
# Metal soaps under the viewpoint of sustainability - One Vision

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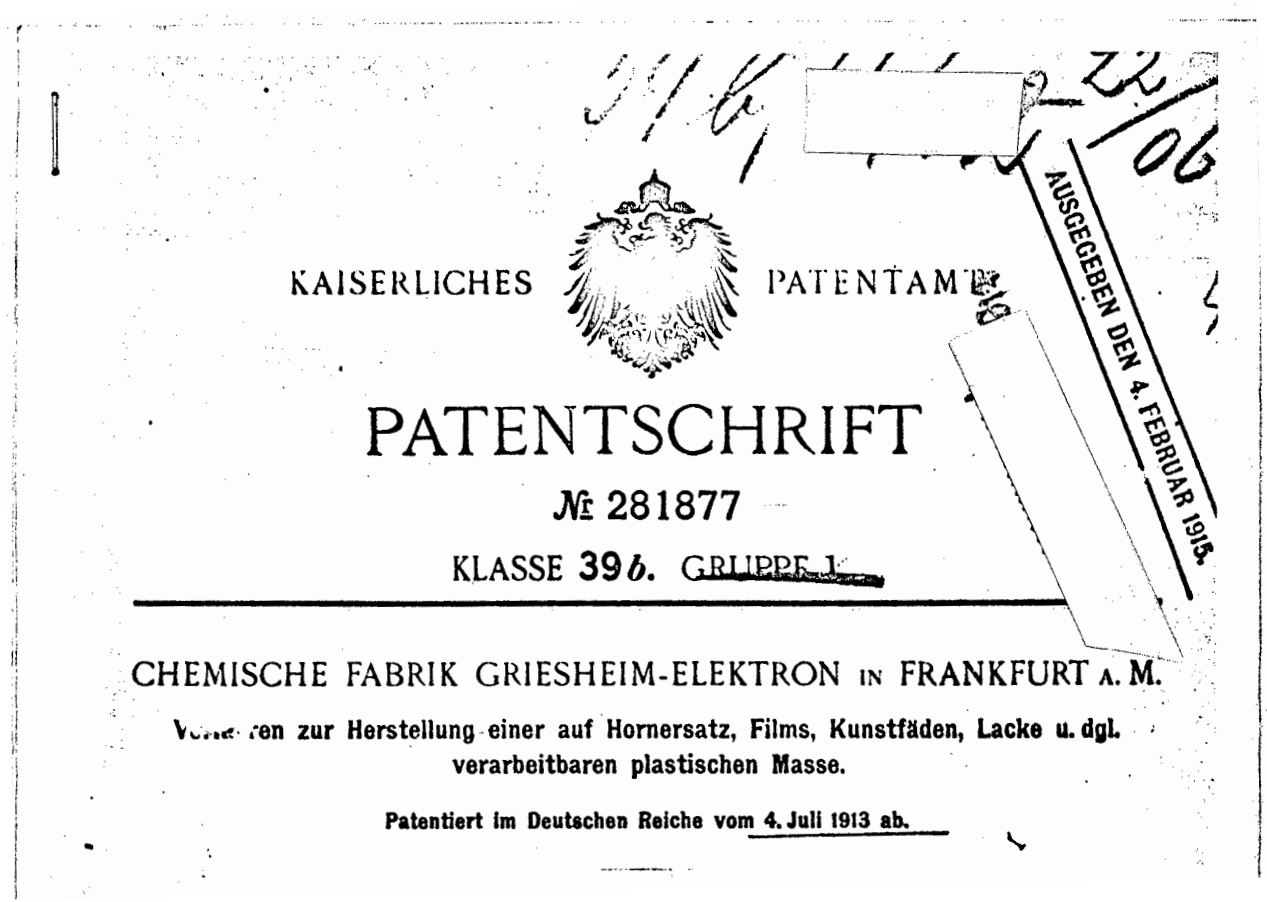
# About PVC

- 1st patent claiming the industrial production of PVC filed by Klatte, Zacharias and Rollett on 04.07.1913



KAISERLICHES PATENTAMT

AUSGEGEBEN DEN 4. FEBRUAR 1915.

# PATENTSCHRIFT

№ 281877

KLASSE 39*b*. GRUPPE 1.

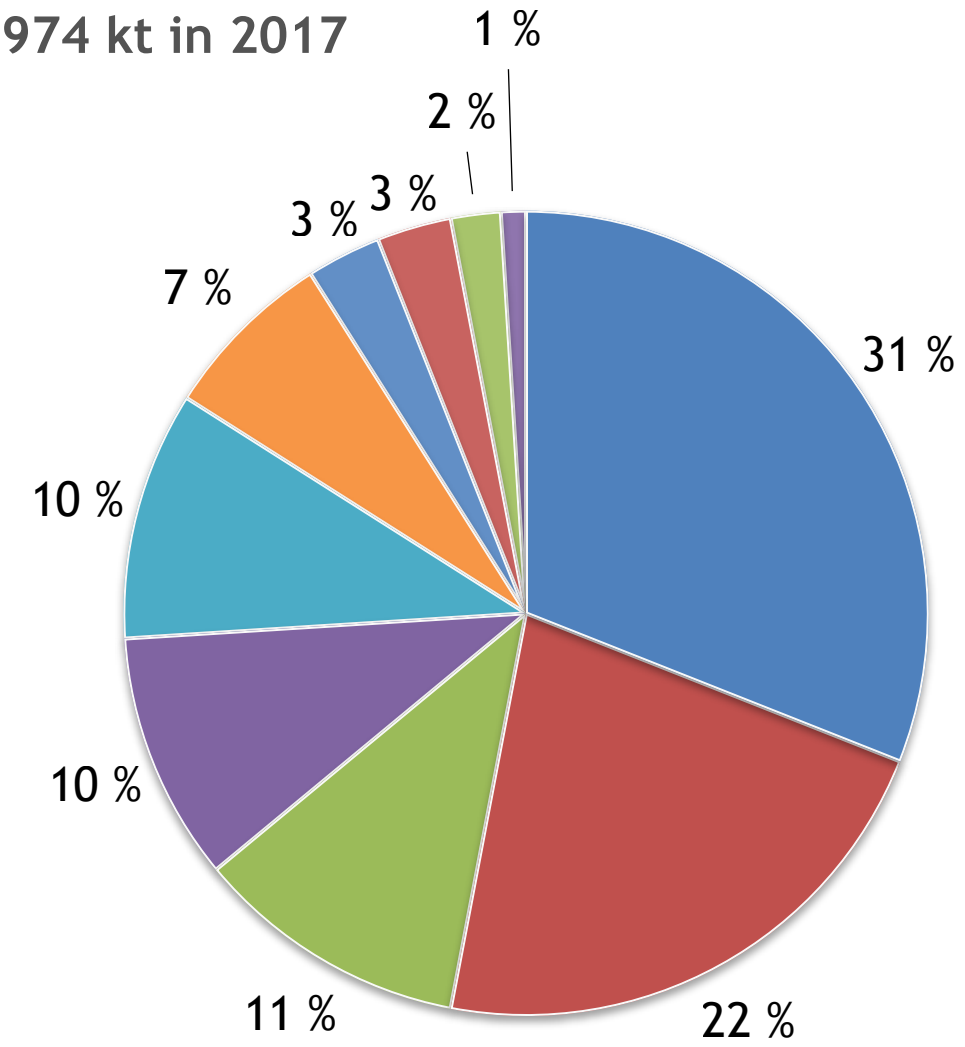
CHEMISCHE FABRIK GRIESHEIM-ELEKTRON IN FRANKFURT A. M.

Verfahren zur Herstellung einer auf Hornersatz, Films, Kunstfäden, Lacke u. dgl. verarbeitbaren plastischen Masse.

Patentiert im Deutschen Reiche vom 4. Juli 1913 ab.

# Global PVC Consumption by Main Applications

44'974 kt in 2017




- Pipe, Conduits
- Others
- Film
- Sheet
- Injection moulding
- Wire &Cable
- Soread coating
- other non-extrusion
- Blow moulding
- Rotomoulding

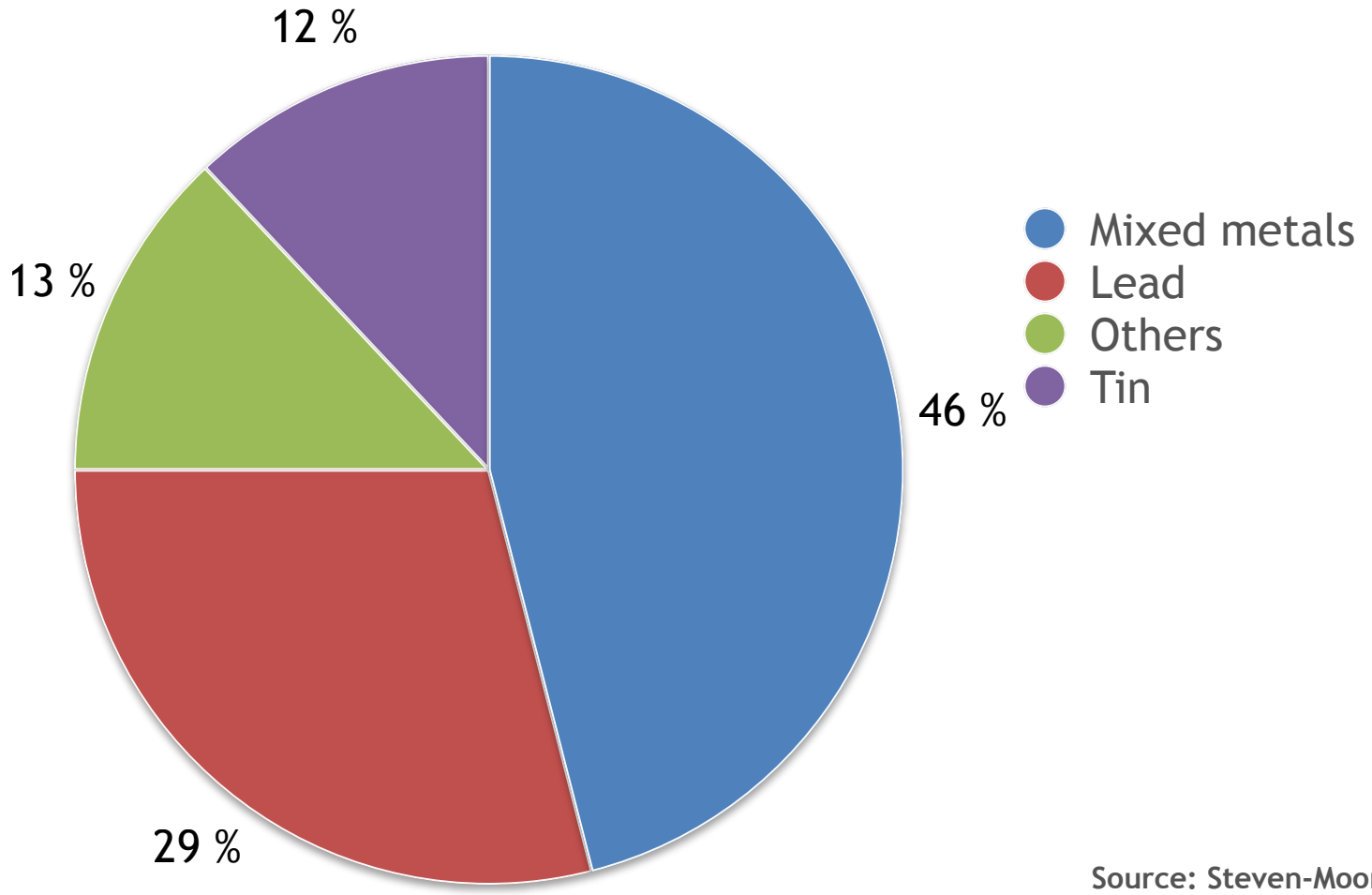
Rigid profiles
- Window
- Door
- Siding
- Ceiling
- Flooring

Flexible profile
Hose & tube
Fiber

Source: Steven-Moore, Townsend Solutions „Global Trends in PVC Resin Applications and Additives Usage“15.03.2018

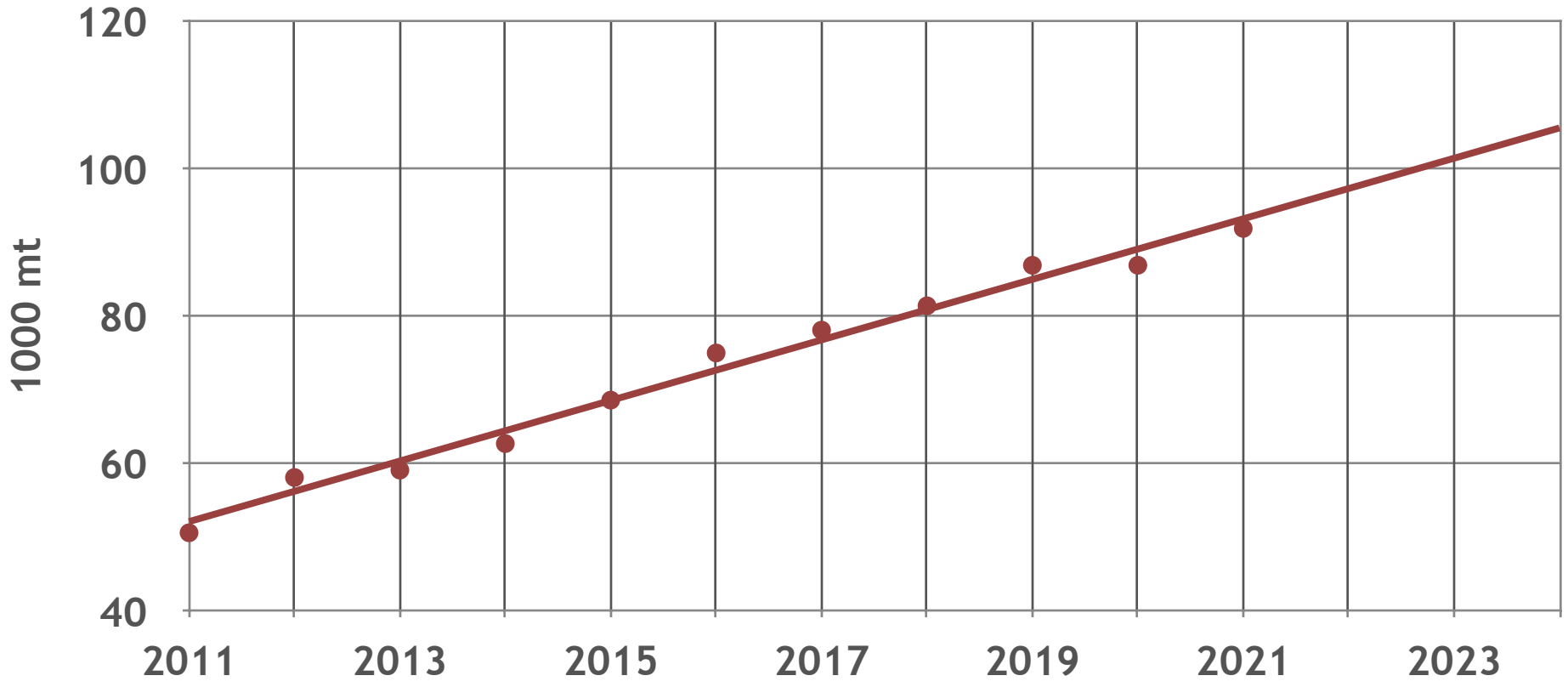
# Global Heat Stabilizer Consumption by Type

1’126 kt in 2017




Source: Steven-Moore, Townsend Solutions „Global Trends in PVC Resin Applications and Additives Usage“15.03.2018

# Annual PVC stabiliser consumption in India

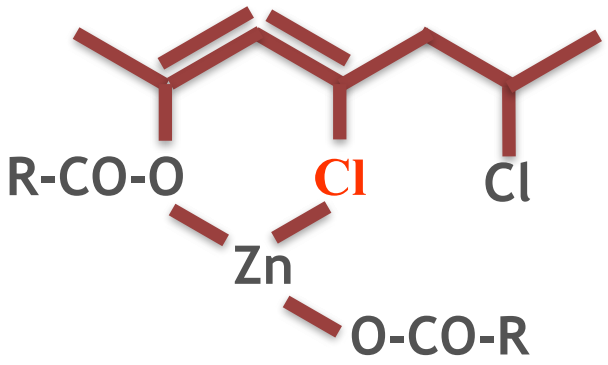


# About PVC stabilisers

- Substitution of unstable chlorine atoms in PVC chain
- Neutralisation of HCl
- Shortening the pollen sequences
- Avoiding autoxidation
- Guaranteeing optimal processing and best performance of final product during ist lifetime
- Systems based on:
  - Lead
  - Tin
  - Antimony
  - Barium
  - Calcium
  - Cadmium
  - Zinc
  - Lanthanum

# How does a metal soap „work“ in PVC?

- Metals: Mg, Ca, Ba, Zn, Cd, Pb, (K)
- Acids: Stearic, Oleic, Benzoic, Lauric, 12-Hydroxystearic, Octanoic, 2-Ethyl-hexanoic, Montanoic




$Zn(O\text{-}CO\text{-}R)Cl + Ca(O\text{-}CO\text{-}R)_2 \Rightarrow Zn(O\text{-}CO\text{-}R)_2 + Ca(O\text{-}CO\text{-}R)Cl$

# Production of metal soaps

- Principles:

$MeO + 2\ HAc \rightarrow MeAc_2 + H_2O$

$Me(OH)_2 + 2\ HAc \rightarrow MeAc_2 + 2\ H_2O$

Me : metal
HAc: acid

# Baseline line analysis of metal soap production

- Direct reaction of metal (hydr)oxide and acid in water as reaction media without any by-product beside water
- Direct and dry conversion of acid and metal (hydr)oxide without solvent in a high speed mixer without any by-product beside water
- Melt process at temperatures depending on the melt temperature of the metal soap and the acid without any by-product beside water
- Two step process in water:
  - Formation of alkaline (mainly Sodium) salt
  - Addition of a solution of the soluble metal salt (e.g. Calcium chloride)
  - By-product: alkaline salt (e.g. Sodium chloride) dissolved in water

# Introduction in TNS Framework - Scientific background

- The earth is a closed system regarding matter. (Nothing disappears. Nothing is added.)
- All geological processes are slow. (Therefore everything that is on the surface of the earth stays permanently there.)
- The earth is an open system regarding energy.

- 1st law of thermodynamics; the conservation of energy. (Energy can neither be created nor destroyed, only converted into other types of energy. Matter can be converted into energy, heat and movement.)

- 2nd law of thermodynamics, the introduction of entropy. (A system is all the more stable the greater the disorder in this system.)
- Photosynthesis is the "motor of all life" on earth.

- From the local to the global.
  From a few, large sources to diffuse, scattered sources.
  From short maturities to long and delayed.

# Introduction - Four System Conditions (SC) of TNS

*In a sustainable society nature is not subject to systematically increasing...*

1 ... concentrations of substances extracted from the earth's crust

2 ... concentrations of substances produced by society

3 ... degradation by physical means

4 ... and, in that society, people are not subject to conditions that systemically undermine their capacity to meet their needs

# System Conditions 1 of TNS

*In a sustainable society nature is not subject to systematically increasing...*

1 ...
concentrations of substances extracted from the earth's crust

| Element | mg/kg in the earth crust | kt/year Erosion (ε) | kt/year Mining (μ) | kt/year Fossil fuels (*f*) | (μ+*f*/ε) |
|---|---|---|---|---|---|
| Ca | 50·10⁶ | 750·10⁶ | | | <1.000 |
| Na | 23·10⁶ | 345·10⁶ | | | <1.000 |
| Si | 310000.0 | 4700000.0 | 4600.0 | 95000.0 | 0.021 |
| Mg | 9000.0 | 140000.0 | 3100.0 | 690.0 | 0.028 |
| Al | 72000.0 | 1100000.0 | 18000.0 | 34000.0 | 0.048 |
| Ti | 2900.0 | 44000.0 | 2500.0 | 1700.0 | 0.096 |
| K | 15000.0 | 230000.0 | 24000.0 | 340.0 | 0.110 |
| La | 32.0 | 480.0 | 12.5 | 0.3-258.2 | 0.027-0.564 |
| Ba | 400.0 | 6000.0 | 4532.0 | 117.8 | >0.800 |
| Fe | 26000.0 | 390000.0 | 540000.0 | 34000.0 | 1.500 |
| P | 430.0 | 6500.0 | 21000.0 | 1700.0 | 3.500 |
| S | 1600.0 | 33000.0 | 58000.0 | 100000.0 | 3.700 |
| Cd | 0.4 | 5.3 | 20.0 | 3.4 | 3.900 |
| C | 25000.0 | 780000.0 | - | 5400000.0 | 6.400 |
| Zn | 60.0 | 910.0 | 7300.0 | 260.0 | 8.300 |
| Sn | 1.3 | 20.0 | 210.0 | 5.7 | 11.000 |
| Pb | 19.0 | 290.0 | 3300.0 | 85.0 | 12.000 |
| Al | 72000.0 | 1100000.0 | 18000.0 | 34000.0 | 0.048 |
| Ti | 2900.0 | 44000.0 | 2500.0 | 1700.0 | 0.096 |

# Compelling vision of fully sustainable metal soaps

**SC 1**

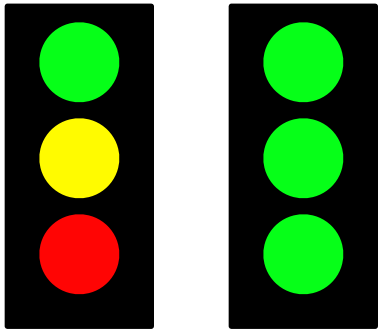
All used substances in a metal soap must have the ratio $(\mu+f/\varepsilon) < 1$.
Energy source must be renewable!
Raw material must be either from renewable sources or based on recycling.
Metal soap itself and its decomposition products must be non-hazardous and non-toxic.

**SC 2**

Organic raw materials used during production of metal soap must be based on renewable resources and degradable.
Organic parts of metal soap, which can migrate, must be degradable.
Emissions and waste of production and during the use of metal soap must be either degradable or recyclable. Recycling process must be clean.
There must not be any contribution to the progressive buildup of chemicals and compounds produced like dioxins…

**SC 3**

The mining of raw materials must be in that way that the natural conditions are not disturbed and later can be restored.
Storage of waste products must be in that way that the natural conditions are not disturbed and later can be restored.



Today



Vision

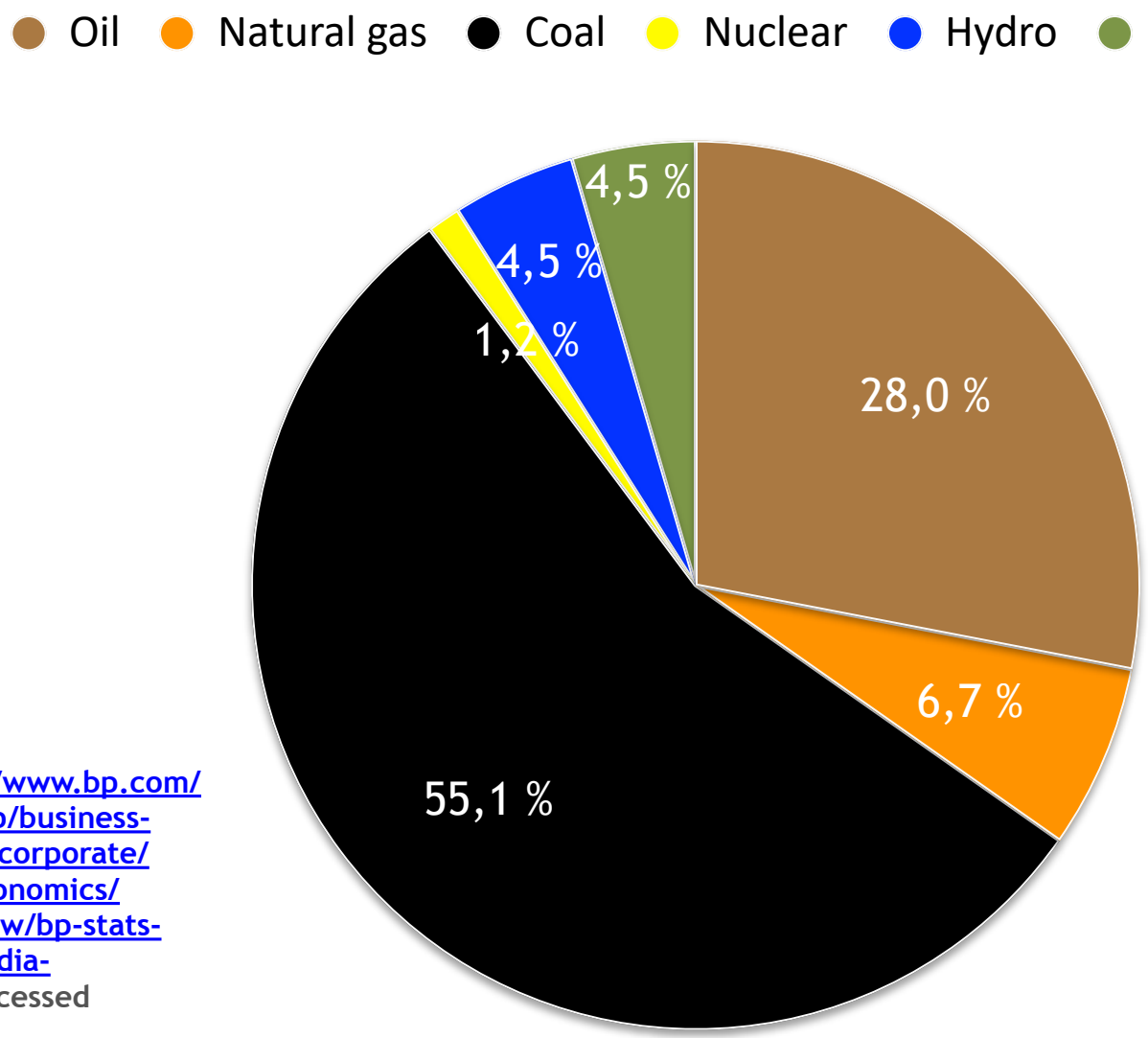
**SC 4**

A reliable performance is required to satisfy the needs of life.
The metal soaps may not have any negative influence during recycling of "end of life" products and on the performance of the new product, if:

- based on the “end of life" product a new analogous product is produced
- recycled material is mixed with fresh material

Social value = social benefit - social costs → final products may not have any negative effect on wealth of people or their environment
The production of metal soaps must guarantee the economical survival of the producer and user.

# Baseline line analysis of metal soap production - use of primary energy in India in 2020




Source: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-india-insights.pdf; accessed 31.10.2022

# Baseline line analysis of metal soap production - metal (hydr)oxides

| | SC 1 | SC 2 | SC 3 | SC 4 |
|---|---|---|---|---|
| MgO |  |  |  |  |
| $Ca(OH)_2$ |  |  |  |  |
| $Ba(OH)_2$ |  |  |  |  |
| ZnO |  |  |  |  |
| PbO |  |  |  |  |
| CdO |  |  |  |  |

# Baseline line analysis of metal soap production - acids

| Acid | SC 1 | SC 2 | SC 3 | SC 4 |
|---|---|---|---|---|
| Stearic |  |  |  |  |
| Oleic |  |  |  |  |
| Lauric |  |  |  |  |
| 12-HOST |  |  |  |  |
| Caprylic |  |  |  |  |
| Benzoic |  |  |  |  |
| 2-Ethyl hexanoic |  |  |  |  |

# Baseline line analysis of metal stearates production - other parameter

| | SC 1 | SC 2 | SC 3 | SC 4 |
|---|---|---|---|---|
| Water |  |  |  |  |
| Energy |  |  |  |  |
| Packaging | ? | ? | ? | ? |
| Production plant |  |  |  |  |
| Waste | ? | ? | ? | ? |
| Transportation | ? | ? | ? | ? |

# Baseline line analysis of metal stearates production - end of service time

| | SC 1 | SC 2 | SC 3 | SC 4 |
|---|---|---|---|---|
| In land fill | Zn | | | |
| In combustion | Zn | | | |
| In recycling | | | | |

# Summary

- Metal soaps (Ca, Mg, Al) have already a high potential to become fully sustainable!
- Exceptiones are all soaps based on toxic metals like Lead and Cadmium
- Another exception is Zinc which will become sustainable if the PVC product is recycled.
- Metals soaps based on renewable acids have the highest sustainability potential today.
- Metal soaps based on fossil fuel have the lowest sustainability potential today.


Cover of QUEEN's Vinyl "Innuendo" © EMI