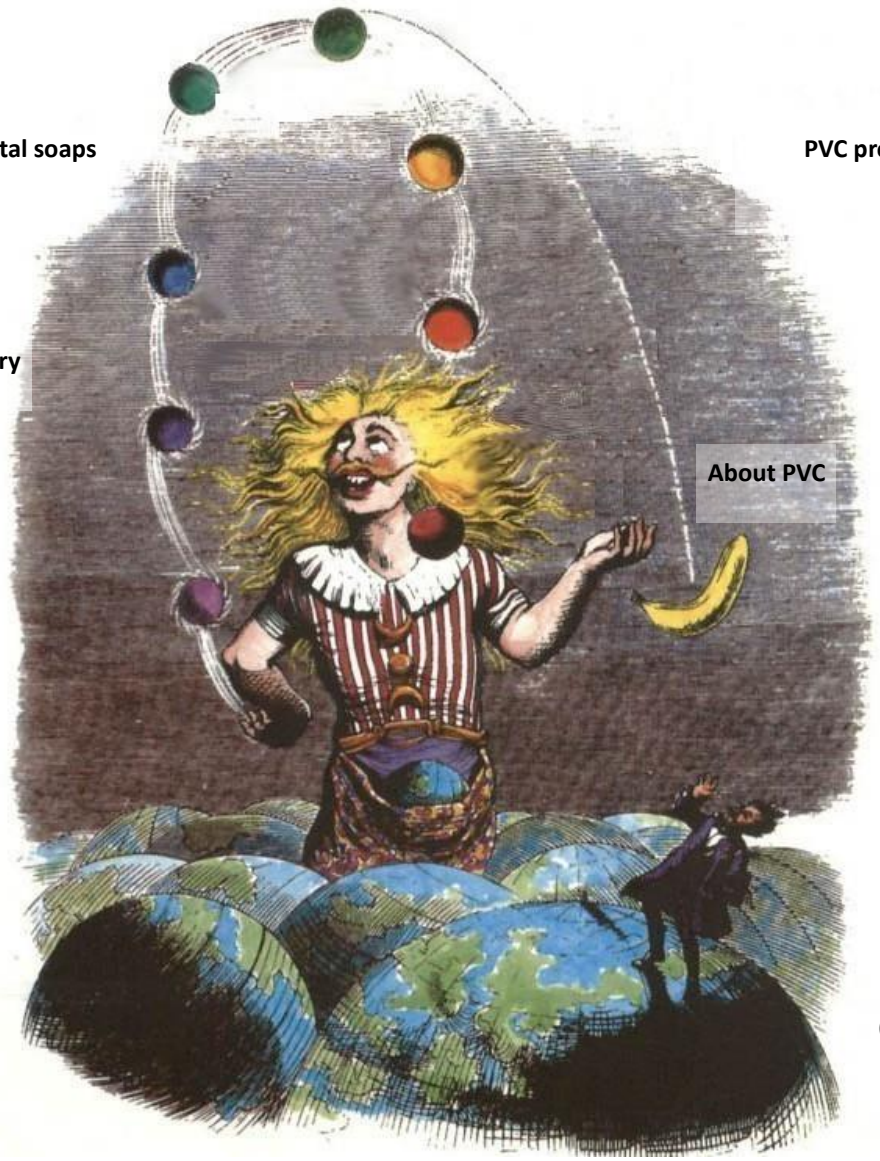
The Future Depends on What We Do Today - One Vision

Dr. M. SCHILLER

Platinum Industries Pvt Ltd

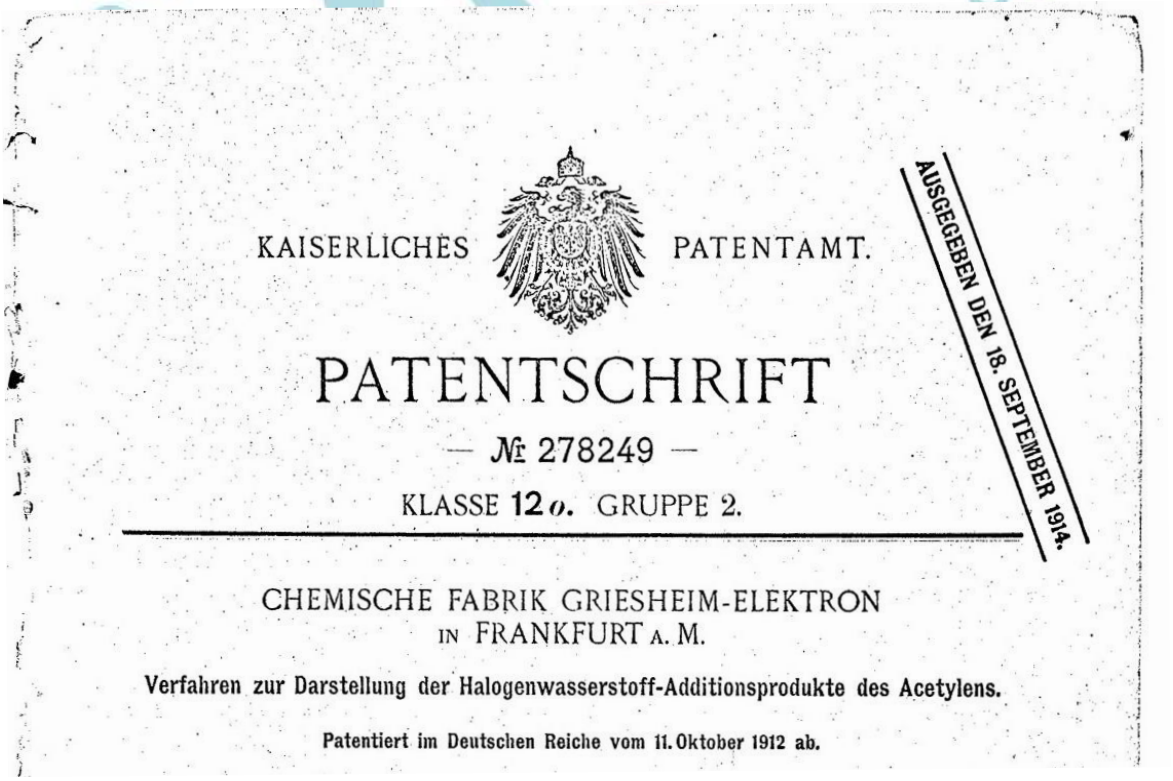


Cover of QUEEN's Vinyl "Innuendo" © EMI

About PVC

- **PVC was discovered in 1835**

- 1st **patent** about industrial production of VCM by Klatte, Zacharias and Rollett in 1912



KAISERLICHES PATENTAMT.

AUSGEGEBEN DEN 18. SEPTEMBER 1914.

PATENTSCHRIFT

— № 278249 —

KLASSE 12 *o*. GRUPPE 2.

CHEMISCHE FABRIK GRIESHEIM-ELEKTRON
IN FRANKFURT A. M.

Verfahren zur Darstellung der Halogenwasserstoff-Additionsprodukte des Acetylens.

Patentiert im Deutschen Reiche vom 11. Oktober 1912 ab.

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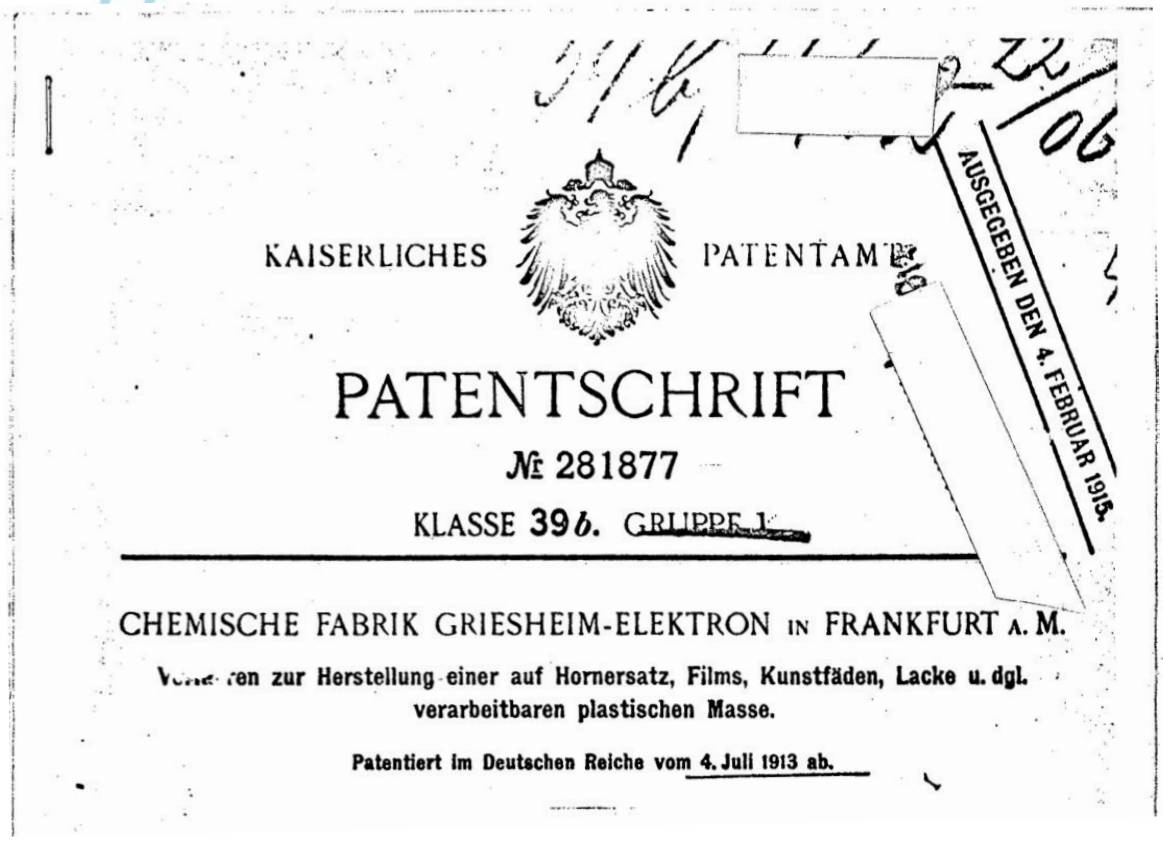
About PVC

- 2nd about industrial production of PVC by Klatte, Zacharias and Rollett in 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.

About PVC

- Industrial use started in 1929 (E-PVC), 1935 (S-PVC) and 1956 (M-PVC)
- PVC is needing stabiliser for processing
- At that time the stabilisers were mainly based on toxic heavy metals
- Vinyl 2010 was launched to phase out Lead stabilisers in Europe in 2000
- Single initiatives regarding sustainability evaluation of PVC and

Indian Vinyl Council

http://indianvinylcouncil.com/index

INDIAN VINYL COUNCIL

Indian Vinyl Council

The Indian Vinyl Council is set up and exclusively dedicated to the cause of entire PVC value chain. The objective of the forum is to serve all the stakeholders of Vinyl Family, that is, the resin producers, additives and related chemical producers, converters, processing and ancillary equipment manufacturers, recyclers of Vinyl products and the end users. With the active and harmonious participation; the members, end users and the public at large will all stand to reap considerable benefits.

The Council will play a pivotal role as the hub of advocacy between the government (state and central), policy makers, regulatory bodies and industry stakeholders to pave the way for the industry by eliminating obstacles and opening the doors to expand the market for the Vinyl industry.

Adding greater momentum to the growth of the Vinyl industry through networking will also be one of the core responsibilities of the Council. It will work towards increasing access to the industry's leaders and enabling them to connect seamlessly with suppliers, academia, regulators, scientists and experts through seminars, conferences, technical meetings and other events.

One of our top priorities is to ensure the efficient diffusion of knowledge to all our members, on the state of art technology, market perspectives, statistics & information and details of global initiatives on sustainability... all relevant to the Vinyl and allied industries.

Our focused approach is to work towards the welfare of mankind and encourage responsible care in an environmentally sustainable manner as practiced and specified in circular economy principles and models.

We strongly believe in supporting & encouraging innovation, and training & skill development within the Vinyl value chain, to facilitate raising the competency and the level of industry to global standards.

We are also committed to developing technical standards for maintaining quality and consistency to enhance the acceptance of Poly Vinyl Chloride and related products and multiply its application in all spheres of life.

Indian Vinyl Council - Members

1	Reliance Industries Limited	Privilege Member
2	Baerlocher India Additives Pvt. Ltd.	Privilege Member
3	Caprihans India Limited	Privilege Member
4	Goldstab Organics Pvt. Ltd.	Privilege Member
5	Indo-Reagens Polymer Additives Pvt Ltd	Privilege Member
6	Bihani Manufacturing Company Pvt. Ltd.	Privilege Member
7	Ori-Plast Limited	Privilege Member
8	The Supreme Industries Ltd	Privilege Member
9	Theysohn Extrusion	Privilege Member
10	Platinum Industries Private Limited	Privilege Member
11	NCL Veka Limited	Privilege Member
12	Manish Packaging Pvt Ltd.	Privilege Member
13	Finolex indistries Ltd	Privilege Member
14	Deceuninck Profiles India Pvt Ltd	Privilege Member
15	Basil Prompt Vinyl Pvt. Ltd.	Privilege Member
16	Amisha Vinyls Pvt Ltd	Privilege Member
17	Asia Pacific Vinyl Network	Honorary Member
18	PVC converters (India) Private Limited	Privilege Member
19	Pioneer Polyleathers Pvt Ltd	Privilege Member
20	Sun Ace Chemical India (Pvt.) Ltd.	Privilege Member
21	Encraft India Pvt. Ltd.	Privilege Member
22	Vihan Engineering Pvt. Ltd.	Privilege Member
23	Lubrizol Advanced Materials India Pvt. Ltd.	Privilege Member

Leading Change for a Sustainable Chemicals Industry

"the biggest sustainability challenge we face is... will there be enough leaders in time?"
Dr. Karl-Henrik Robèrt & Dr. Göran Broman

Certificate of Course Completion
granted to

Michael Schiller

from the Blekinge Institute of Technology
and the Natural Step

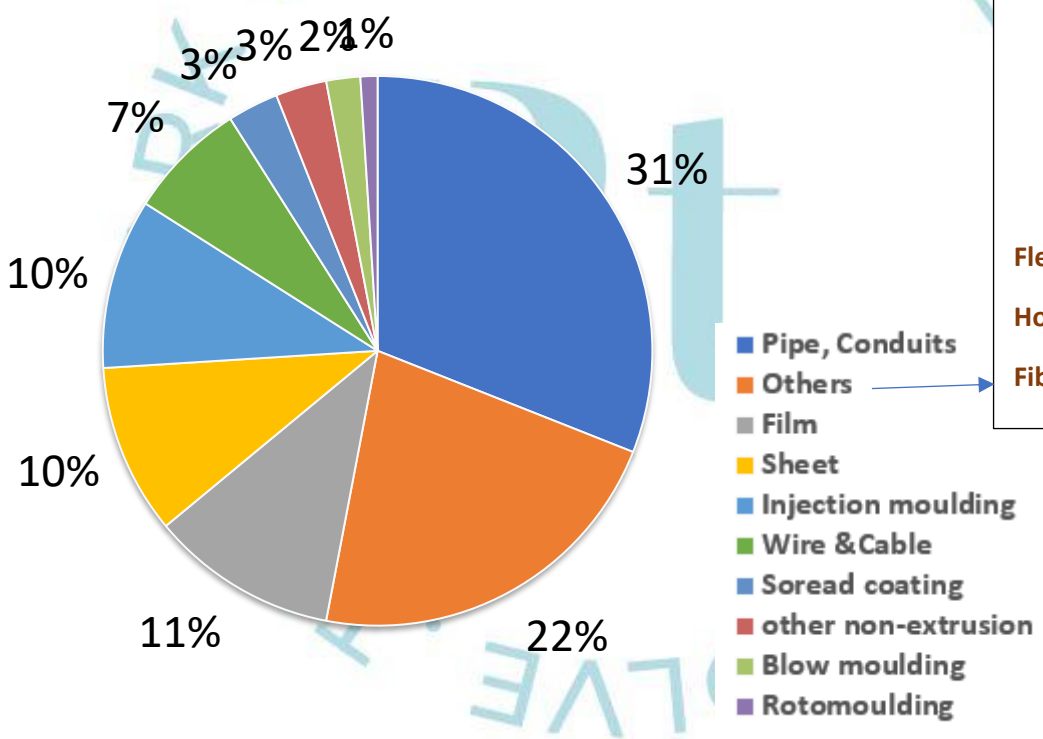
Göran Broman
Dr. Göran Broman
Blekinge Institute of Technology

Dr. Karl-Henrik Robèrt
Blekinge Institute of Technology
The Natural Step

the Natural Step

Global PVC Consumption by Main Applications

44'974 kt in 2017



Rigid profiles

- Window
- Door
- Siding
- Ceiling
- Flooring

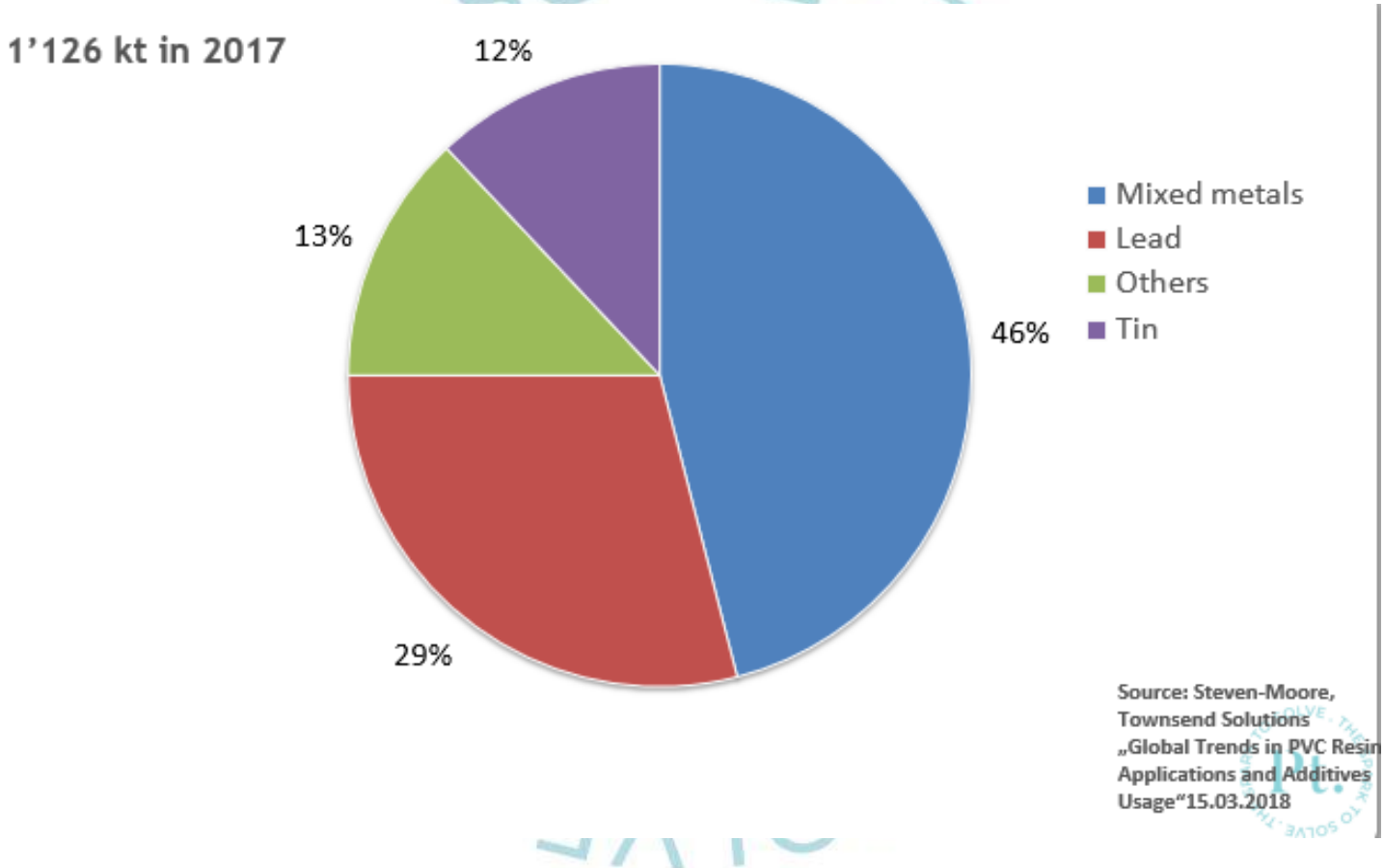
Flexible profile

Hose & tube

Fiber

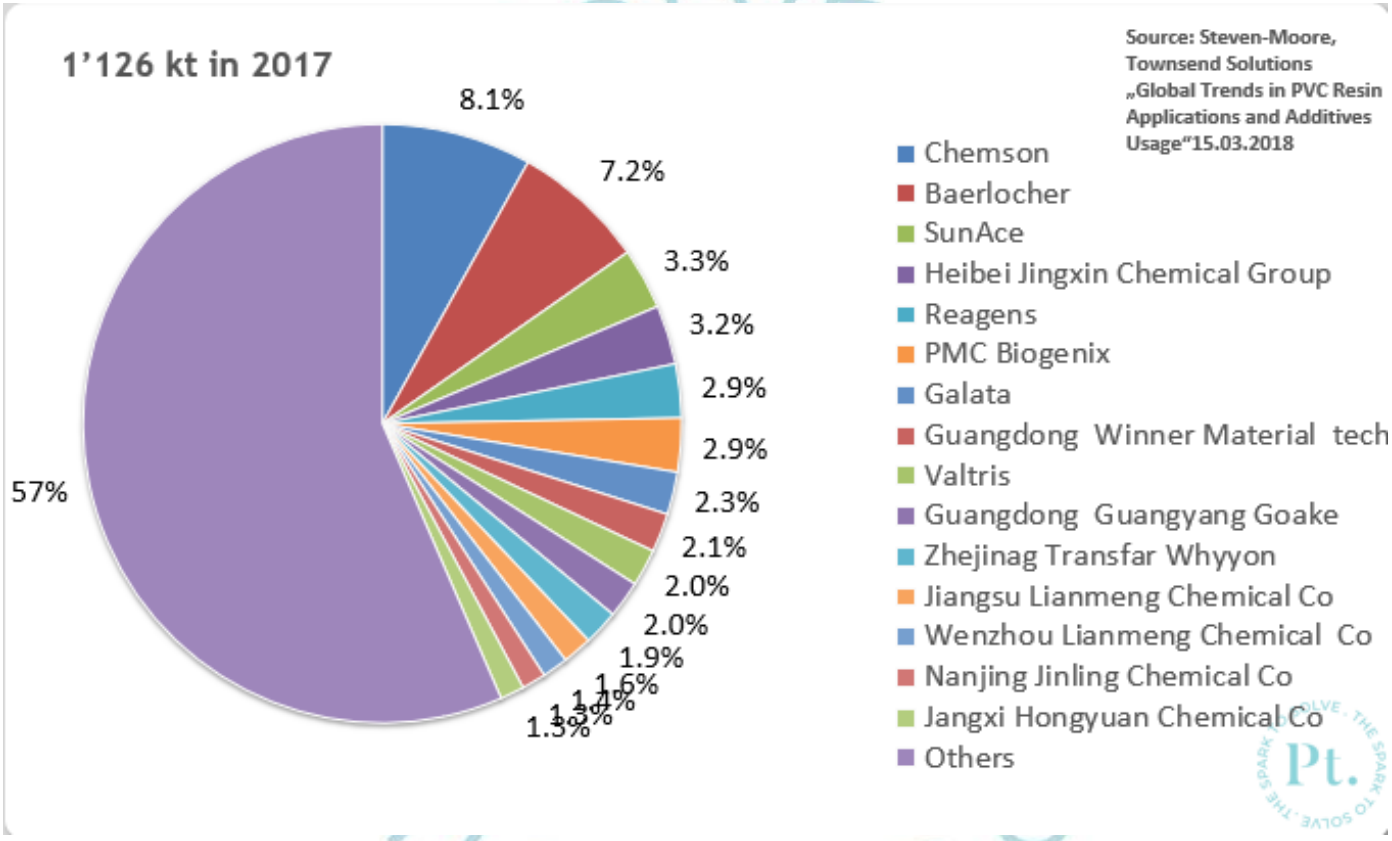
Source: Steven-Moore, Townsend Solutions „Global Trends in PVC Resin Applications and Additives Usage"15.03.2018

Global Heat Stabilizer Consumption by Type



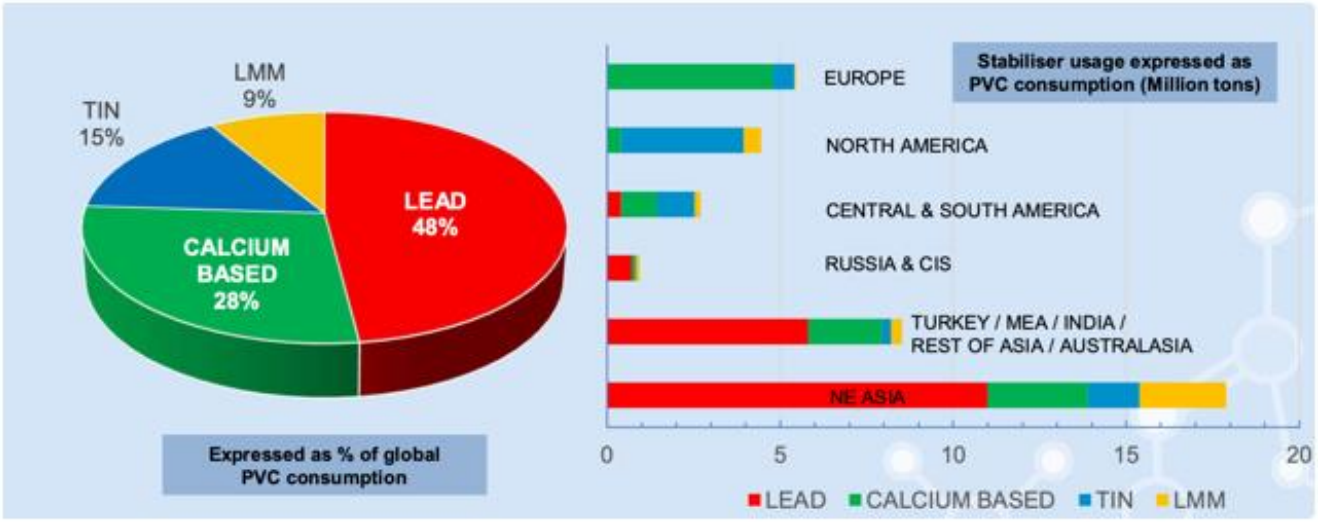
Source: Steven-Moore, Townsend Solutions „Global Trends in PVC Resin Applications and Additives Usage"15.03.2018

Global Heat Stabilizer Consumption by Type



Global Heat Stabilizer Consumption by Type

2019, expressed as PVC consumption (1000 kt)



Source: S. Fokken, R. Grasmück; „Stabilisation of PVC - A review of the switch away from Lead", PVC Formulation 2020, Cologne, Germany (02/2020)

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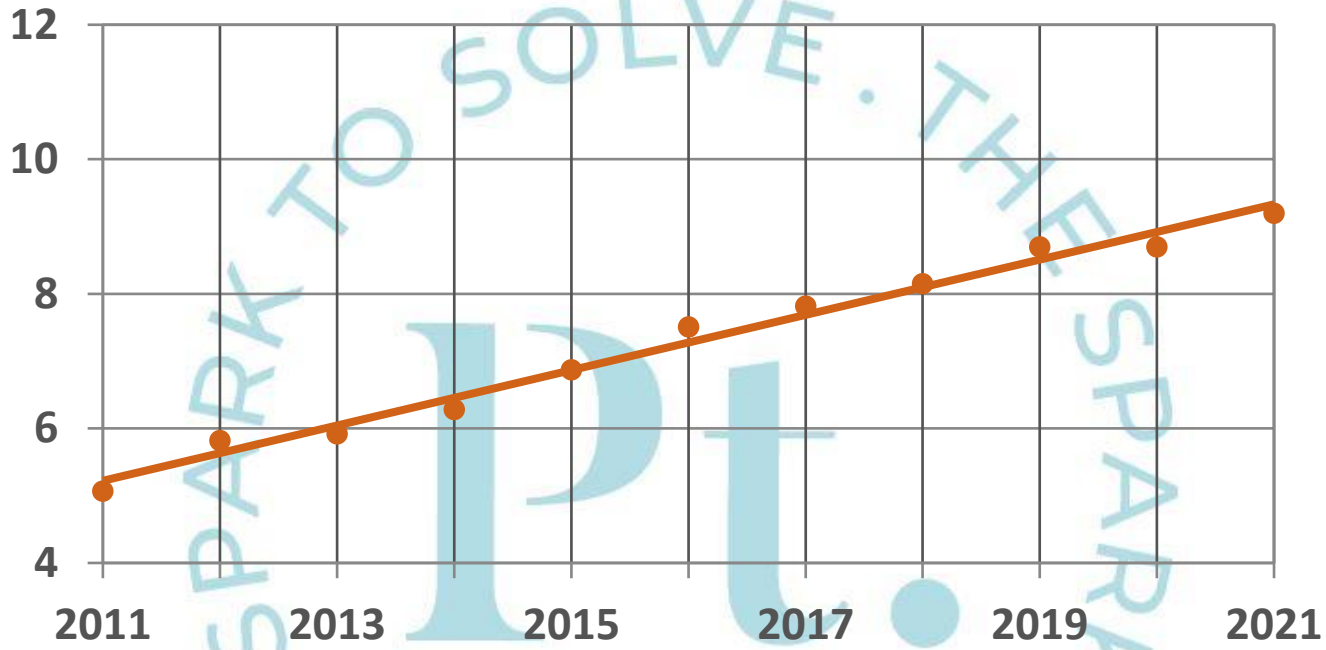
About Platinum

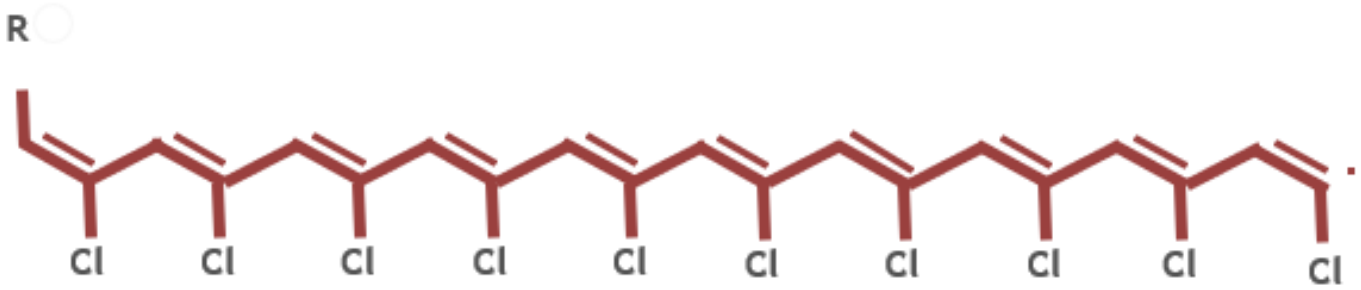
- Our vision: To be a globally respected name in the field of additives for the entire polymer range while pursuing scientific research for environment friendly products.
- Our mission: To become a leading global manufacturer of high-quality additives with a high sustainability and growth through innovations for the benefit of society, environment, and our customers.
- At the very early beginning in 2015 we sold 800 mt standard lead stabilisers per year.
- Now we reached >800 mt stabiliser sales per month. 65 to 80% of this is lead-free.

PVC market in India (million mt)

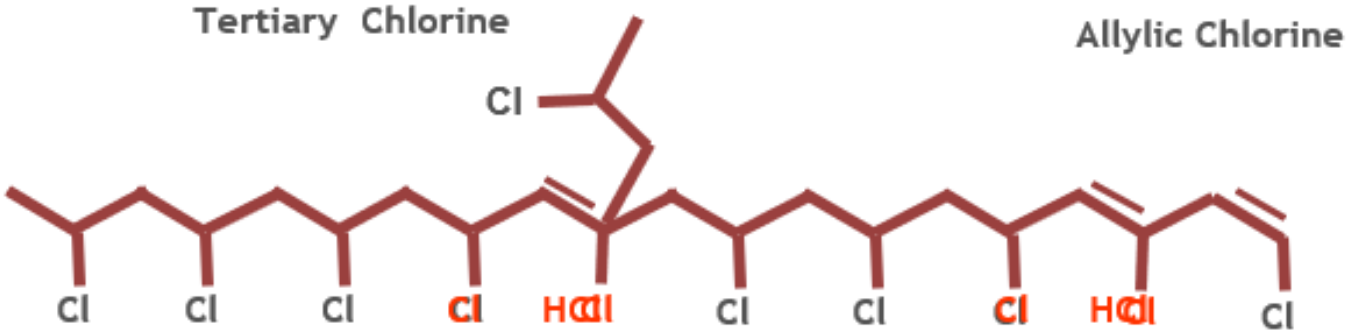
PVC stabiliser market in India (10’000 mt)



About PVC - polymerisation



Degradation of PVC by heat and shear



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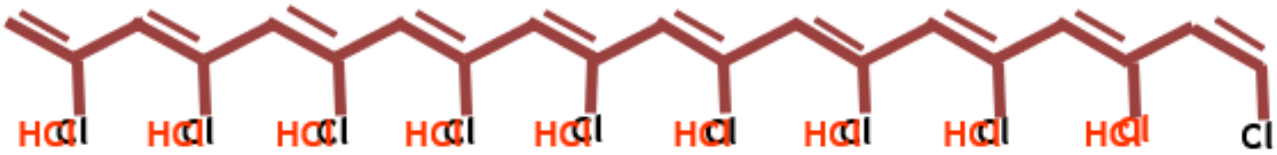


Periodic system of elements in 2016

The tool box of chemists

After elimination of noble gases

After elimination of radioactive elements

After elimination of noble metals

The theoretical tool box of chemists in PVC industry

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	113	Fl	115	Lv	117	118

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

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

What is Sustainability? - Three good questions

- Does your organisation have a definition of sustainability?
- What is, with reference to this definition, your gap to sustainability?
- What are you doing, at the strategic level of the organisation, to bridge that gap?

Answer to question 1

- There is no unique definition of sustainability
- If you googled it in 2008 you would have got >40'900'000 hits
- ...and 1'280'000'000 in 2022
- The Brundtland definition from 1987 is the most popular:

Sustainable development = „Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Answer to question 2 – the key challenges

- The 5 key challenges for PVC industry
  - The industry should commit itself long-term to becoming carbon-neutral
  - The industry should commit itself long-term to a controlled-loop system of PVC waste management
  - The industry should commit itself long-term to ensuring that releases of persistent organic compounds
  - The industry should review the use of PVC additives and move towards more sustainable additive systems
  - The industry should commit to the raising of awareness about sustainable development across the industry, and the inclusion of all participants in its achievement
  - Biodiversity

Introduction in TNS Framework - Scientific background

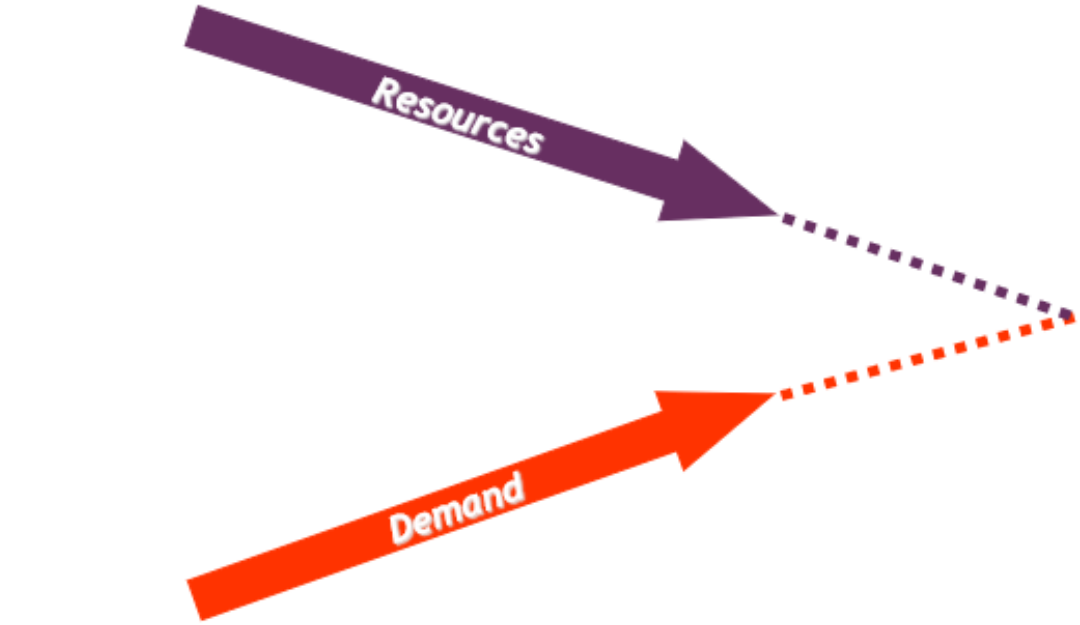
- The earth is a closed system regarding matter. (Nothing disappears. Nothing is added.)
- All geological processes are slow. (Therefore everything that is on the surface of the earth stays permanently there.)
- The earth is an open system regarding energy.

- 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.)

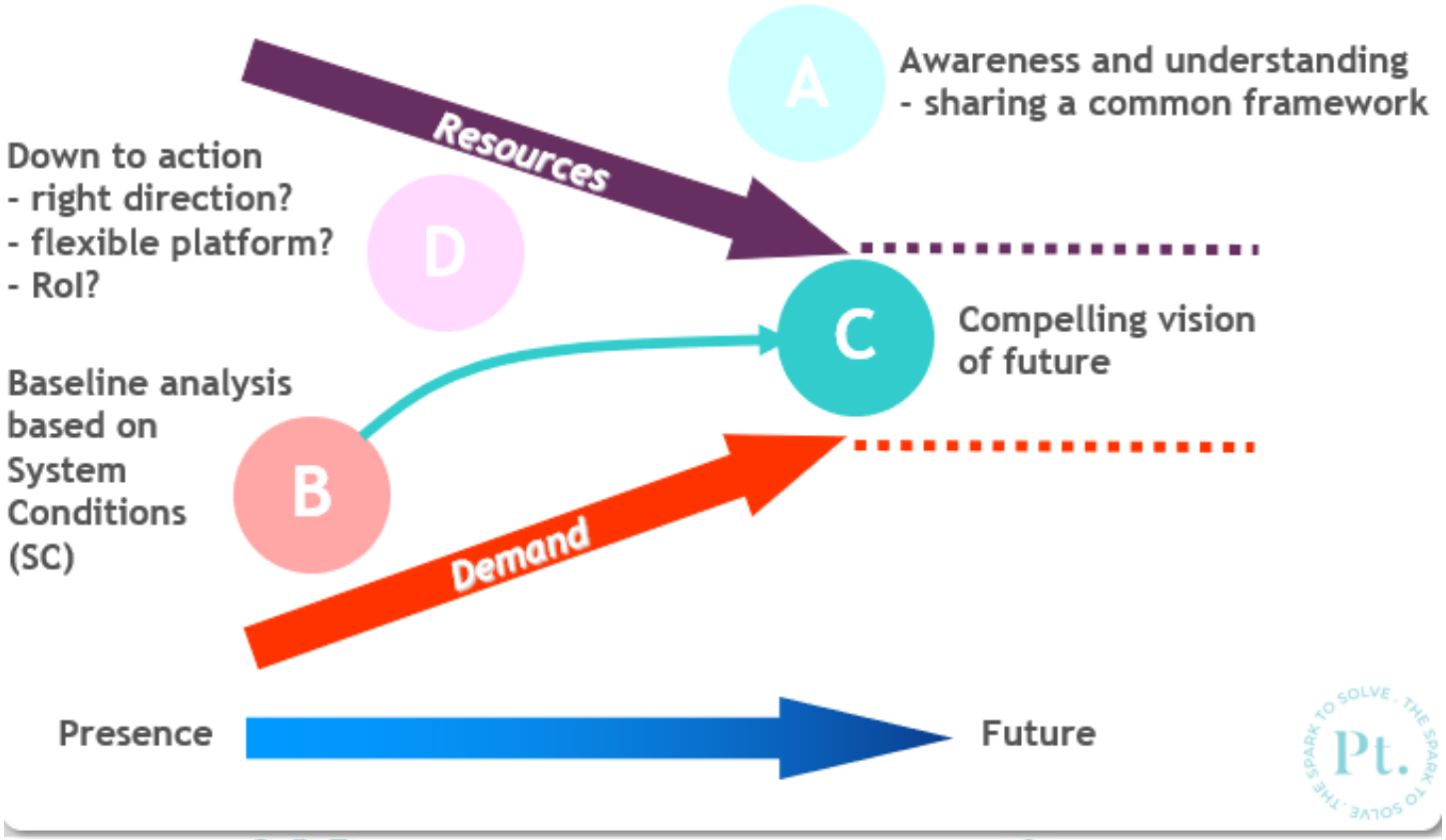
- 2nd law of thermodynamics, the introduction of entropy. (A system is all the more stable the greater the disorder in this system.)
- Photosynthesis is the "motor of all life" on earth.

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

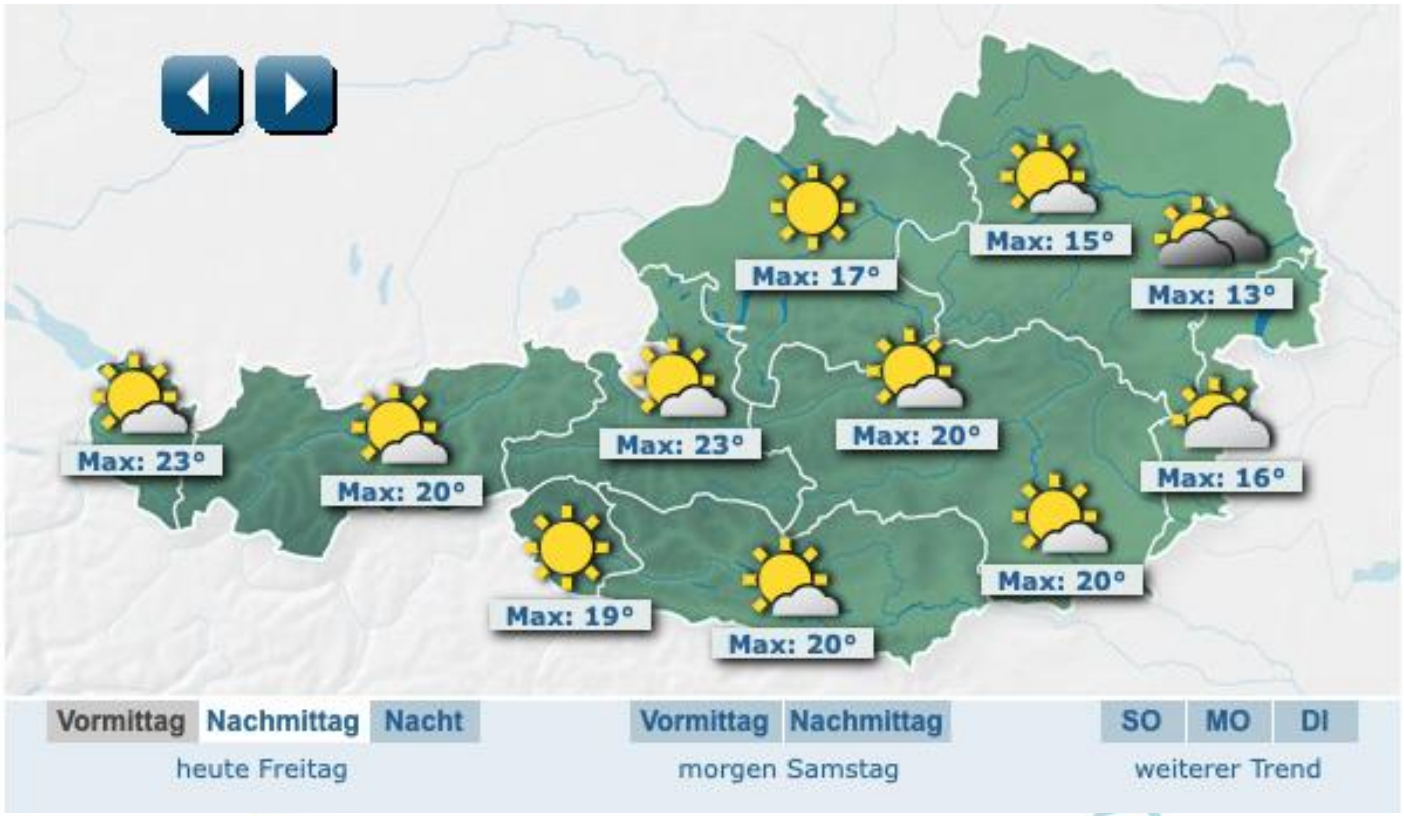
Introduction - The A B C D process



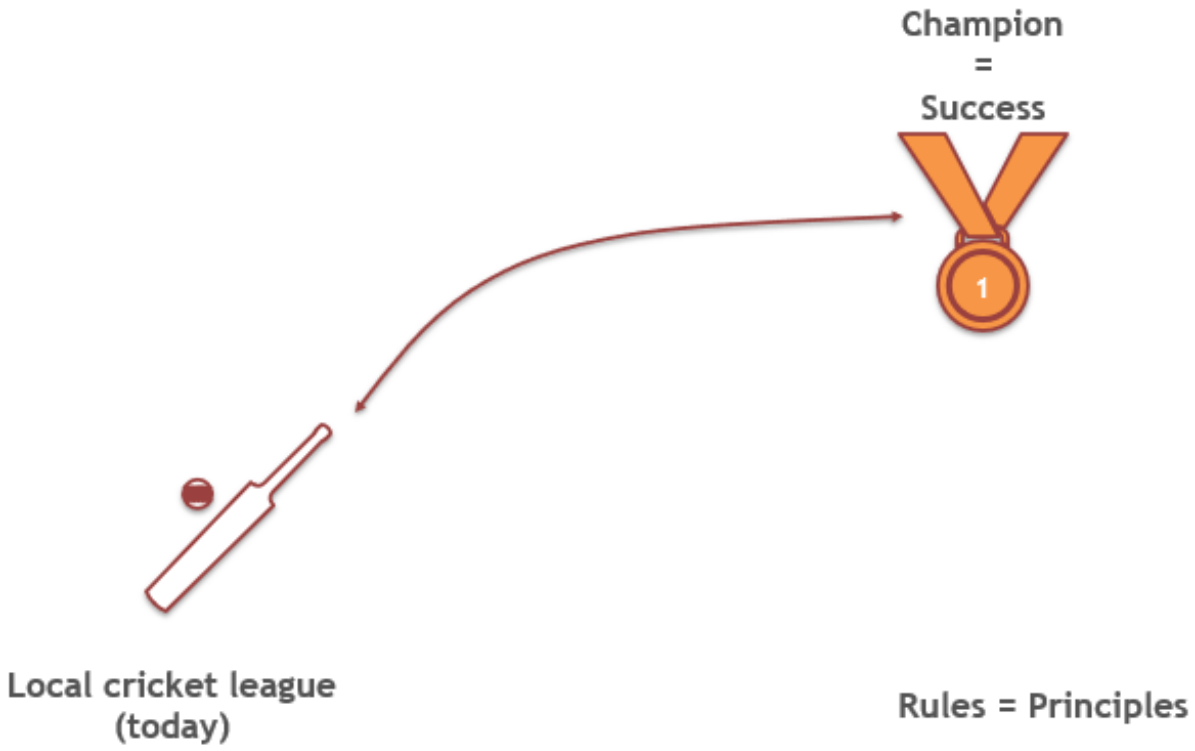
Introduction - The A B C D process



Forecasting vs Backcasting



Forecasting vs Backcasting by Principles



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	$50 \cdot 10^6$	$750 \cdot 10^6$			<1.000
Na	$23 \cdot 10^6$	$345 \cdot 10^6$			<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

What was done in Europe until today?

- Both cadmium and lead were phase out as stabiliser system
- M. Everard's book: "PVC: an evaluation using the natural step framework"
- M. Schiller etal.;"Sustainability assessment of stabiliser systems for use in PVC pipes" at PVC'05 in Brighton
- Sustainability assessment of an European stabiliser producer at PVC'08 in Brighton
- M. Schiller, M. Everard; "Metals in PVC Stabilization considered under the Aspect of Sustainability - One Vision" J. Vinyl & Additive Technology
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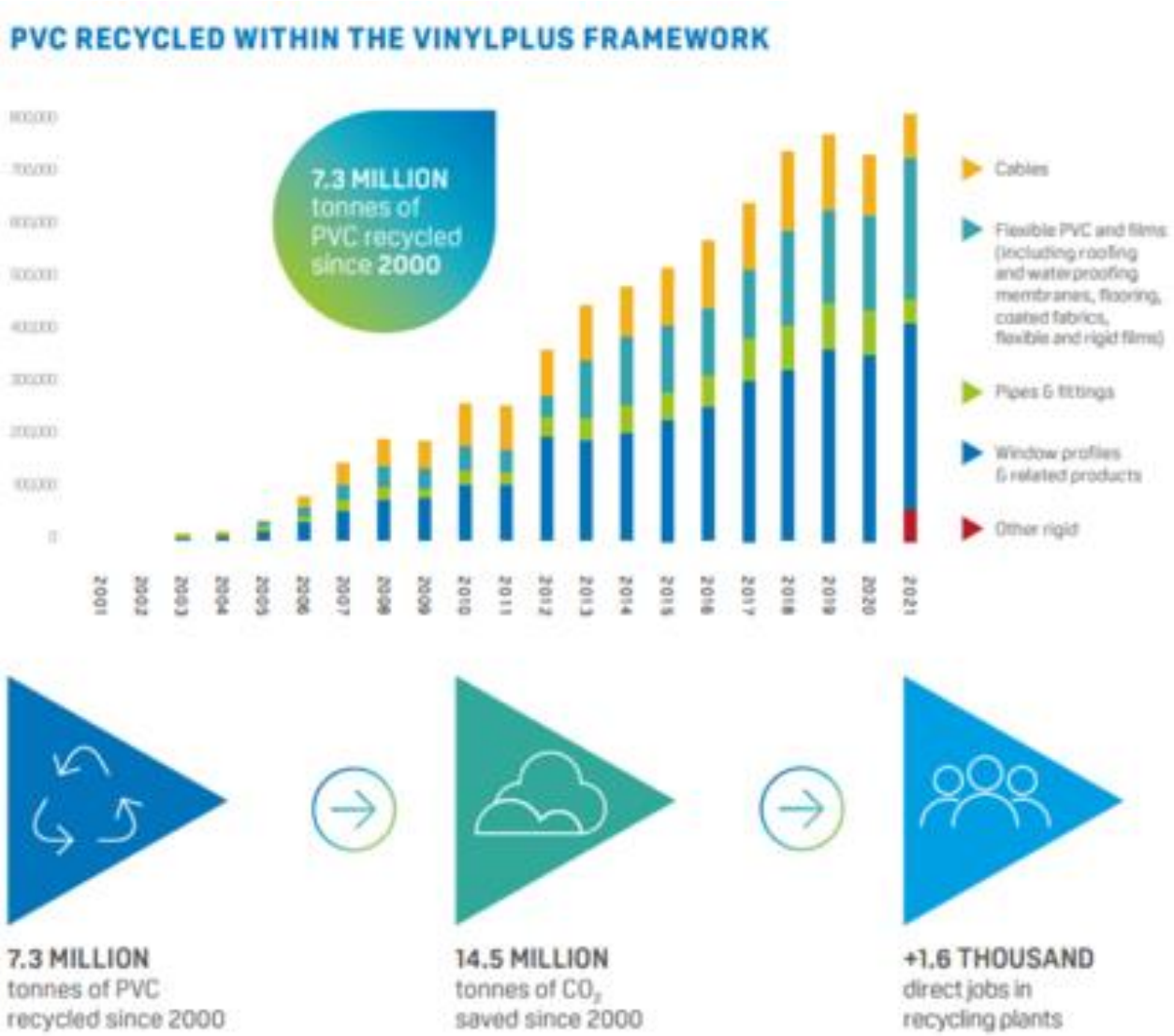
- X

What was done in Europe until today?



Phase out of Lead stabilisers

रजिस्ट्री सं० डी०एल०-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग II—खण्ड 3—उप-खण्ड (i)
PART II—Section 3—Sub-section (i)
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सं. 529] नई दिल्ली, शुक्रवार, सितम्बर 13, 2019/भाद्र 22, 1941
No. 529] NEW DELHI, FRIDAY, SEPTEMBER 13, 2019/BHADRA 22, 1941

About PVC Phase out of Lead stabilisers - RULES

- „Short title and commencement.—(1) These rules may be called the Lead Stabilizer in Polyvinyl Chloride (PVC) Pipes and Fittings, Rules…“
- „(2) They shall come into force on the date of their publication in the Official Gazette.“
- „Prohibition of use of lead or lead compounds…“
- „…(3) The manufacturer of PVC pipes and fittings shall be prohibited to use lead or lead compounds as stabilizer in manufacturing of such PVC pipes and fittings as provided in column (2) of the Schedule, from the date as specified in column (4) of the said Schedule…“

LIST OF PVC PIPES AND FITTINGS AND CORRESPONDING INDIAN STANDARDS PUBLISHED BY THE BIS

Sl. No.	Indian Standard No. and Title[1]	Lead extraction limits as on date of notification	Date of application of prohibition
(1)	(2)	(3)	(4)
CATEGORY A: Use of PVC Pipes and Fittings for Potable Water Supply			
A.1.	Type A of IS 4985 (Part 1):xxxx Specification for unplasticised PVC pipes for potable water supplies and agricultural use (*fourth revision*)	1 ppm (first extraction) and 0.05 ppm (third extraction)	After one year from the date of publication of these rules

Compelling vision of fully sustainable metal soaps

SC 1

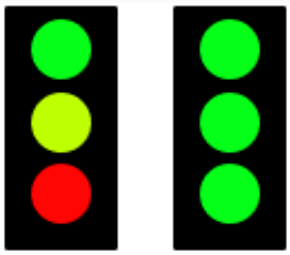
All used substances in a metal soap must have the ratio (μ+f/ε) < 1.
Energy source must be renewable!
Raw material must be either from renewable sources or based on recycling.
Metal soap itself and its decomposition products must be non-hazardous and non-toxic.

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, PCBs and DDT.

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 (e.g. Red mud) must be in that way that the natural conditions are not disturbed and later can be restored.



B C

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

- 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

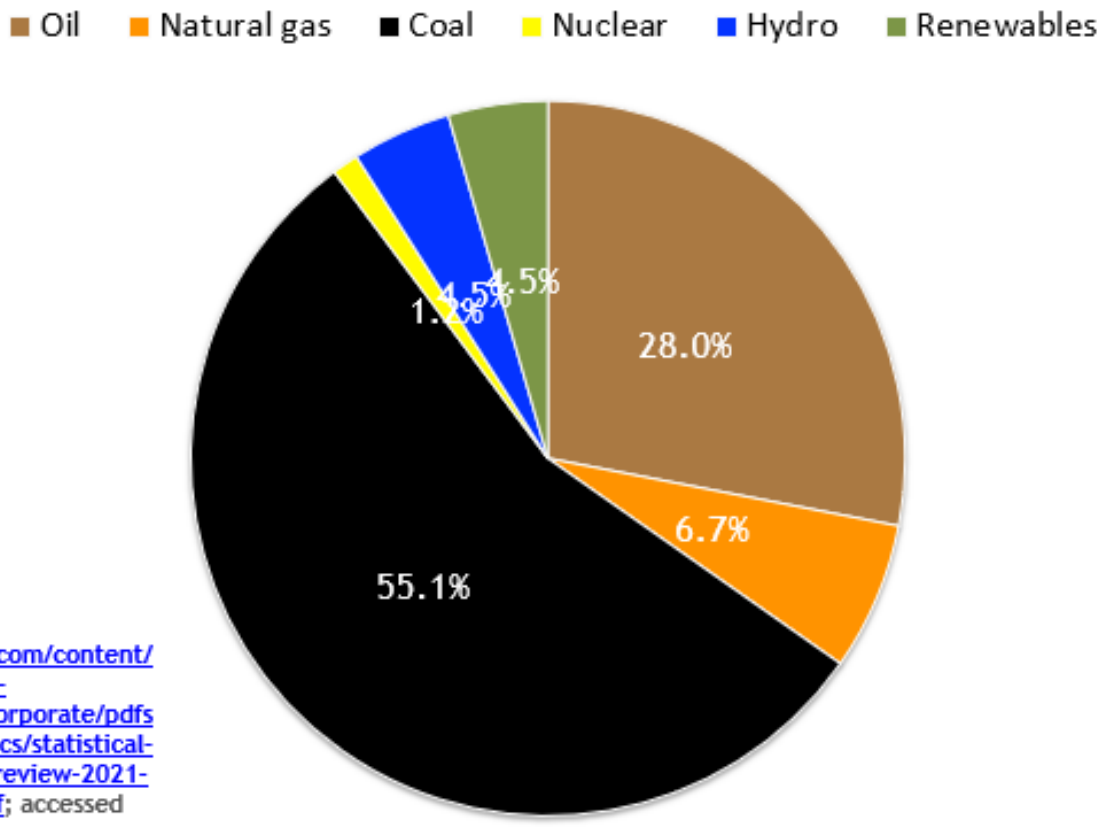
Baseline line analysis of metal soap production - metal (hydr)oxides

	SC 1	SC 2	SC 3	SC 4
NaOH				
MgO				
$Ca(OH)_2$				
$Ba(OH)_2$				
ZnO				
PbO				
CdO				
$Al(OH)_3$				

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 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 stearates production - other parameter

	SC 1	SC 2	SC 3	SC 4
Water	🟢	🟢	🟢	🟢
Energy	🔴	🔴	🔴	🔴
Packaging	?	?	?	?
Production plant	🟢	🟢	🟢	🟢
Waste	?	?	?	?
Transportation	?	?	?	?

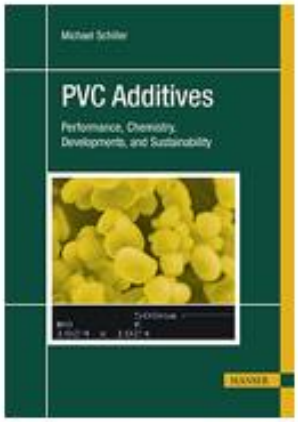
Baseline line analysis of metal stearates production - other parameter

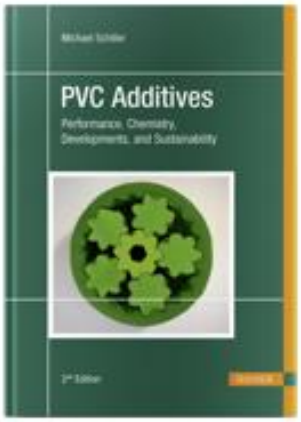
	SC 1	SC 2	SC 3	SC 4
End of use				
In land fill	Zn			
In combustion	Zn			
In recycling				

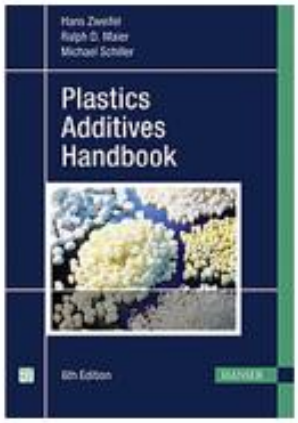
Summary

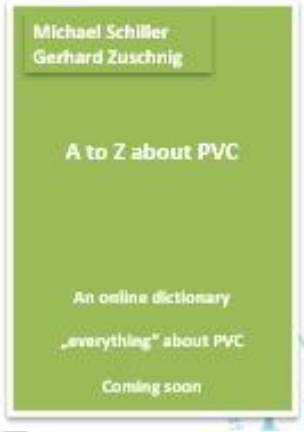
- Metal soaps (Ca, Mg, Al) have already a high potential to become fully sustainable!
- Exceptiones are all soaps based on toxic metals like Lead and Cadmium
- Another exception is Zinc which will become sustainable if the PVC product is recycled.
- Metals soaps based on renewable acids have the highest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

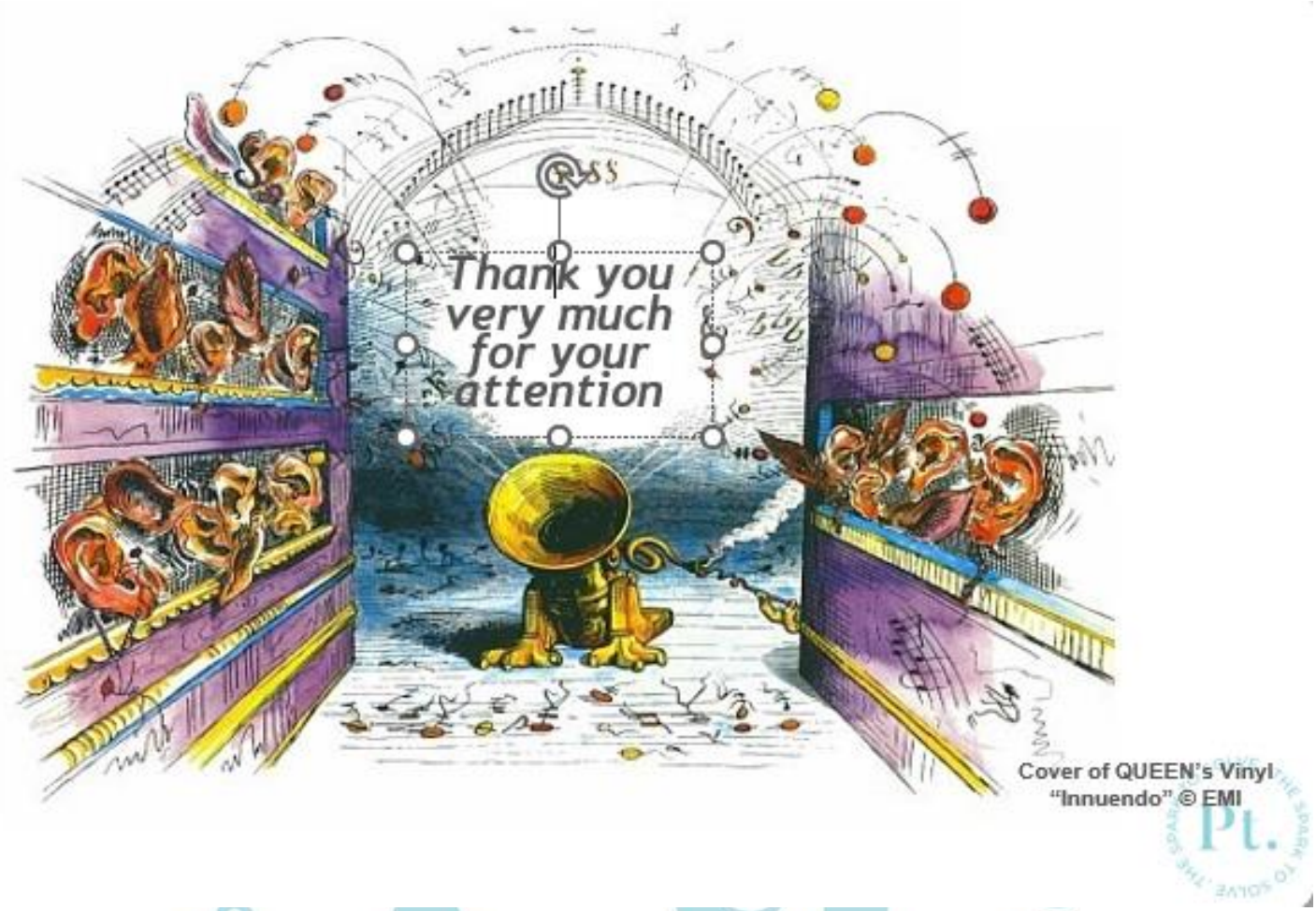
Further readings











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