 hours)
- Smoke gas-cleaning with waste
- Linked control circuits → due to safety critical!
- No adjustable heating zones
- No emergency flare

Process 2012



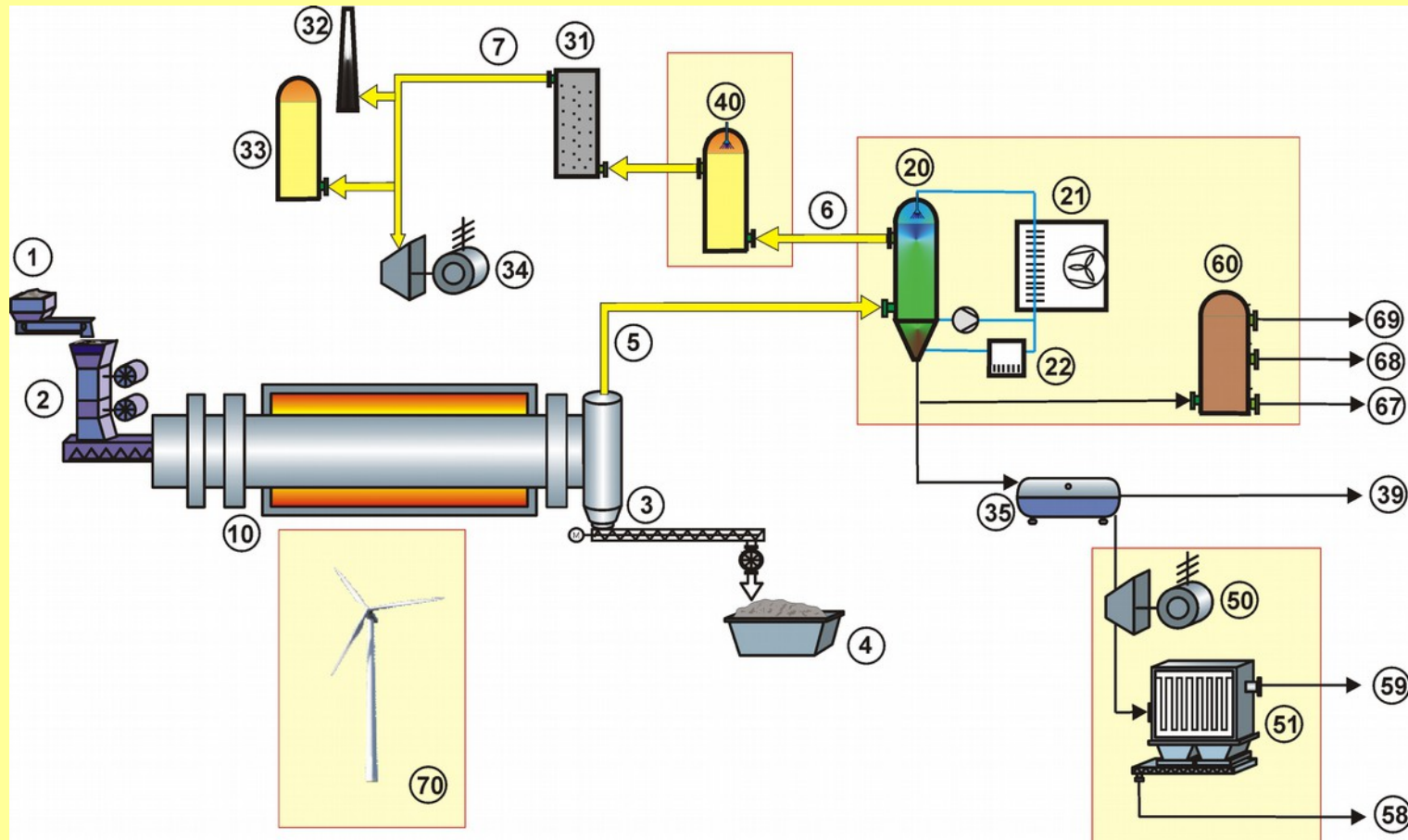
Enhancements:

- Fully automatically operation
- Short warm-up time
- Variable heating zone control
- Self-sustaining operation
- Remote Control
- Comprehensive safety concept

Products:

- Coke
- Condensate oil similar to diesel
- Permanent gas
- Optional: liquid gas
- Elementary precipitated sulphur
- Power for own usage
- Waste heat (steam, warm water)

Process 2015



- 1 Hopper
- 2 Input sluice
- 3 Thermolysis coke hot
- 4 Thermolysis coke cold
- 5 Thermolysis raw gas
- 6 Permanent gas
- 7 Permanent gas, cleaned
- 8 GPL / natural gas
- 10 Rotary kiln unit

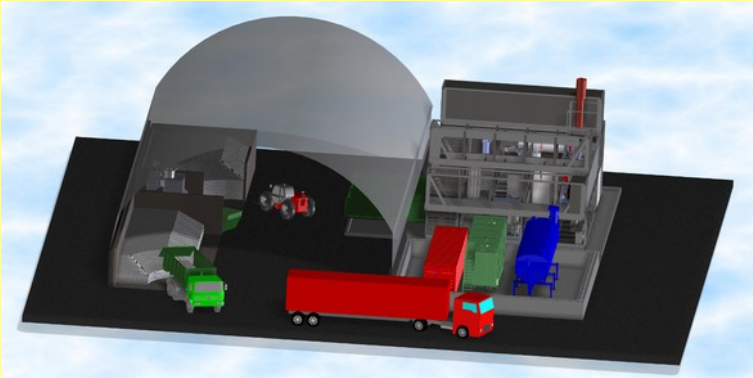
- 20 Condensation
- 21 Cooler
- 22 Bypass filter
- 31 Activated Carbon Filter
- 32 Emergency Flare
- 33 Gasometer
- 34 CHP

- 35 Raw oil storage
- 39 Thermolysis raw oil
- 60 Condensation
- 67 Super fraction
- 68 Light oil fraction
- 69 Heavy oil fraction

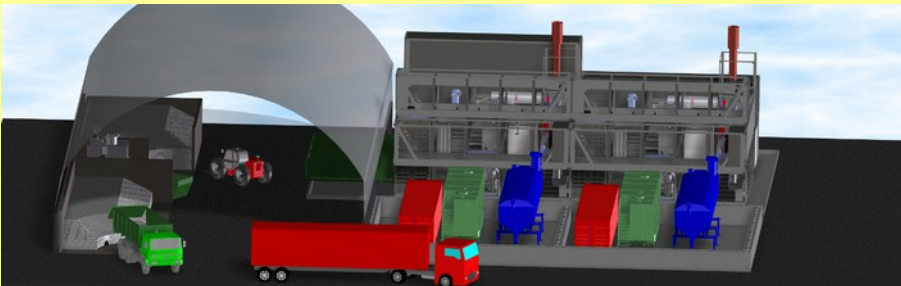
•Optional:

- 40 Desulphuring
- 50 Oil CHP (own power+ external peak power)
- 70 Wind generator / photovoltaic

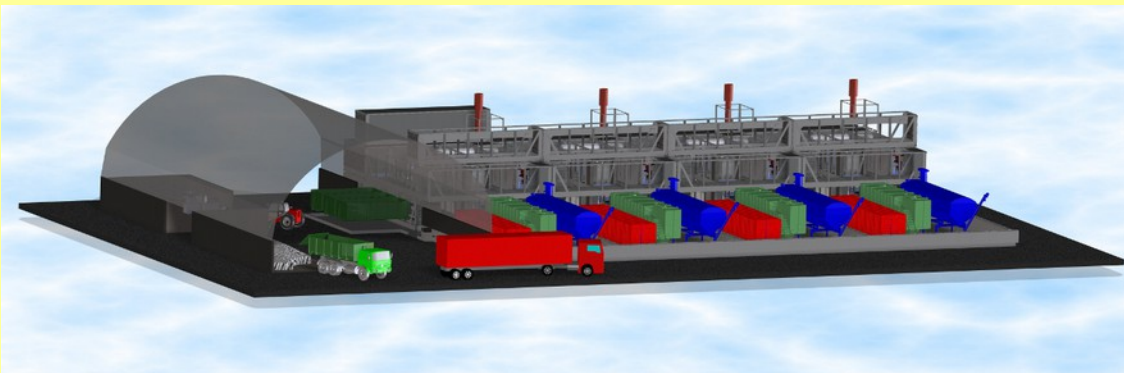
Performance data MIDI



600°C		Mass-%	MIDI
Product input	scrap tires		600,00 kg/h
Products output	Carbon 83%	40,0%	240,00 kg/h
	condensate	49,0%	294,00 kg/h
	gas	11,00%	66,00 kg/h



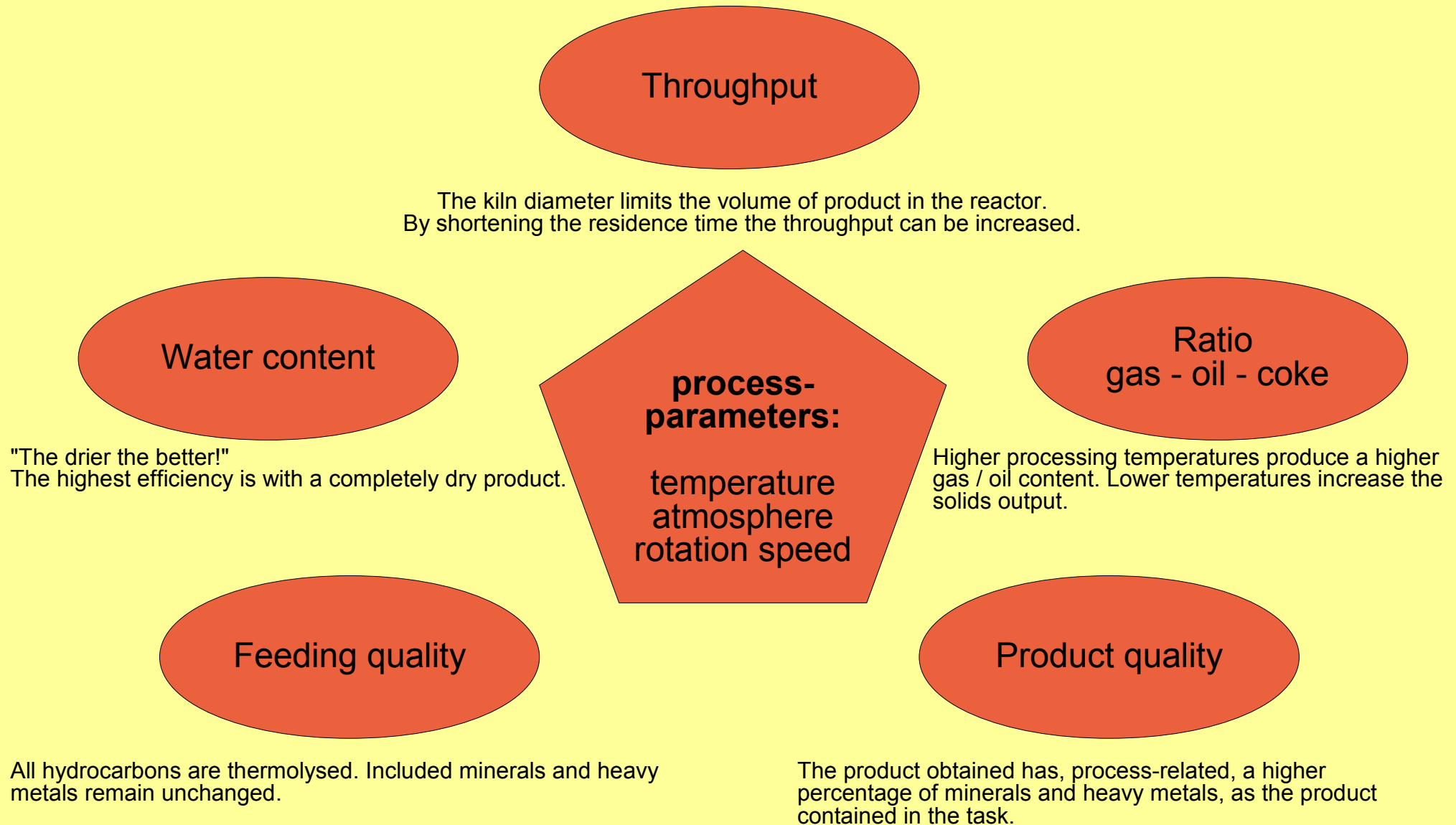
600°C		Mass-%	MIDI-Duo
Product input	scrap tires		1.200,00 kg/h
Products output	Carbon 83%	40,0%	480,00 kg/h
	condensate	49,0%	588,00 kg/h
	gas	11,00%	132,00 kg/h



600°C		Mass-%	MIDI-Quad
Product input	scrap tires		2.400,00 kg/h
Products output	Carbon 83%	40,0%	960,00 kg/h
	condensate	49,0%	1.176,00 kg/h
	gas	11,00%	264,00 kg/h

Please note: Special customer's designs are possible!

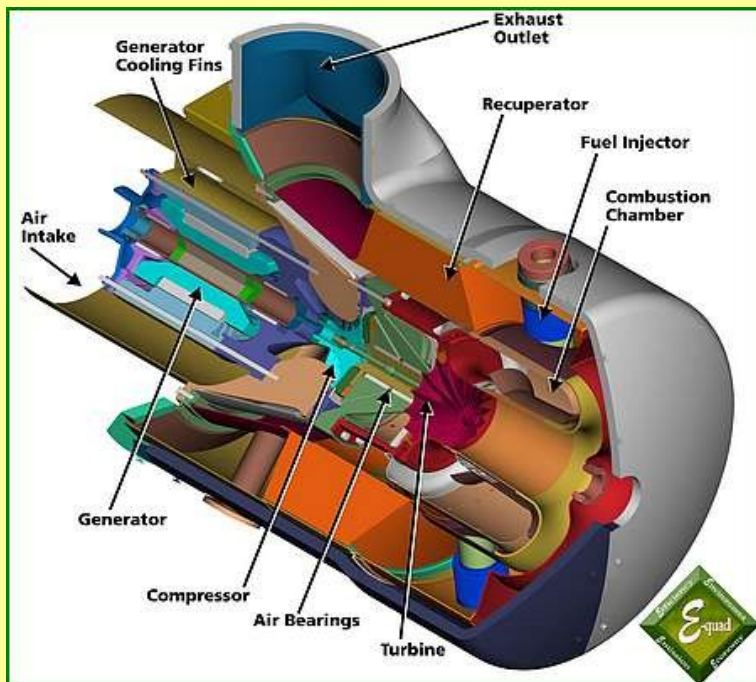
Influences on the process



Using of permanent gas

Due to safety reasons the permanent gas must be depolluted.

In worst case this gas can be simply burnt.
In standard case a power generation is much more sensefull.



The following points are advantages of this technology:

- No lubricating oils that need to be replaced regularly
- Air bearings for wear-free, long life
- No pistons or abrasive components
- High control range from 10 – 100% which allows an energy generation on demand
- High off gas temperature (280°C), can be used for generating steam and drying

Specification C1000 (5x C200)

- Manufacturer: Capstone
- Type: Gas turbine
- Nominal power: 5x 200 kW_{el.}
- Full load speed: 61.000 rpm (Nominal speed)
- Cooling type: air
- Off-gas temperature: 280°C
- Cooling liquid: -
- Consumption ca. 300g/KW at full load ca. 300 kg/h
- electrical effectiveness ca. 33%

Off-gas from the turbine

		Heating oil extra	scrap tire oil	scrap tire	scrap tire	oiling oil extra	ling oil extra	lig	limit value
Power, el.	kW				25,0	30,0	25,0		
T-air	°C	21,0	22,1	23,1	20,7	20,6	20,5		
T-Off-gas	°C	77,2	231,6	269,0	267,6	270,6	272,4		
CO	ppm	213	29	8	11	6	6		
CO	mg/Nm ³	266	36	10	14	8	8		50
NO	ppm	21	111	104	106	21	19		
NO2	ppm	4	0	0	0	0	0		
Nox Cal.	mg/Nm ³	51	228	213	217	43	39		200
NOx	ppm	25	111	104	106	21	19		
SO2	ppm	1	98	105	115	5	4		
SO2	mg/Nm ³	3	280	300	329	14	11		50

Notes:

The shown values have been measured with a standard diesel turbine.

The high SO₂-content results from a high sulphur content within the oil.
A reduction of the oil sulphur will decrease the SO₂-values.

The NO_x depends on the combustion parameters and can be reduced with appropriate adjustment.

Emergency power generation



Multi-fuel engines can use condensate oils of (almost) every quality.

Specification MTU 837 BA 500

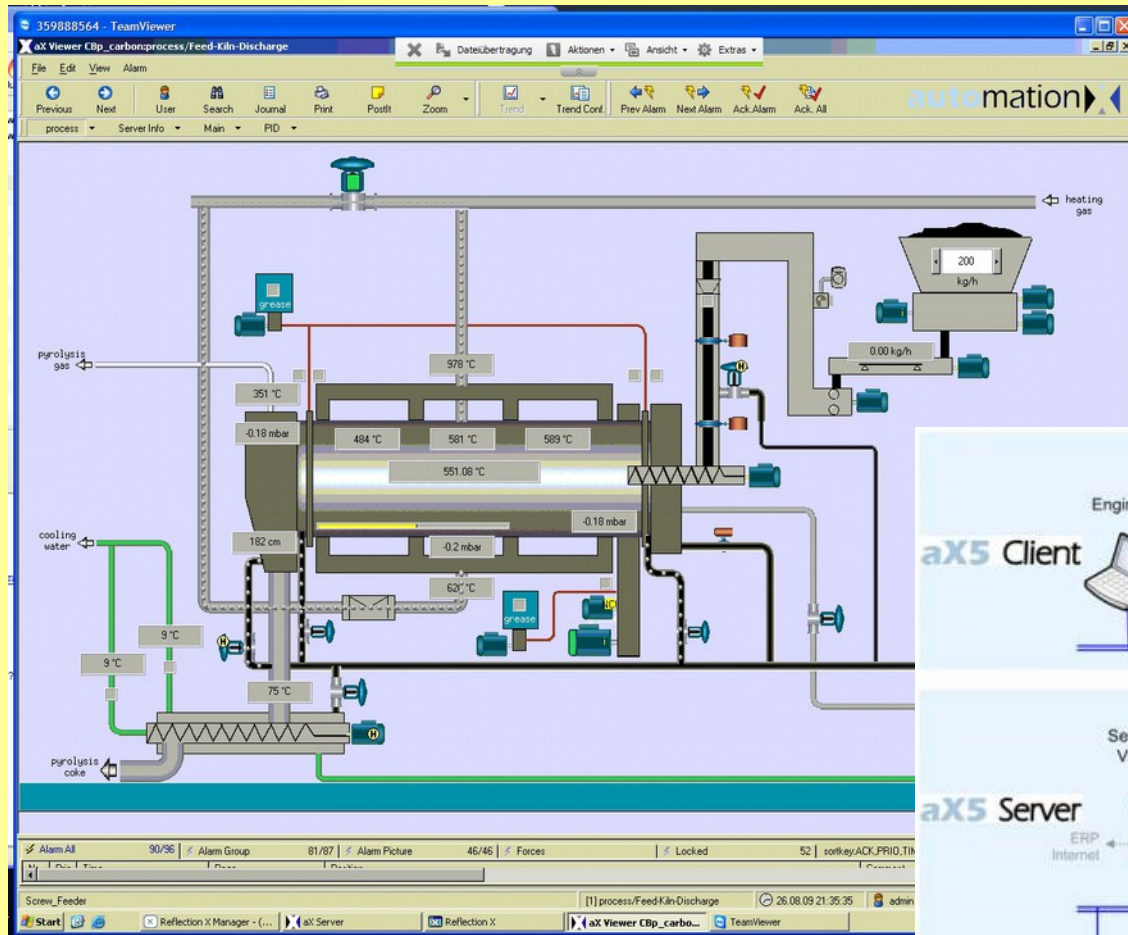
- Manufacturer: MTU Mercedes Benz Manufacture
- Design: V-shape 90 Type
- Mode of operation: Four stroke precombustion chamber with mechanical charging
- Number of cylinders: 8
- Total cylinder capacity: 29900 ccm
- Nominal power: 460 bis 485 kW according to DIN at 2200/ min
- Max. torque: 2206 Nm at 1750/ min
- Idle-running speed: 600 bis 630 / min (motor at operating temperature)
- Full load speed: 2200/ min (nominal speed)
- Cooling type: water circulation cooling
- Cooling liquid: 115 liter up to -20 °C frost-proof
- Engine oil pressure at operating temperature 6 bis 8 bar at 2200/ min
- Consumption 240g/KW at full load ca. 108 kg/h
- electrical effectiveness ca. 39%

A safe process?



Not this way !

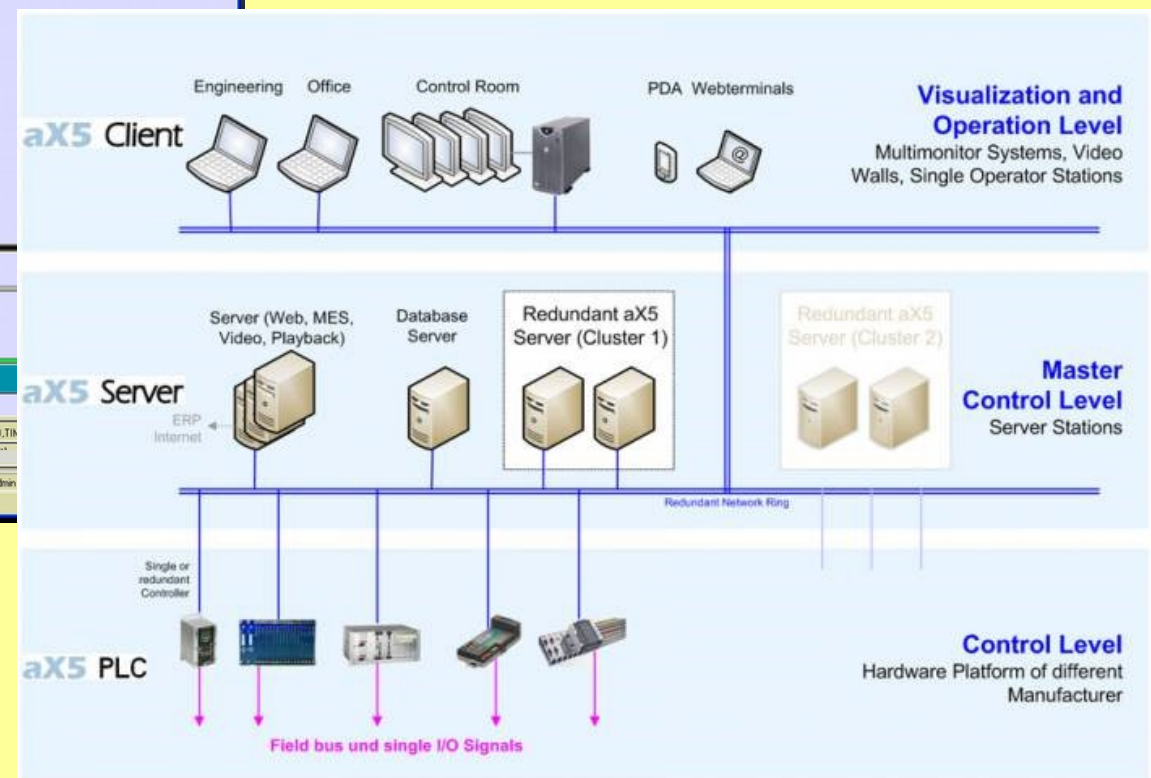
Process control system



The AutomationX is an industrially successful management and control system.

The plants are operated usually by local staff.

For optimizing or troubleshooting a remote access via a secure VPN-line via Internet.





Process safety !

Only by using **comprehensive sensor technology** the process control system can react appropriate on possible changes and incidents.

Only by **redundancy of measurement points**, especially of the relevant measurements, according to SIL-concept, the control system receives reliable data.

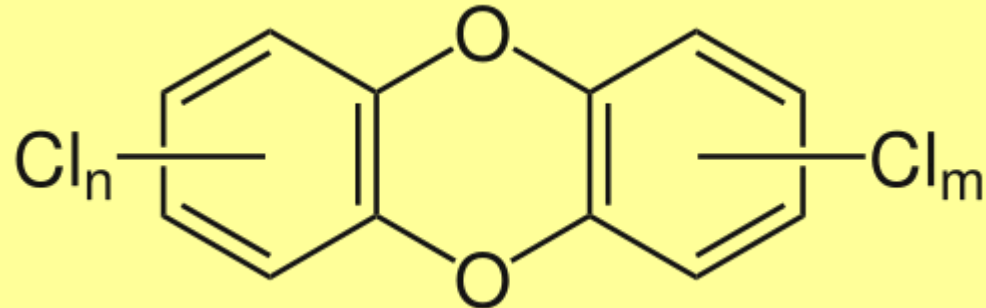
Only by thorough **FME-analysis** the control system gets routine to guarantee safe handling of malfunctions.

Only by comprehensive **Log-functions** of all parameters a correct operation is traceable and the QS-system reliable.

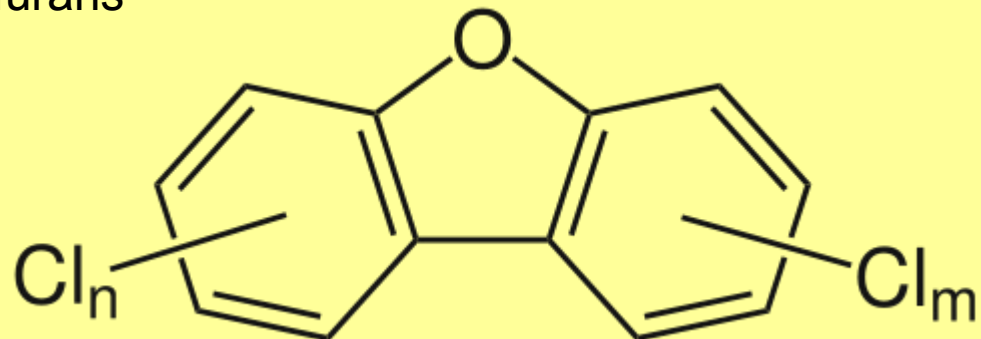
Only by **comprehensive connecting of the complex measurement results** regulation of the process is possible at all.

Prejudice: dioxines + furans

Polychlorinated dibenzodioxines



Polychlorinated dibenzofurans



Prejudice: emissions

Fine dust

Limit value for this facility according to 17. BImSchV	Measured value MPA Burgau (LUA Bayern)	Bagatelle mass flow TA-Luft	Limit value For pellet heating	Limit value for stoves 1. BImSchV
10 mg/m ³	1,3 mg/m ³	1.000.000 mg/h (1.000 m ³ /h * 1 g/m ³)	60 mg/m ³	100 mg/m ³

Dioxine

Limit value Daily average value for this plant according to 17. BImSchV	Measured value Annual average value MPA Burgau (LUA Bayern)	Bagatelle mass flow Technical instructions on air quality control
0,1 ng/m ³	0,0013 ng/m ³ (unsorted waste + combustion chamber)	-- mg/m ³

Mercury

Limit value Daily average value for this plant according to 17. BImSchV	Measured value Annual average value MPA Burgau (LUA Bayern)	Bagatelle mass flow According to technical instructions on air quality control
0,03 mg/m ³	0,00089 mg/m ³ (unsorted waste + combustion chamber)	2.500 mg/h (1.000 m ³ /h * 2,5 mg/m ³)

Prejudice: new patent



HERKO Pyrolyse GmbH.
& Co. Recycling KG.

AUSFÜHRLICHE SYSTEMBESCHREIBUNG

des

H. R. R. - Systems



H.R.R. System

Projekt: Altreifen-Pyrolyse

Projekt Nr.:

Datum: 31. März 1981

bearbeitet durch: Herrmann

Blatt: 19

7.3.2

Physikalische und chemische Kennwerte des Kondensats (Mittelwerte)

Kenngrößen

Einheit

Wert

Nachweismethode

Gesamtausbeute

best. auf %

43,1

gravimetrisch

Farbe

tiefschwarz

Auge

Geruch

intensiv

Heizwert

spezifisch

Nasse

Brennwert

Ho

40'161

Kalorimeter

Wassergehalt

42'406

Kalorimeter

Dichte bei 15 °C

8,6

DIN 51 582

Viskosität bei 15 °C

g/ml

0,937

DIN 51 757

Viskosität bei 20 °C

m Pa s

8,42

DIN 51 562

Viskosität bei 25 °C

m Pa s

7,09

DIN 51 562

Viskosität bei 30 °C

m Pa s

6,03

DIN 51 562

Viskosität bei 35 °C

m Pa s

5,21

DIN 51 562

Viskosität bei 40 °C

m Pa s

4,55

DIN 51 562

Spez. Wärme bei 20 °C Cp

m Pa s

4,13

DIN 51 562

Koksrückstand nach Conradson

kJ/kg.K

1,96

Kalorimeter

Flammpunkt im geschlossenen Tiegel

Gew. %

2,7

DIN 51 511

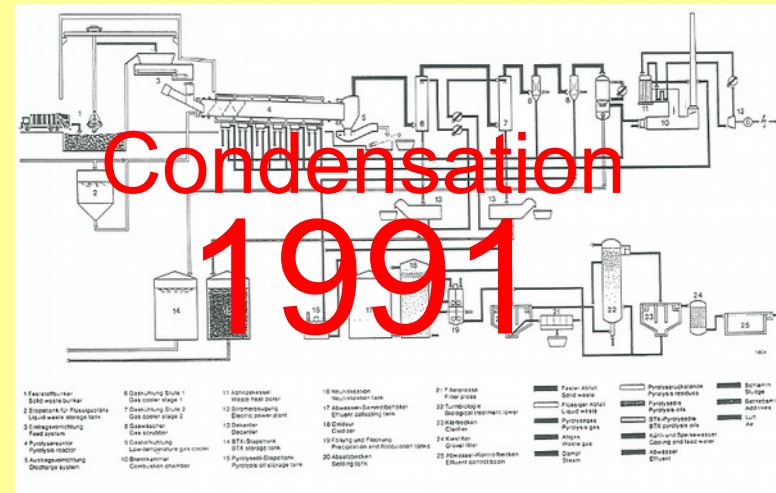
Brennpunkt

°C

~8

DIN 51 758

Scrap tires
1981



Condensation
1991



Altreifen
2009

New:

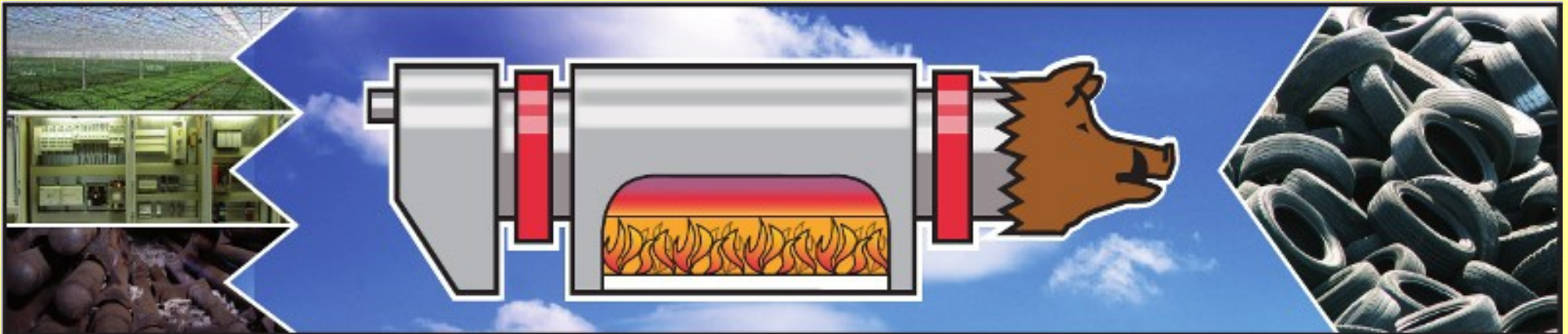
Equal consideration of all three products:

- Solid (coke / carbon black / fertilizer)
- Condensate (chemical raw material)
- Gas

... additionally:

- Combination with re-newable energies
- Possibility of power network stabilization

Thank you!



Further product applications

wood
wood chips
wood pellets

Animal manure
camel dung

plastic chips

straw pellets

hazelnut shells
coconut shells
palm oil shell

sewage sludge

bamboo

oil sludge
(for cleaning of contaminated soil)

miscanthus

Waste wood

tetra pack fluff
(creates aluminum chips)

**Mixing of the products is generally possible,
but economical not recommendable!**

Tires - Ingredients

Element	Unit
Rubber	47 %
Carbon Black + filler	21,5 %
Mesh	5,5 %
Ferrum	16,5 %
Oils	9,5 %

Element	Unit
Zinc oxide	1 %
Sulphur	1,5 %
Nitrogen	0,5 %
Stearic acid	0,3 %
Halogenes	0,1 %
Copper compounds	450 mg/kg
Lead	410 mg/kg
Cobalt	250 mg/kg
Chrome	97 mg/kg
Nickel	77 mg/kg
Arsis	20 mg/kg
Cadmium	8 mg/kg
Quicksilver	0,177 mg/kg

Source: Newsletter Bavarian State office for environment June 2011

German regulations ...

Minimum distance

Scrap tires are declared as **non hazardous waste** (waste classification key 160103)

According to the 4th BImSchV such a plant is classified (in accordance with 8.1(1)a)) as:
Facilities for removal or recycling of solid, liquid or gaseous materials by means of thermal treatment (pyrolysis facilities) up to 3 t/h.

In agreement with appendix 2 distance decree "Immission relevant facilities which are not included in the distance list", valid for this type of facility is : **No minimum distance!**

Requirements for sites

For such a facility (in Germany) a commercial-industrial site or a special site is required