RoHS Exemption for Lead

Project Delivery

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Content

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Project Goals & Drivers

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Goal:

- Exemption under RoHS that lead can be used in medical equipment, mainly for x-ray shielding

Key Objectives:

- Displaying the environmental differences between an application using Lead and Tungsten over the life cycle
- Conducting a comparative LCA to evaluate the life cycle environmental profiles of the products

Deliverables:

- Final report as slide deck, capturing main aspects from ISO 14040/44

Project Steps - Overview

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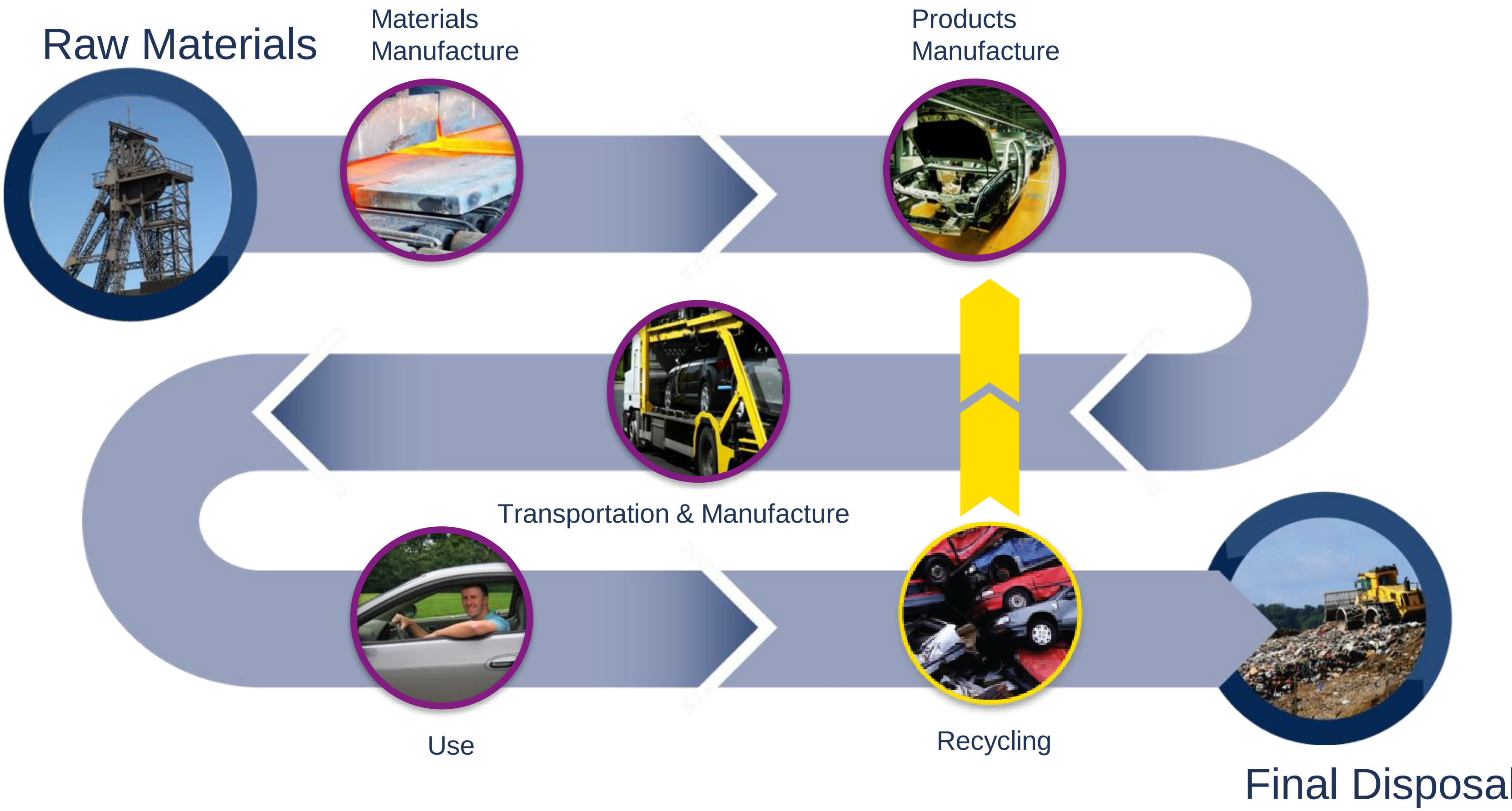
Project tasks		Responsibility		Timeline
		thinkstep	COCIR	
Kick-off meeting				**01.02.2018**
	Defining goal & scope	X	X	
	Clarify open points	X	X	
Data collection				
	Provision of data collection template	X		
	Collection of specific primary data		X	**End April**
	Plausability check	X		
Modeling in GaBi				**End May**
	Modeling	X		
	Quality checks	X		
Evaluation / Interpretation				**End June**
	Analysis of the LCA	X		
	Visualize results (i.e. diagrams, charts)	X		
	Interpretation of results	X		
	Discuss results	X	X	
Reporting				**End June / Mid July**
	Creation of Powerpoint	X		
	Final meeting	X	X	

Life Cycle Thinking

..a lens to assess business & supply chain sustainability



GaBi is the most widely used product sustainability solution

- GaBi is a **diagnostic modelling, reporting software** tool that drives product sustainability performance during design, planning and production.
- It helps businesses to achieve a better understanding of **product sustainability performance**
- Powerful LCA tools and databases for product and process sustainability

GaBi is the most widely used product sustainability solution

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- The GaBi Software Suite combines software for modelling, analysing and reporting related to the life cycle of products or processes.
- It contains a centralized database (externally reviewed by DEKRA) and user management, interfaces to existing IT systems for automation, data import from various standard formats and database content.
- It allows to model every element of a product, process or system from a life cycle perspective.
- GaBi comes with consistent databases, which are continuously updated and extended.
- The databases give access to industry representative data for materials, products, manufacturing steps, transports, recycling etc. enabling to look at emissions and resource consumptions and their economic, social and environmental impacts.

Product Sustainability Solution

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Services

GaBi Training & workshops	EPD Development	LCA Services	PSRT
Increase knowledge and expertise from basic to expert user.	Turn-key service for EPD development (HPDs can be offered)	LCA Screening Comparative LCA ISO Compliant LCA PEF	Join top product sustainability leads and openly share and learn.

Software

GaBi ts Software	GaBi DfX	GaBi Server	GaBi Envision	LCA Hub
Drive product sustainability during design and planning providing modelling, reporting and diagnostic tools.	Rapid analysis of products containing complex assemblies right from BoM.	Collaborate on projects, improving quality assurance and return on investment.	Quick evaluation of 'what-if' scenarios, optimising product design and communication of performance.	Data collection application to accelerate LCA, increase data quality and consistency.

Content

GaBi Professional & Extension Databases	3rd Party LCA Database ecoinvent	Trucost NCA Factors

LCA – A Standardized Methodology

ISO 14040 and 14044

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The ISO 14040 series of standards are a set of rules and guidelines for conducting LCA that have been developed and revised by the international LCA expert community since the 1990s.

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040, section 3.2).

INTERNATIONAL STANDARD

ISO 14044

First edition
2006-07-01

Environmental management — Life cycle assessment — Requirements and guidelines

Management environnemental — Analyse du cycle de vie — Exigences et lignes directrices

Reference number
ISO 14044:2006(E)

Goal and Scope

Functional unit, system boundary, impact categories

Functional Unit

To compare the 3 different material compositions for any application the following **Functional Unit** has been defined based on intended function:

1m² comparable radiation shielding* is equivalent to following weights

- 11,3 kg Lead
- 15,4 kg Tungsten
- 16,1 kg Tungsten – Composite (95.7wt% Tungsten with Nylon 6)

For the use phase identical durability and operating years are assumed. This allows to exclude the use phase from the LCA analysis.

*Calculation conditions:

an averaged X-ray energy of 70keV and X-ray absorption of 3,4

(Density: Lead = 11,3kg/dm^3 ; Tungsten = 19,3kg/dm^3)

Research approach

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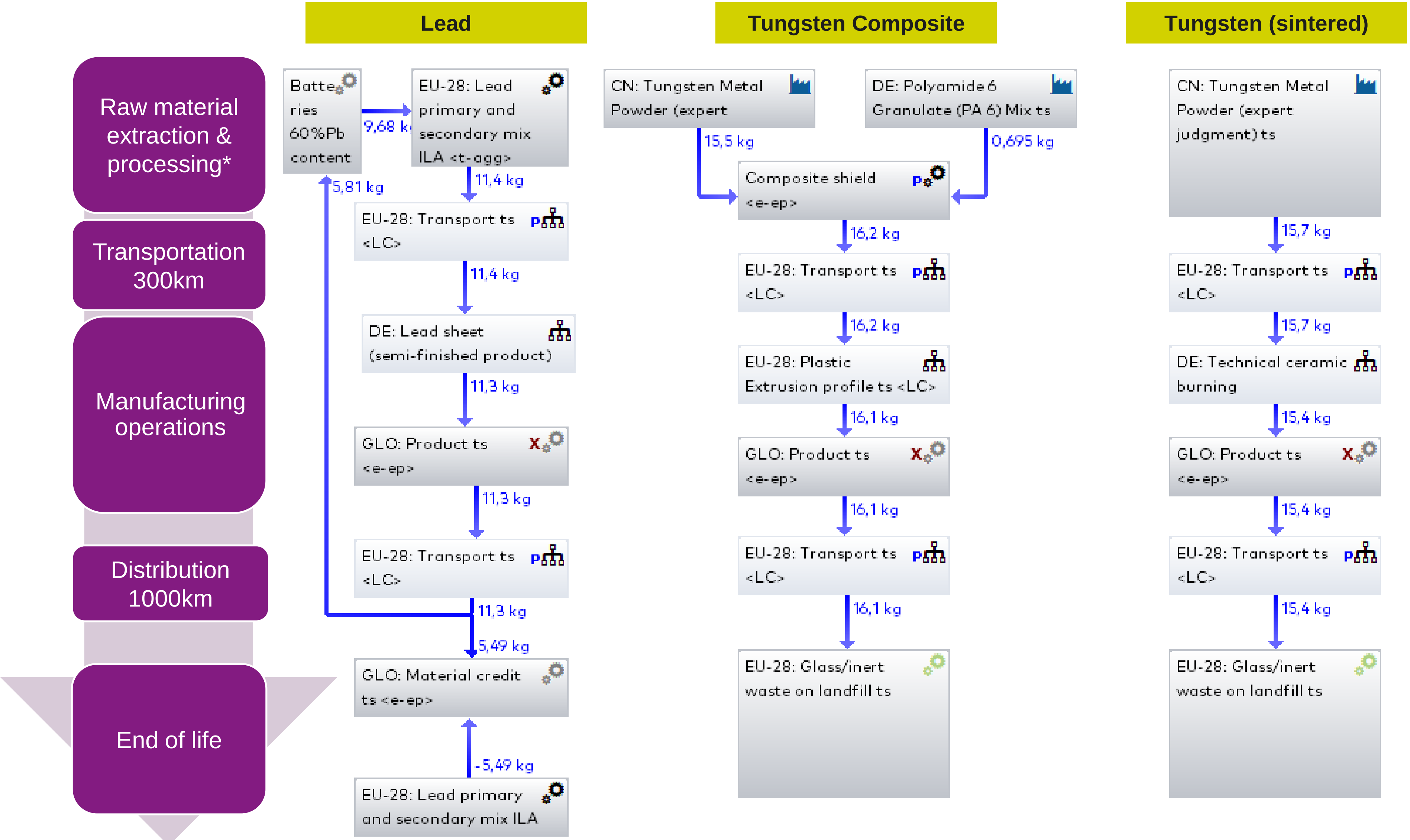
To cover the key objectives…

1. The Basic Scenario displays the results of the life cycle of Lead and Tungsten according to the current technology and information (**state of the art)**.
2. Additional Scenarios based on possible changes in the End of Life show the potential consequences on the life cycle

In this comparative study, estimations and judgement follow **worst case assumptions** in order to avoid preferences and ensure robustness:

worst case assumptions: worst for Lead and best for Tungsten

System Boundaries



* Includes aggregated data on raw material extraction (such as ore mining or oil extraction), transport, processing and if applicable secondary material inputs (i.e. lead)

System Description

	Lead	Tungsten Composite	Tungsten (sintered)
Raw material extraction & processing	European Lead (Primary 46% / Secondary 54%) (worst case) Lead from the International Lead Association (ILA) Batteries (60%Pb content) for sec. Lead production is taken from EoL (less credit)	Chinese Tungsten Powder Polyamide 6 Granulate (PA 6)	Chinese Tungsten Powder
Transport	Distance 300 km	Distance 300 km	Distance 300 km
Manufacturing operations	Sheet making process incl. Melting and Rolling 1% loss of Lead (cut off)	Standard Plastic Extrusion (<1%loss)	Grinding and Sintering based on Continuous Burning Ceramic process (2% loss) (Best case)
Distribution	Distance 1000 km	Distance 1000 km	Distance 1000 km
End of life – Basic Scenario:	100% Lead is recycled w/o collection losses	100% landfill	100% landfill
End of life – Additional Scenario:	100% of Lead is landfilled (worst case)	1. 100% of Tungsten Metal Powder is recycled (clean scrap) (Best case) Scenario has been simulated only for Tungsten Composite; neglecting any treatment to access only tungsten metal powder 2. 100% of Tungsten Metal Powder is recycled (clean scrap) including scrap re-melting process (Conservative Best case)	1. 100% of Tungsten Metal Powder is recycled (clean scrap) (Best case) Scenario has been simulated only for Tungsten Composite; neglecting any treatment to access only tungsten metal powder 2. 100% of Tungsten Metal Powder is recycled (clean scrap) including scrap re-melting process (Conservative Best case)

Data Collection & Assumptions

Legend: Primary Data / Secondary Data / Assumptions

	Lead	Tungsten Composite	Tungsten (sintered)
Raw material extraction & processing	Thinkstep provided data	Thinkstep provided data	Thinkstep provided data
	Best industry available data Conservative approach; mix of prim. and sec. Lead (reference year 2011)	Chinese Tungsten based on expert judgment using literature and industry knowledge (reference year 2017)	Chinese Tungsten based on expert judgment using literature and industry knowledge (reference year 2017)
Transport	COCIR provided data; Distance agreed in Kick of Meeting	COCIR provided data; Distance agreed in Kick of Meeting	COCIR provided data; Distance agreed in Kick of Meeting
Manufacturing operations	COCIR provided functional unit / Thinkstep provided background data	COCIR provided functional unit / Thinkstep provided background data; Manufacturing based on industry data not Tungsten specific (reference year 2017)	Energy for Grinding + Sintering from industry data ceramic burning (Electricity 21MJ/kg, Thermal energy 91MJ/kg). (**Best case**) [Literature for WC-Co cermets (Electricity 114MJ/kg); variations depend on temperature, power and time]
Distribution	COCIR provided data; Distance agreed in Kick of Meeting	COCIR provided data; Distance agreed in Kick of Meeting	COCIR provided data; Distance agreed in Kick of Meeting
End of life	Thinkstep provided data and Scenarios	Thinkstep provided data and Scenarios	Thinkstep provided data and Scenarios
Additional Scenario: End of life	Analysis of the impact of Lead into the environment in case of landfill (based on thinkstep's composition element model)	Identification of potential consequences in case Tungsten is recycled. 1) Tungsten is recycled as clean scrap (assuming primary quality) only with shredding based on industry data 2) Re-melting added based on energy demand for oven of 3422°C	Identification of potential consequences in case Tungsten is recycled. 1) Tungsten is recycled as clean scrap (assuming primary quality) only with shredding based on industry data 2) Re-melting added based on energy demand for oven of 3422°C

Used data documentation

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- All datasets can be accessed online (http://www.gabi-software.com/international/databases/gabi-data-search/)
- All used datasets follow the GaBi modelling principle (http://www.gabi-software.com/international/support/gabi/gabi-modelling-principles/)
- Selected dataset documentations:
  - Lead mix prim/sec: http://gabi-documentation-2018.gabi-software.com/xml-data/processes/137f2286-e426-4231-b65d-e65503fa6e5c.xml
  - Tungsten metallic powder: http://gabi-documentation-2018.gabi-software.com/xml-data/processes/1c6bd98c-45d7-402c-802b-4d2e4c45a221.xml
  - PA6 granulate: http://gabi-documentation-2018.gabi-software.com/xml-data/processes/6e078dba-bc25-44e6-bf33-364e72ca36fe.xml

Life Cycle Impact Assessment Categories

Impact Categories used:

- CML2001 - Jan. 2016, Abiotic Depletion (ADP elements) [kg Sb eq.]
- CML2001 - Jan. 2016, Abiotic Depletion (ADP fossil) [MJ]
- CML2001 - Jan. 2016, Acidification Potential (AP) [kg SO2 eq.]
- CML2001 - Jan. 2016, Global Warming Potential (GWP 100 years) [kg CO2 eq.]
- CML2001 - Jan. 2016, Eutrophication Potential (EP, Copy) [kg Phosphate eq.]
- CML2001 - Jan. 2016, Ozone Layer Depletion Potential (ODP, steady state) [kg R11 eq.]
- CML2001 - Jan. 2016, Photochem. Ozone Creation Potential (POCP) [kg Ethene eq.]
- Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]

<u>Toxicity Categories</u>

- CML2001 - Jan. 2016, Human Toxicity Potential (HTP inf.) [kg DCB eq.]
- CML2001 - Jan. 2016, Terrestric Ecotoxicity Potential (TETP inf.) [kg DCB eq.]
- CML2001 - Jan. 2016, Marine Aquatic Ecotoxicity Pot. (MAETP inf.) [kg DCB eq.]
- CML2001 - Jan. 2016, Freshwater Aquatic Ecotoxicity Pot. (FAETP inf.) [kg DCB eq.]

Results

Basic scenario

Results: Life Cycle

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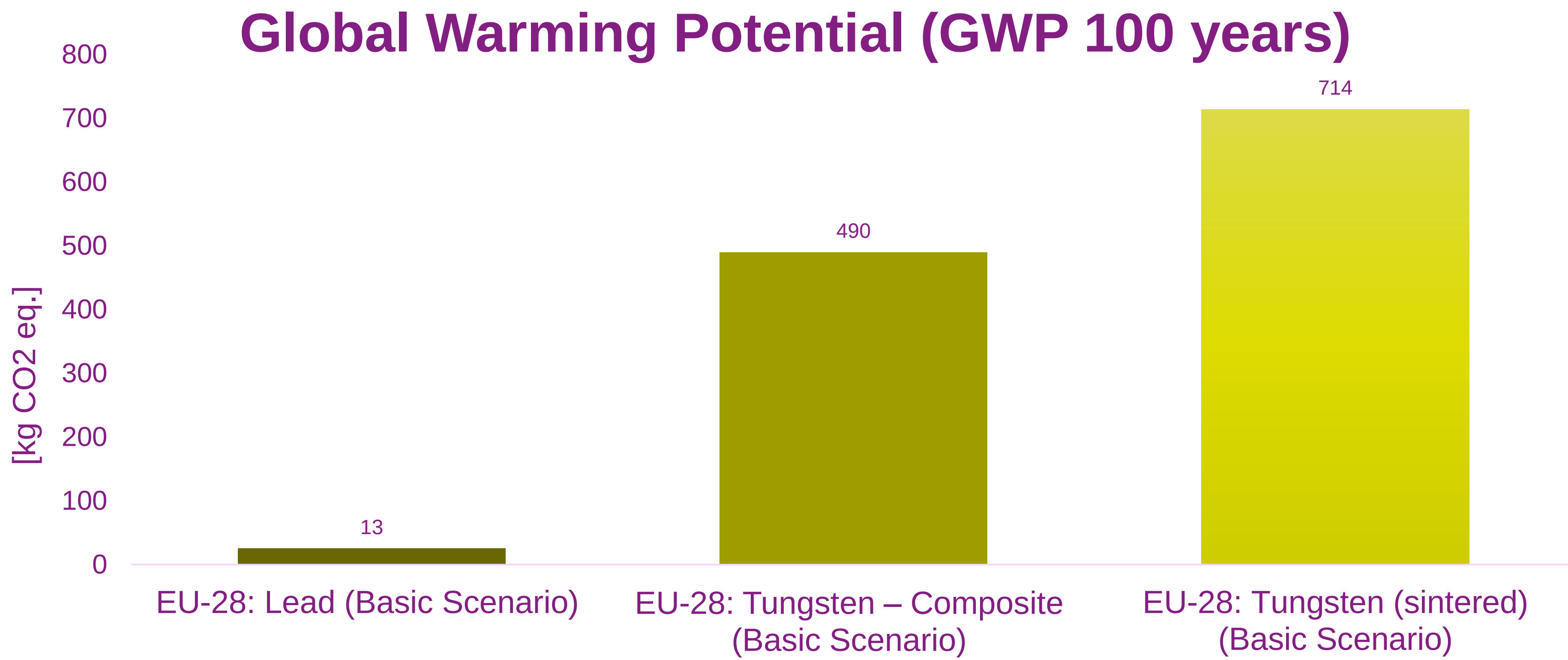

- Lead has the lowest impact due to ore concentration and melting point
- Tungsten (sintered) has highest impact due to ore concentration, high demand in solvent extraction and energy demand for sintering
- Tungsten-Composite reduces impact from Tungsten (sintered) by substituting sintering process by polymer extrusion with very low energy demand

Hotspot: Life Cycle Stage

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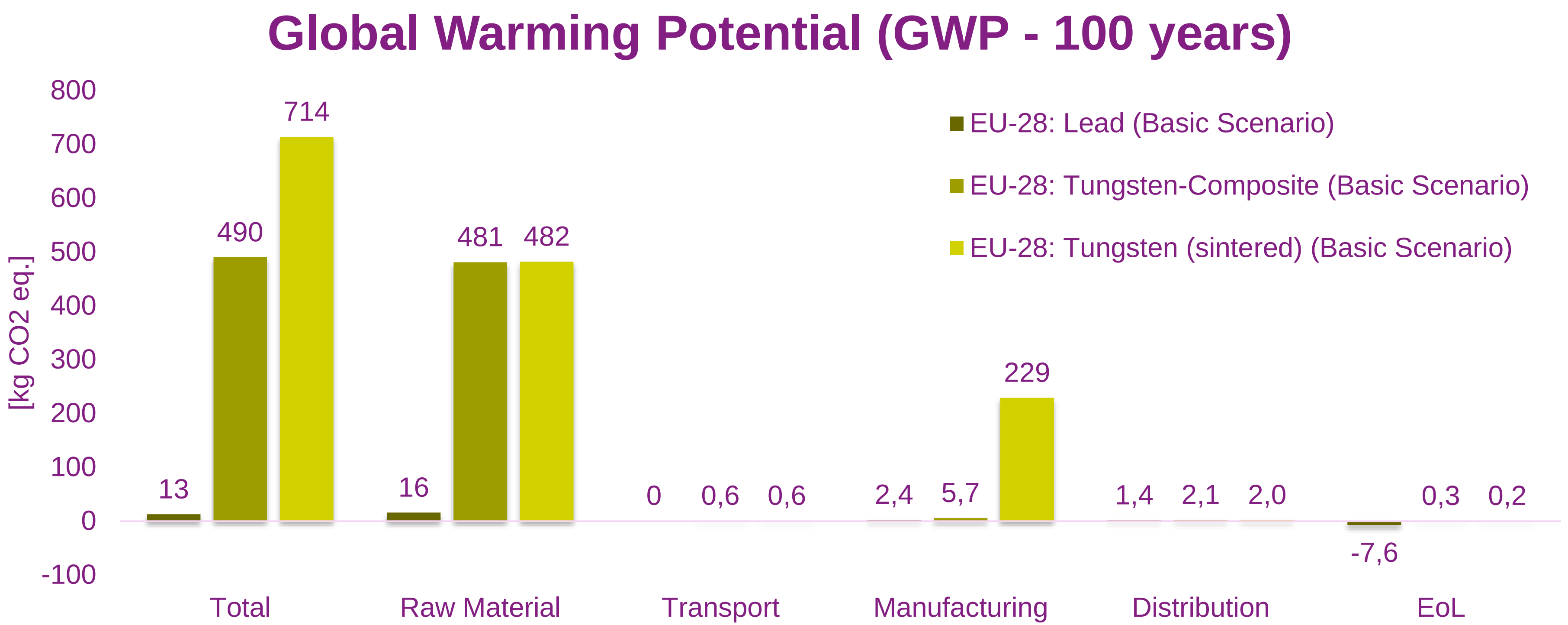
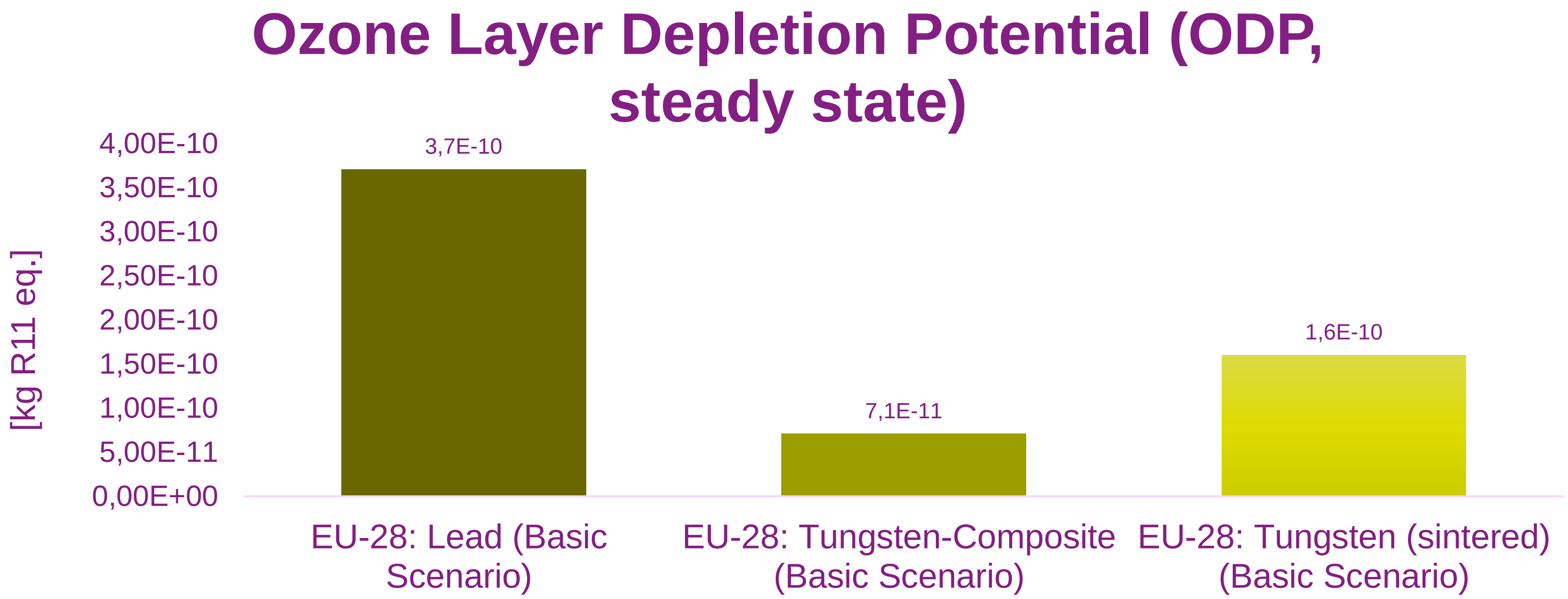


- Raw Material acquisition share the mayor contribution in the 3 material compositions (Tungsten-Composite based on Tungsten and Polyamide, Tungsten (sintered) 2% losses)
- Manufacturing at Lead is approx. 87% of cradle to gate impact and at Tungsten between approx. 1% (composite) and approx. 32% (sintered).
- EoL at Lead includes re-melting and credits primary / secondary mix.

All other impact categories

- All other impact categories follow the same pattern as GWP
- ODP is the only impact category with a different share of contribution



- In principle any emission contributing to ODP is banned worldwide; therefore results for ODP never can show representative results today, only fragments of non-representative emissions on inventory level
- ODP is dominated by the flow R 22 (chlorodifluoromethane) which was used as refrigerant mainly in the first generation of European nuclear power stations.
- European Lead uses European Electricity mix whereas Tungsten is gained with Chinese electricity mix which do not use R22 (new generation).

Results: Life Cycle

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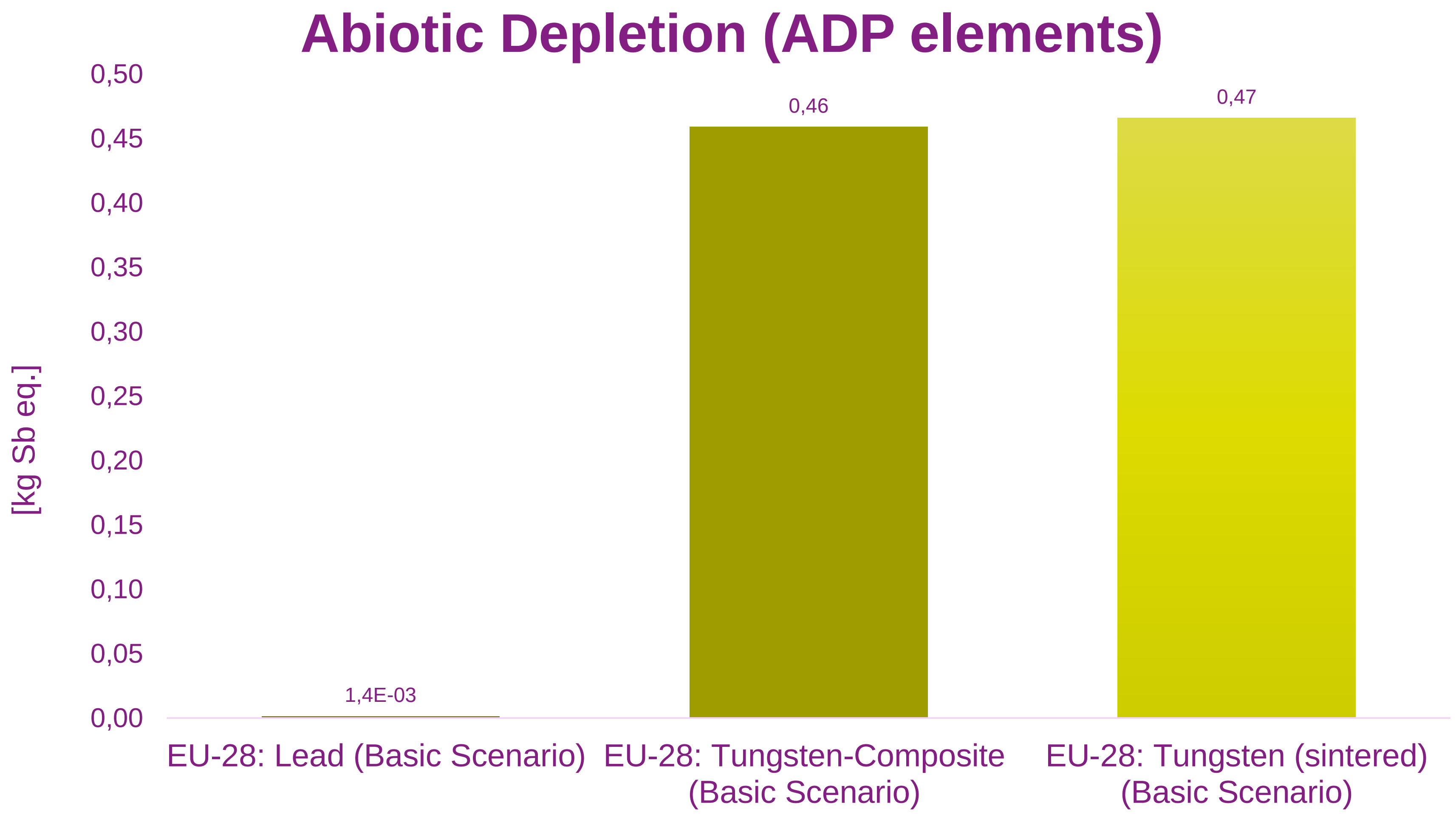
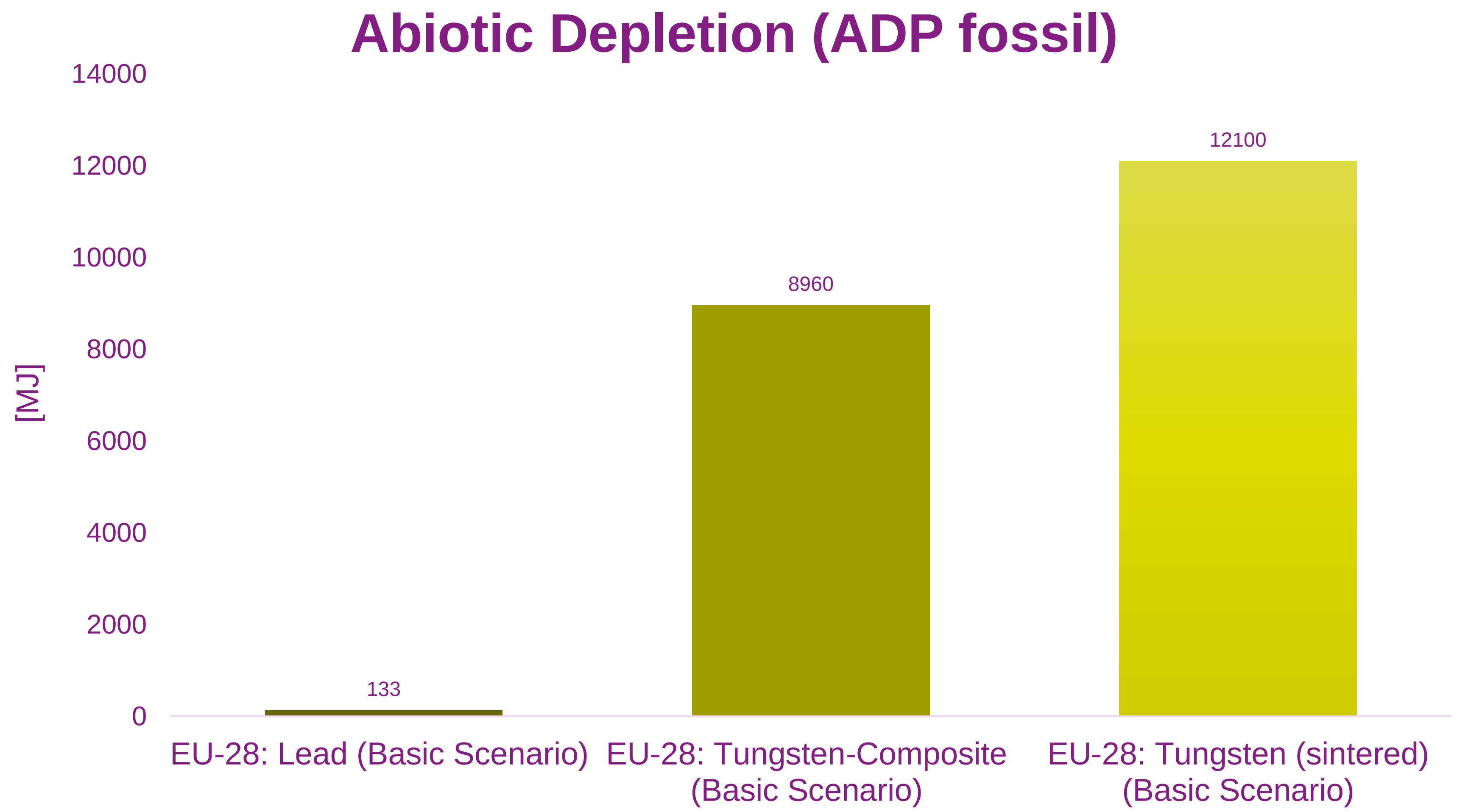
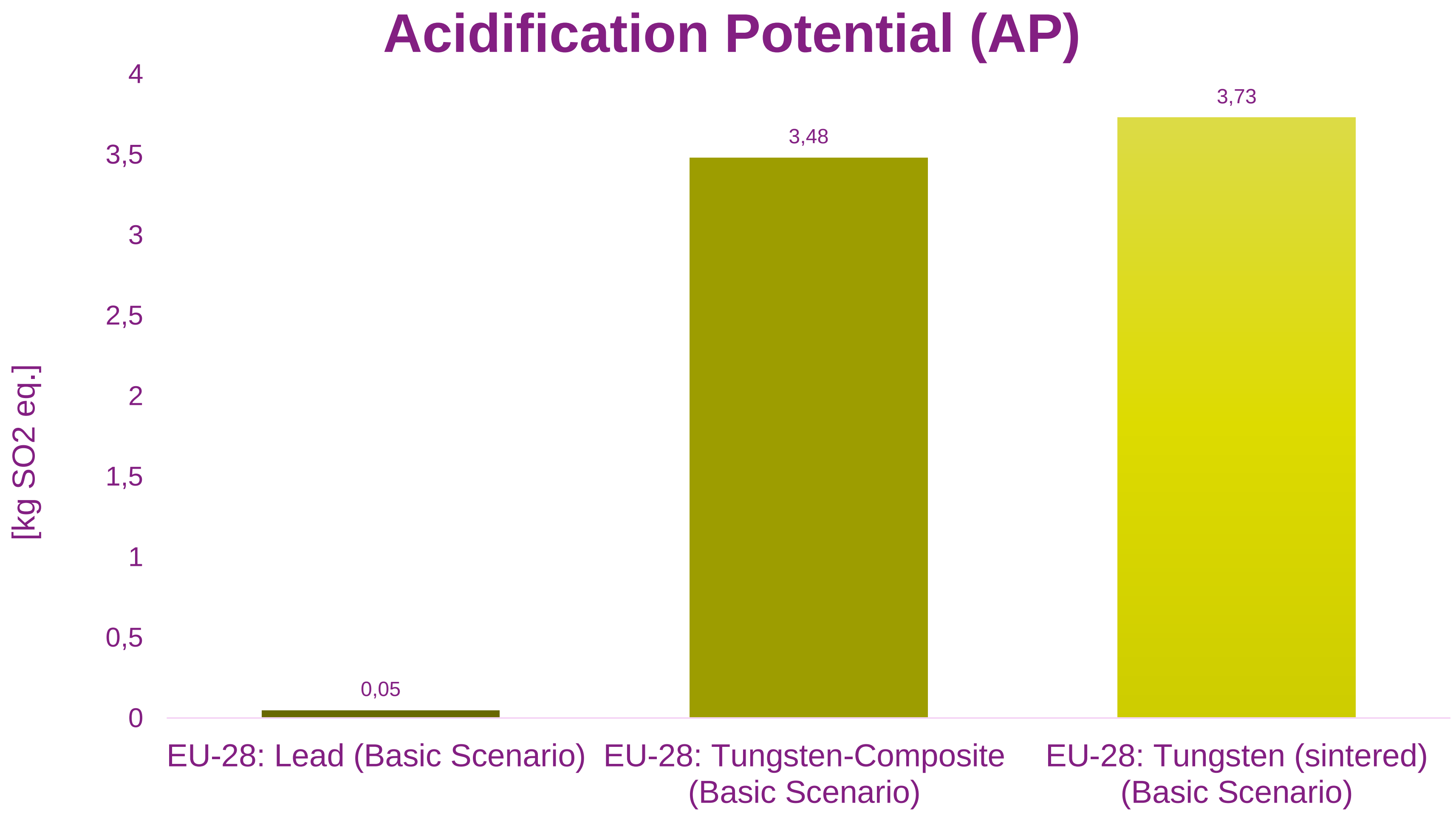


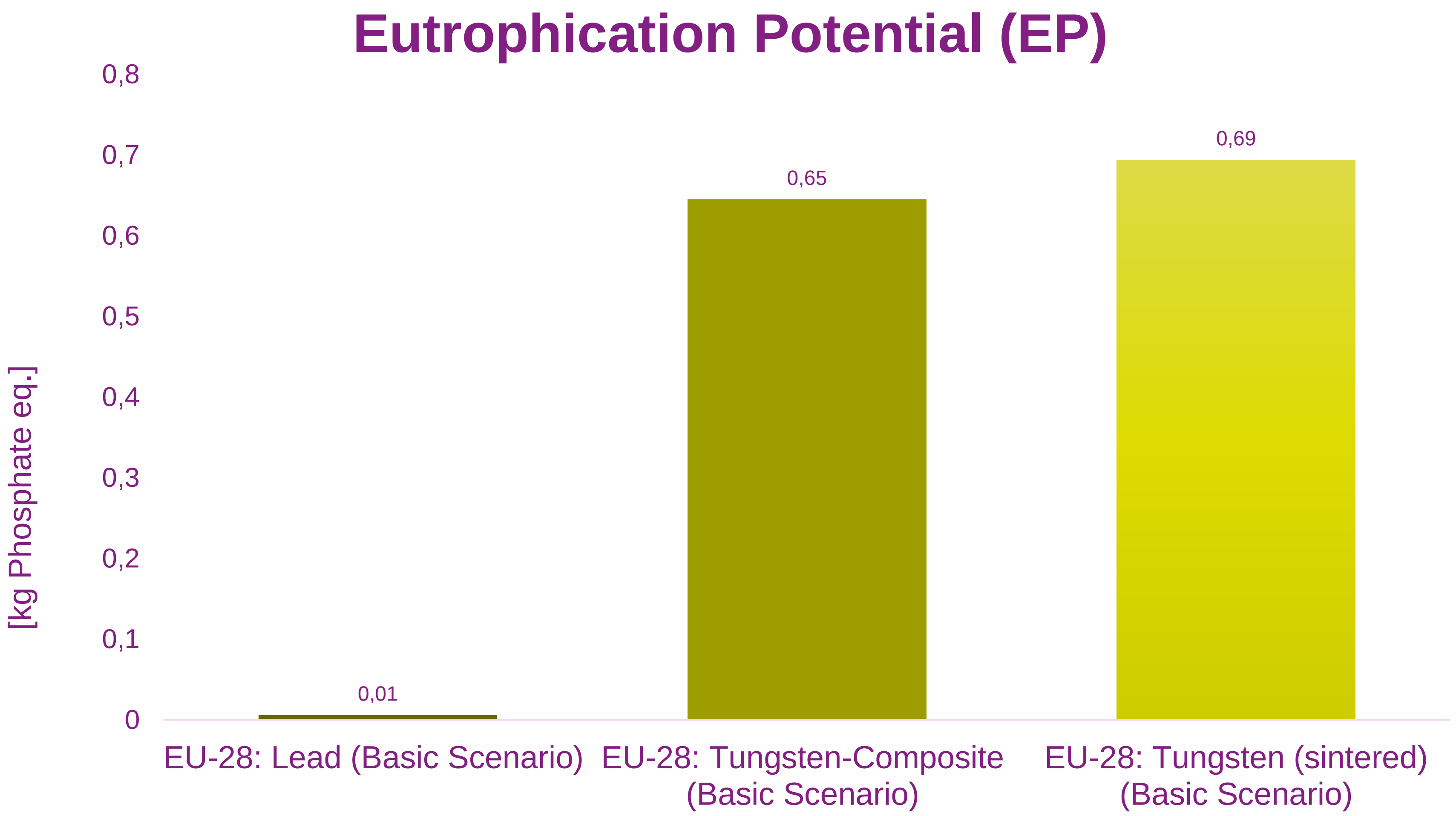
Results: Life Cycle



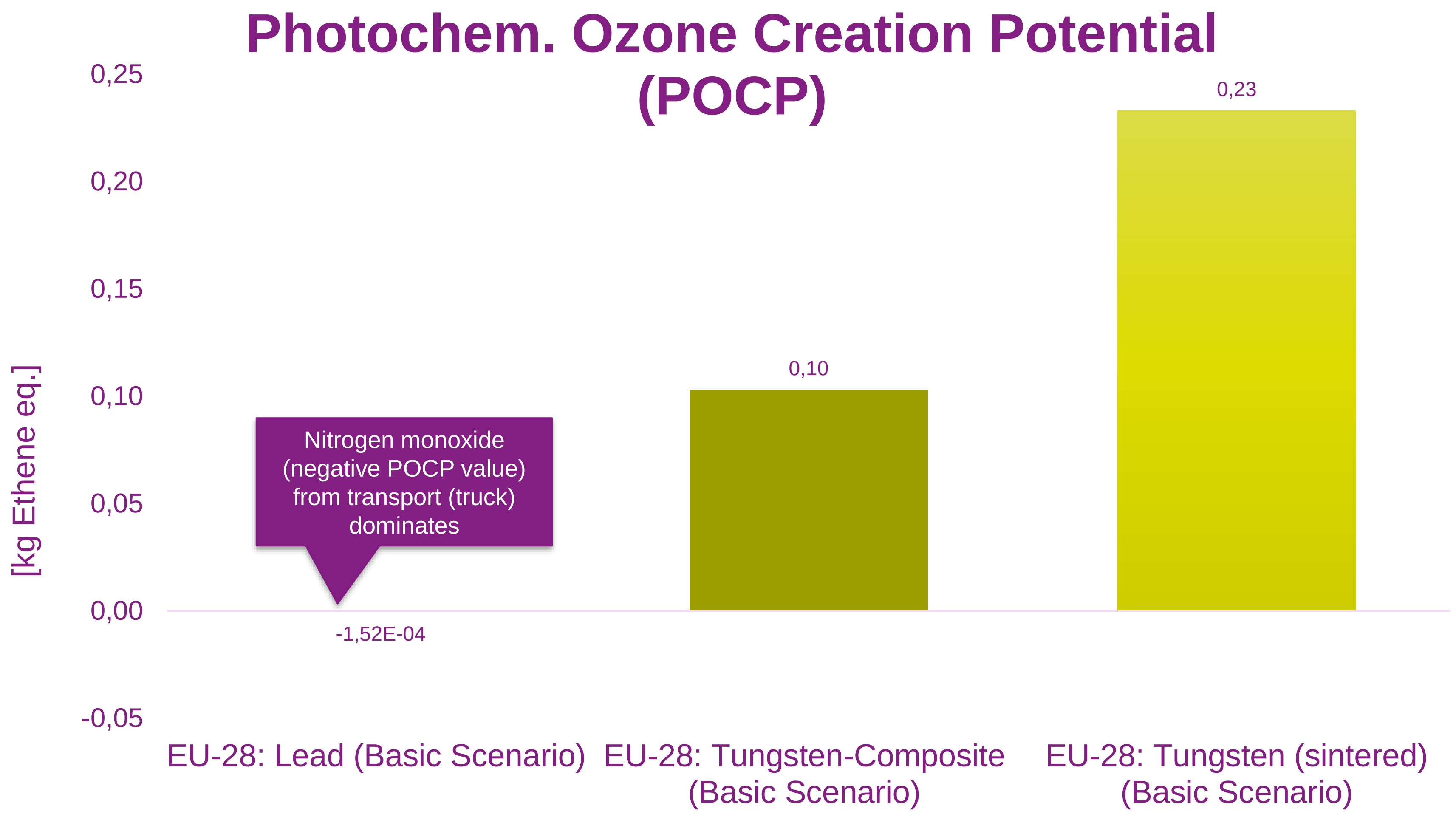
Results: Life Cycle



Results: Life Cycle



Results: Life Cycle



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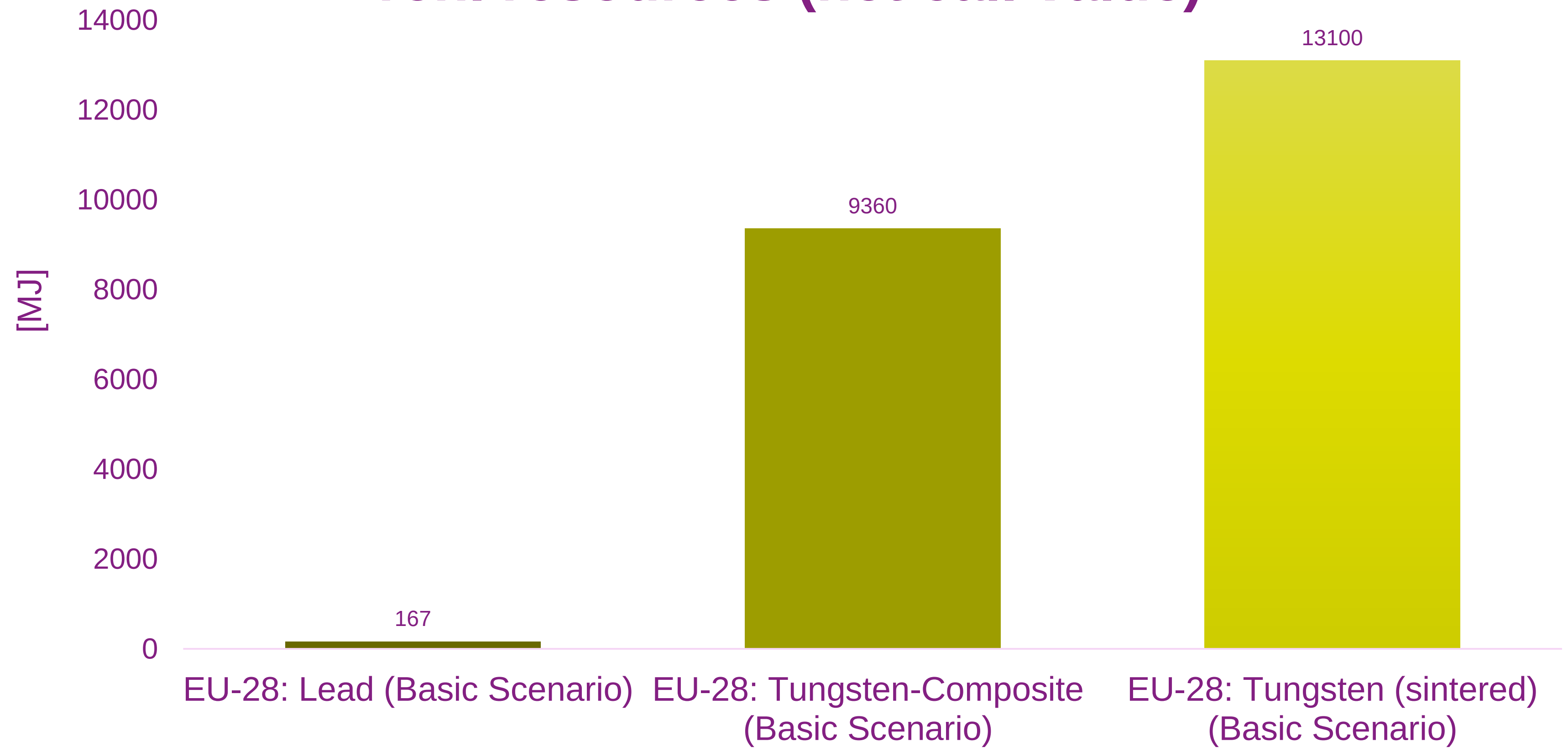
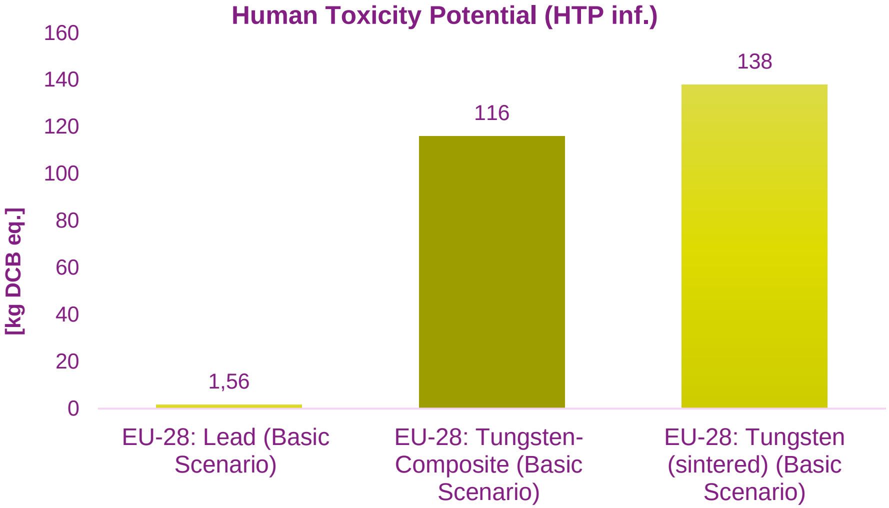
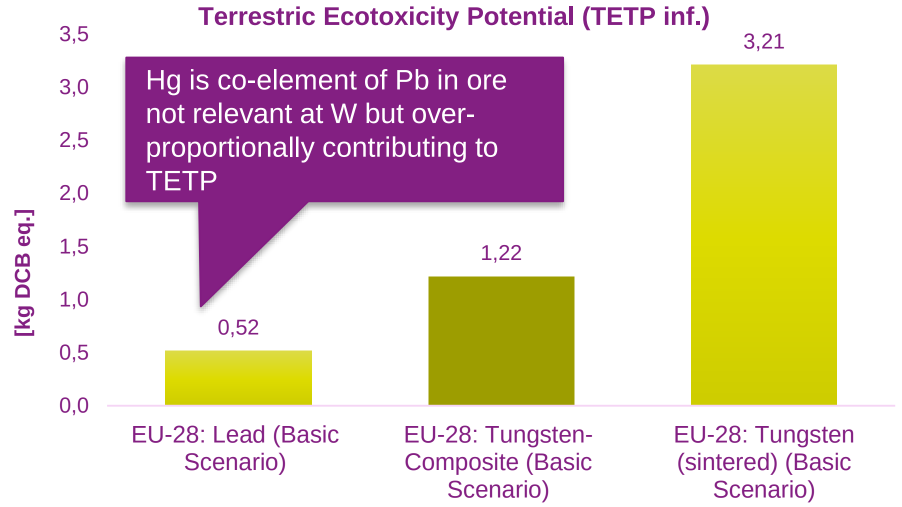
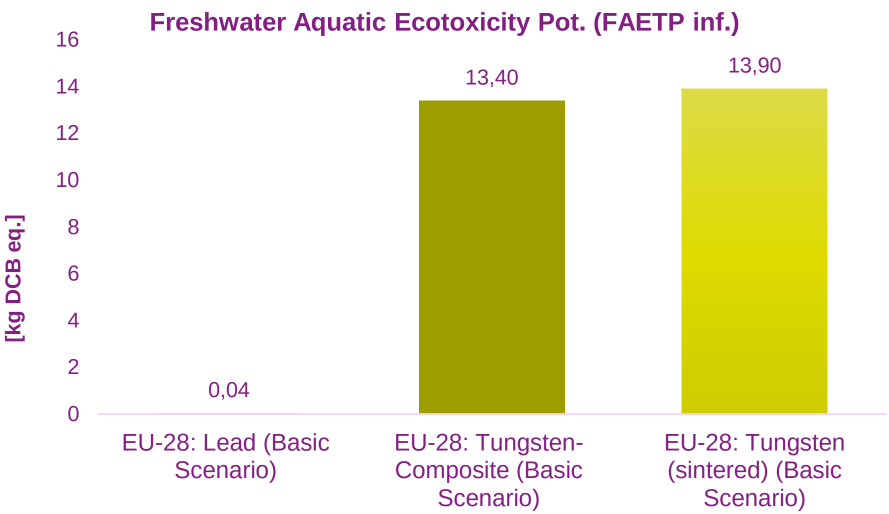
Primary energy demand from ren. and non ren. resources (net cal. value)

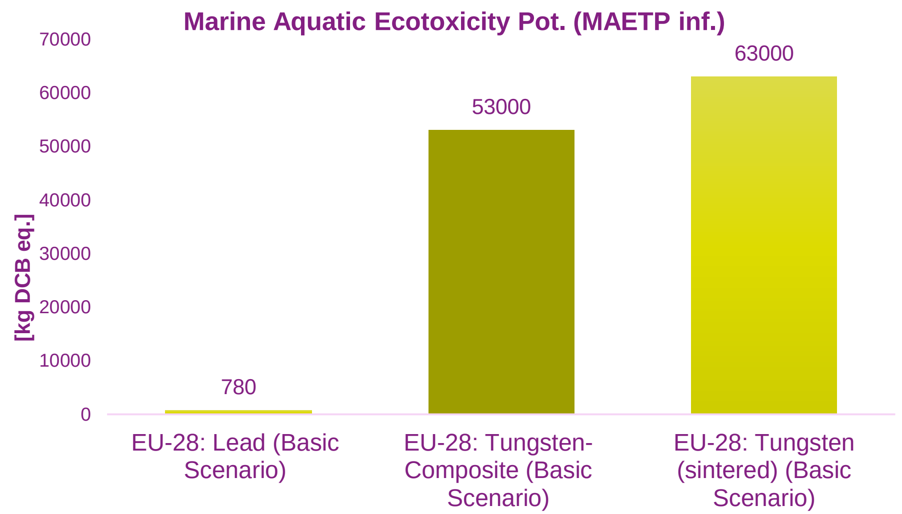


Results: Life Cycle









Additional Scenarios

System Description & System Boundaries

System Description

Tungsten Composite

Stage	Input	
Raw materials	Chinese Tungsten Powder Polyamide 6 Granulate (PA 6)	Same for all scenarios
Transport	Distance 300 km	
Manufacturing operations	Standard Plastic Extrusion	
Distribution	Distance 1000 km	

To cover the key objectives…

1. Basic Scenario displays the results of the Life Cycle of Lead and Tungsten according to the current technology and information (**state of the art**).
2. Additional Scenarios based on possible changes in the End of Life show the potential consequences on the life cycle

End of life

Basic Scenario: 100% landfill

Additional Scenario:

1. 100% of Tungsten Metal Powder is recycled (clean scrap) (Best case) Scenario has been simulated only for Tungsten Composite; neglecting any treatment to access only tungsten metal powder
2. Tungsten scrap re-melting replaces Tungsten metal (Conservative Best case)

System Boundaries - Tungsten Additional Scenario

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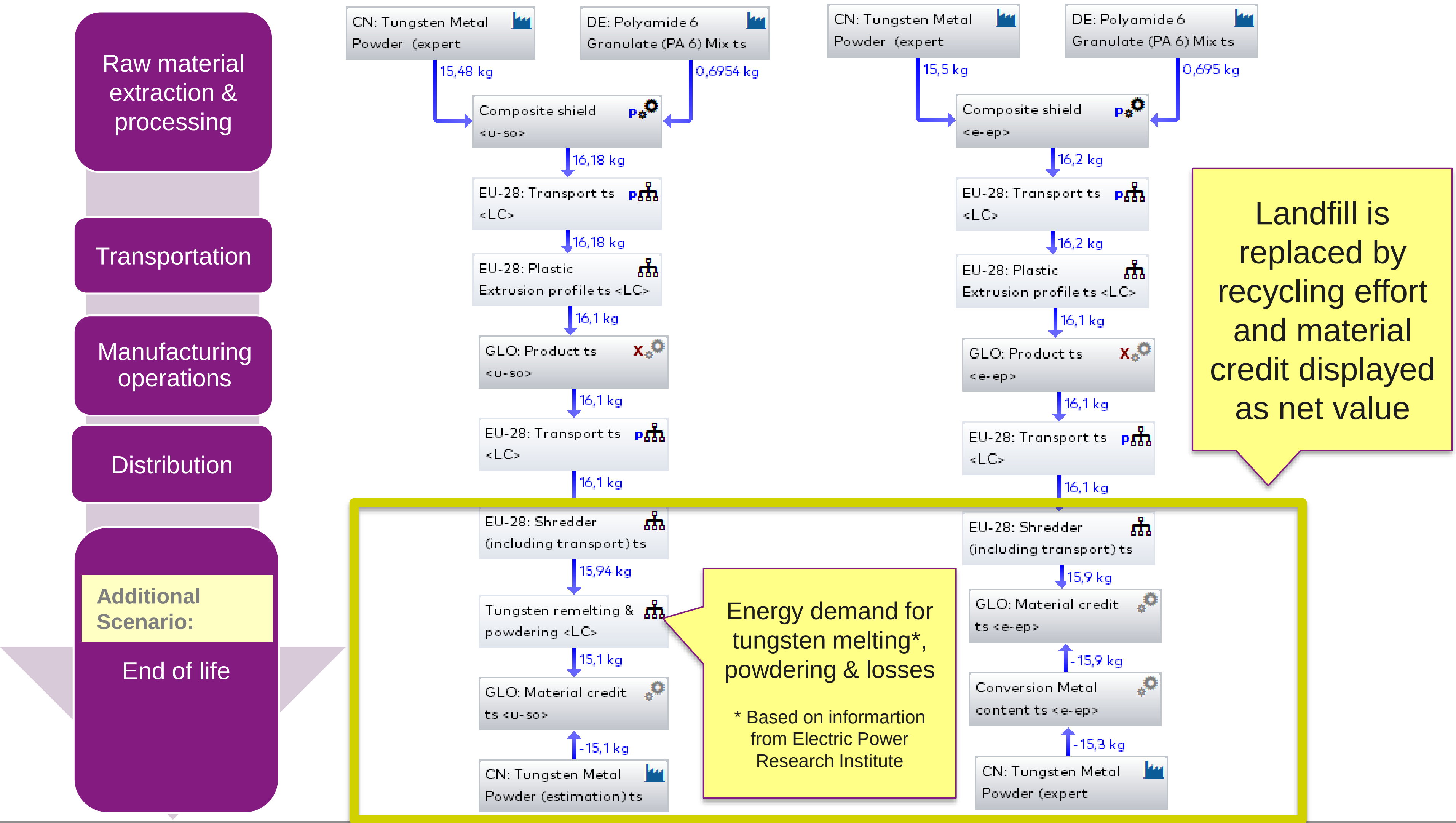
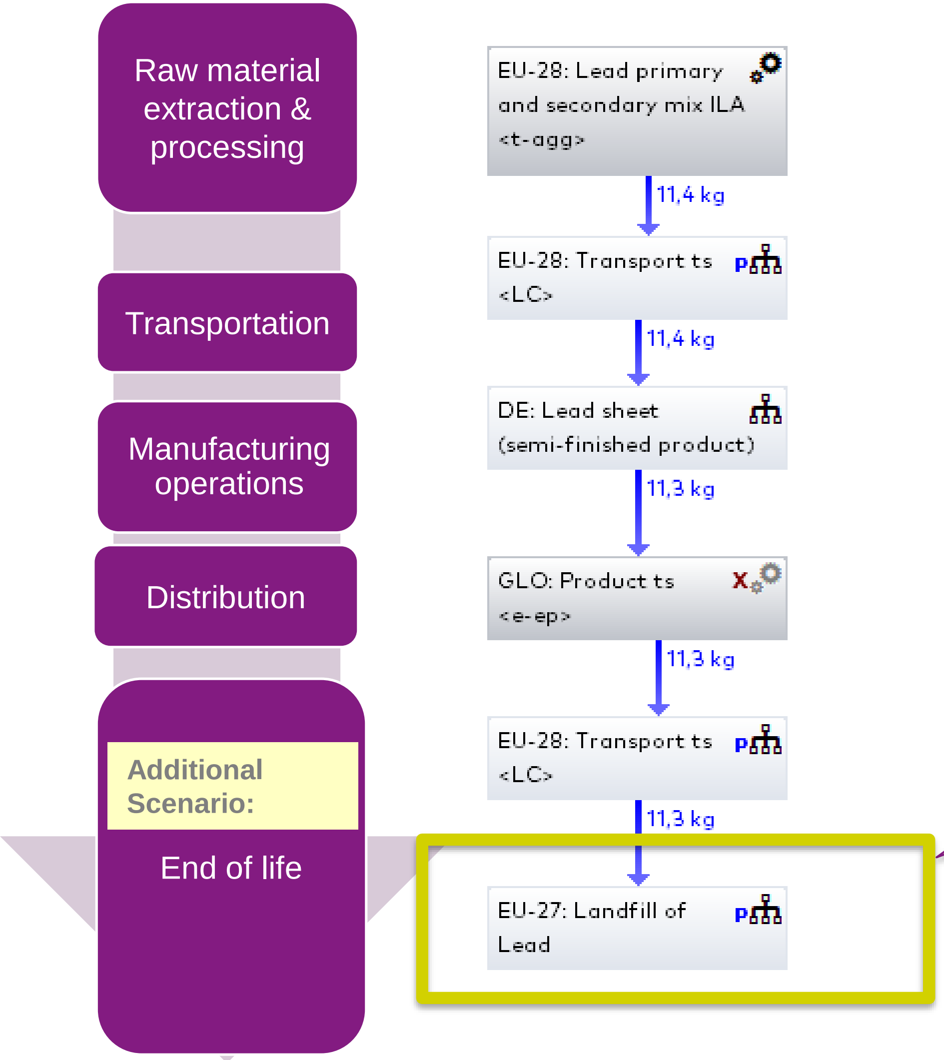


System Boundaries - Lead Additional Scenario

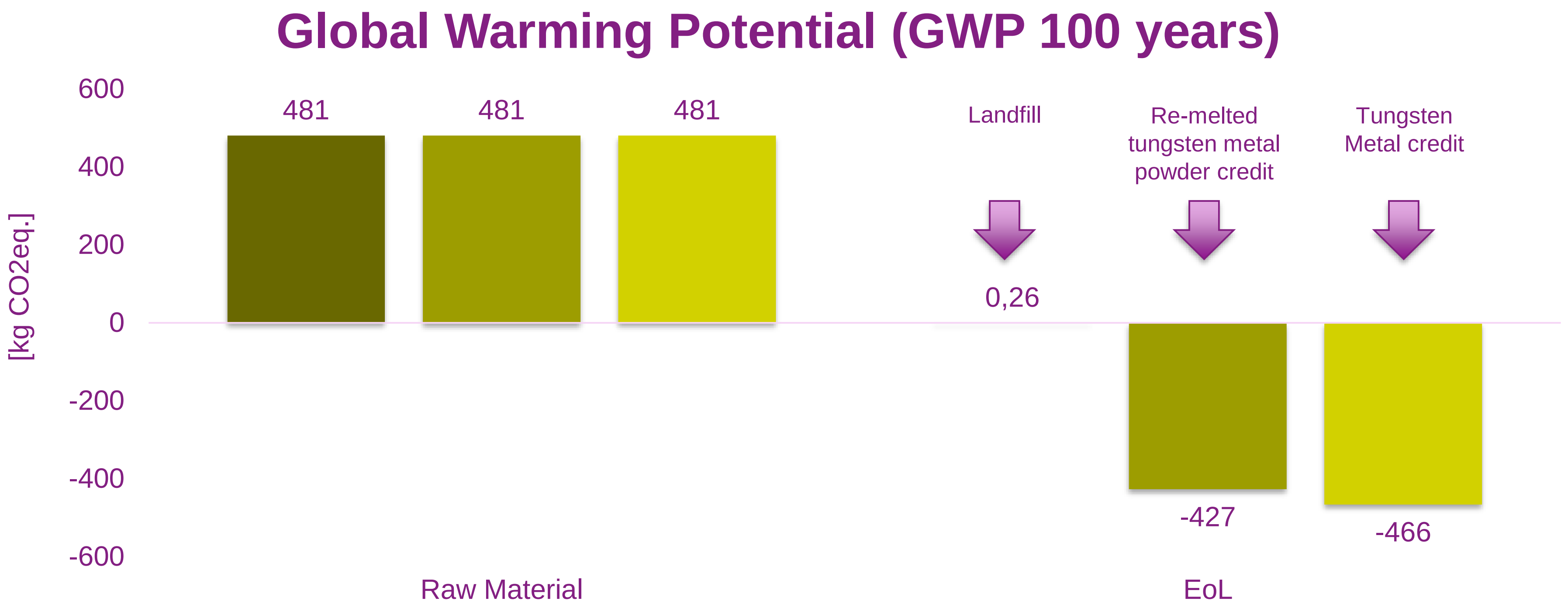


Lead credit is replaced by Lead landfill

Results

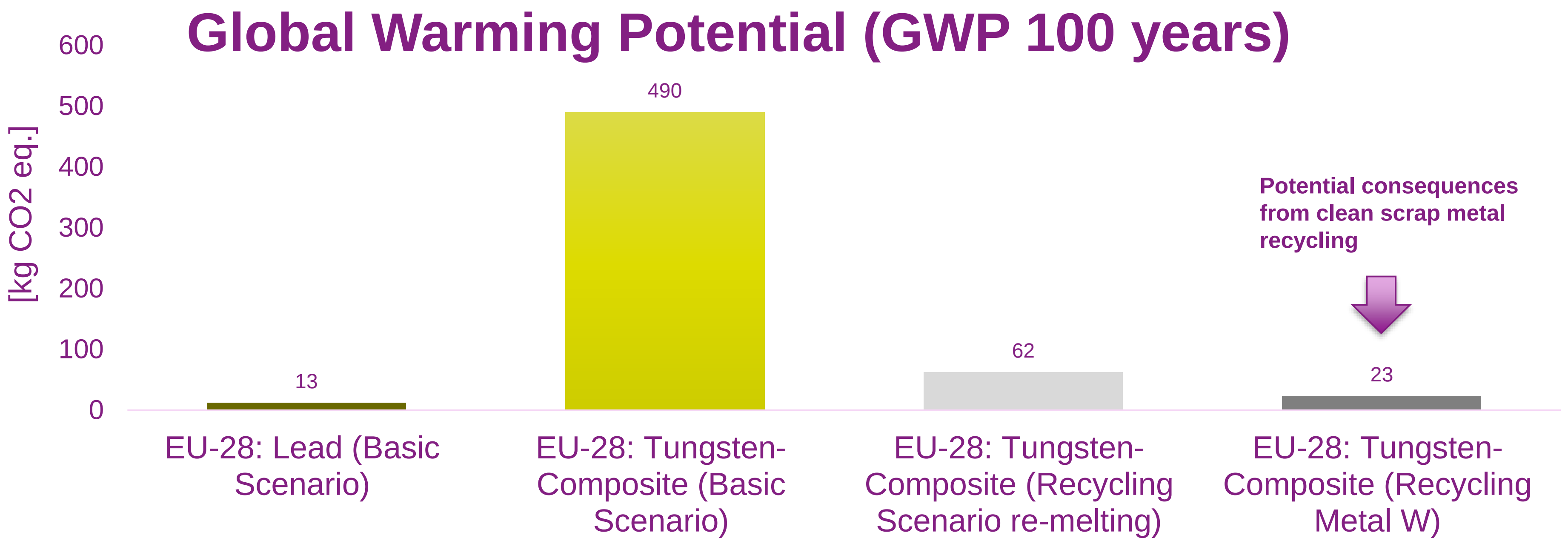
Additional Scenarios

EoL Analysis – Tungsten Composite Hotspot



- Only Hotspot Raw Material acquisition and the changes in the EoL is displayed
- Credit is always primary metallic Tungsten powder for the share of tungsten in composite
- Effort for EoL treatment is
  - For both shredding of sheets including 1% losses
  - For clean scrap no additional efforts, for re-melting energy demand for melting and powdering including 1% additional losses (3422°C + grinding)

EoL Analysis – Comparison all Life Cycles, net values



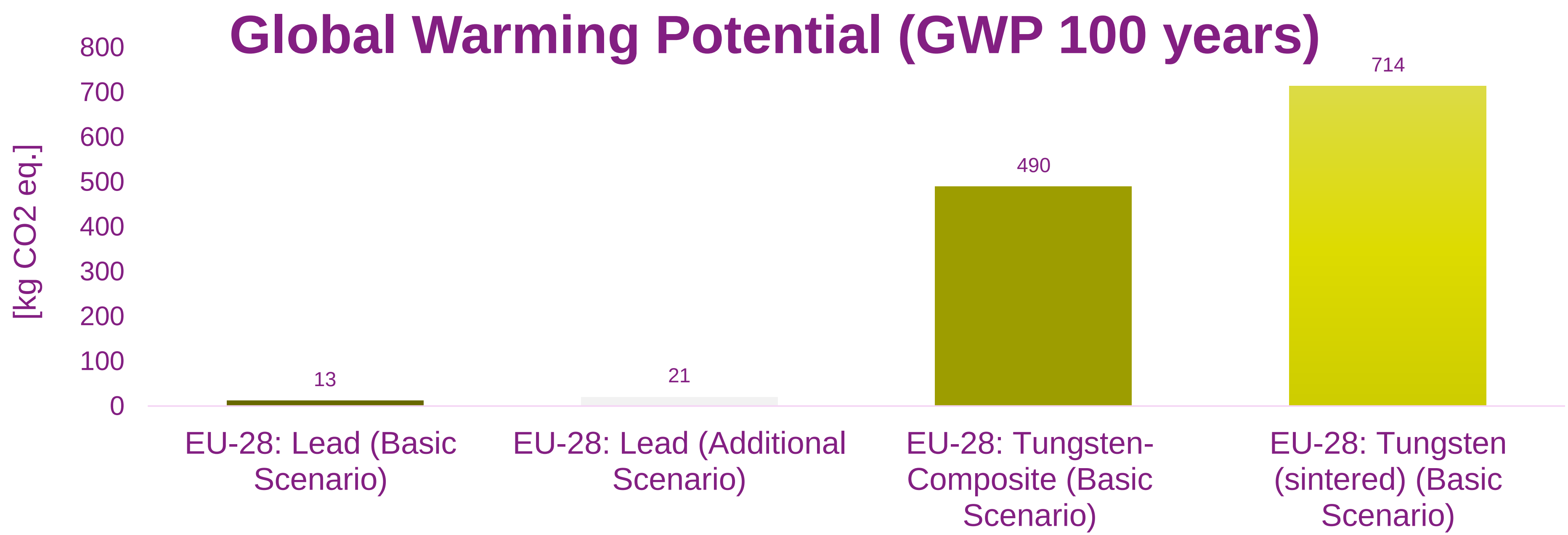
- Best Case Scenario for Tungsten (100% W is recycled) shows a reduction of 95%
- The scenario re-melted tungsten metal powder shows a reduction of 87%
- If 100% of Tungsten is recycled it would share a similar impact in magnitude than Lead. Please note that this is only the case in Tungsten polymer, in the case of Tungsten (sintered) the difference would be higher (GWP of Tungsten sintered approx. 252kg CO_2eq.)

Method Singularities

- Lead Model is based on a net scrap approach i.e. the required secondary input for the Lead production is fed with post-consumer scrap (less credit) (*state of the art*)
- Lead Input is a share of primary/secondary however Tungsten is 100% primary material

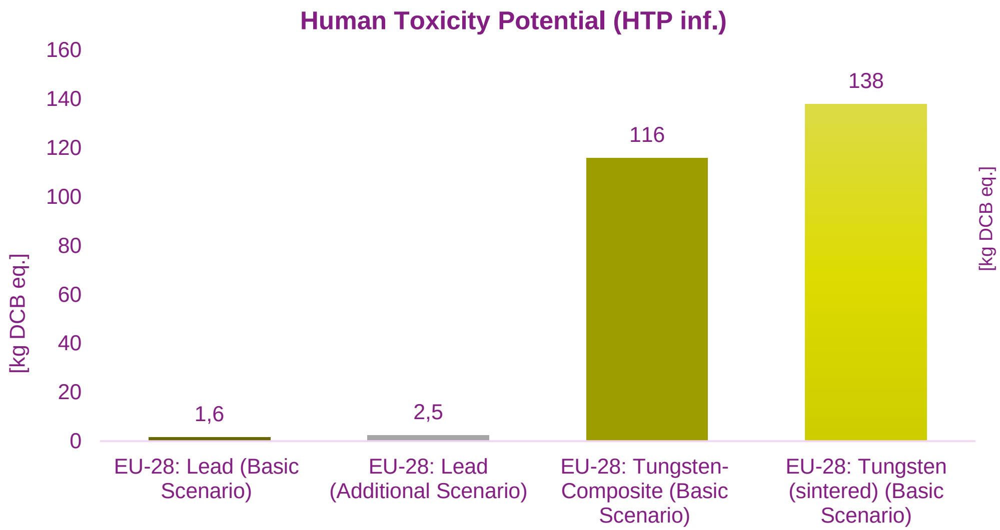
→ An application of the net scrap approach to Tungsten might have a positive impact on the results

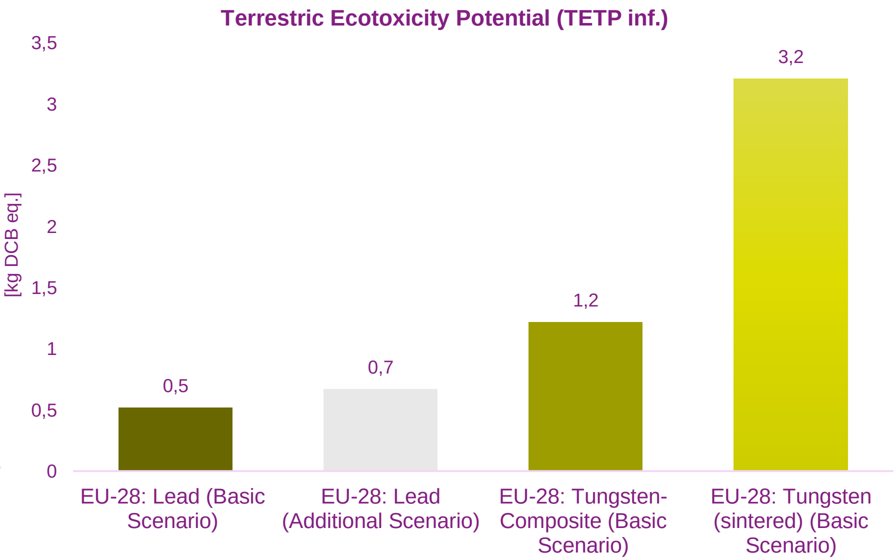
EoL Analysis, Lead landfilled – LC net values for GWP



- The landfill model assumes 42% leaching of Lead. Technical boundaries consider leachate treatment. Emissions refer to efforts of the leachate treatment and final sludge drying.
- The 7,6 kgCO_2eq. credit (see hotspot analysis for Lead) is lost and added to the net value of the life cycle resulting 21 kgCO_2eq.
- The effort from landfill are negligible

EoL Analysis, Lead landfilled – LC net values for TOX





- The landfill model assumes 42% leaching of Lead. Technical boundaries consider leachate treatment. Emissions refer to efforts of the leachate treatment and final sludge drying.
- Loss of credit plus the effort of landfill increase HTP from 1,6 kgDCBeq. to 2,6 kgDCB eq and TETP from 0,5 to 0,7.
- Direct Lead emissions in a technical controlled landfill are not applicable
- Even losing the credit, Lead at TETP is still lower than Tungsten. (See influence of Hg on TETP in slide LC overview TOX)

Conclusions

Findings & Outlook

Conclusions

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- Functional unit ensures comparability due to identical function i.e. radiation shielding
- Base scenario shows significant lower impact for Lead compared to both Tungsten material options over the life cycle following a state of the art approach and worst case assumption (worst for Lead best for Tungsten)
- It applies for all impact categories with exemption of ODP due to non-representative ODP relevant inventories
- Additional scenarios proof stability of results
- Analysis of toxicity in EoL for Lead provides no hints on potential risks
- The life cycle comparison of Lead and Tungsten show a potential risk (net values show similar order of magnitude), only if Tungsten is recycled via clean scrap or scrap re-melting.

Outlook

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- A comparative LCA study according to ISO 14040/44 requires an ISO conform report and external reviewer panel
- New Lead industry data will be available end of 2018 allowing split of primary and secondary as well as new state of the art data (supposed to be lower in impact)
- All expert judgements and assumptions could be improved by additional investigation and primary data acquisition going beyond the given scope of the project (e.g. Tungsten at cradle to gate (including secondary share), sintering and EoL)
- EoL investigation with focus on recycling of Tungsten (research relevant field) could stabilize the results with future proof scenarios (*Is Tungsten recycling state of the art in the future?)*

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