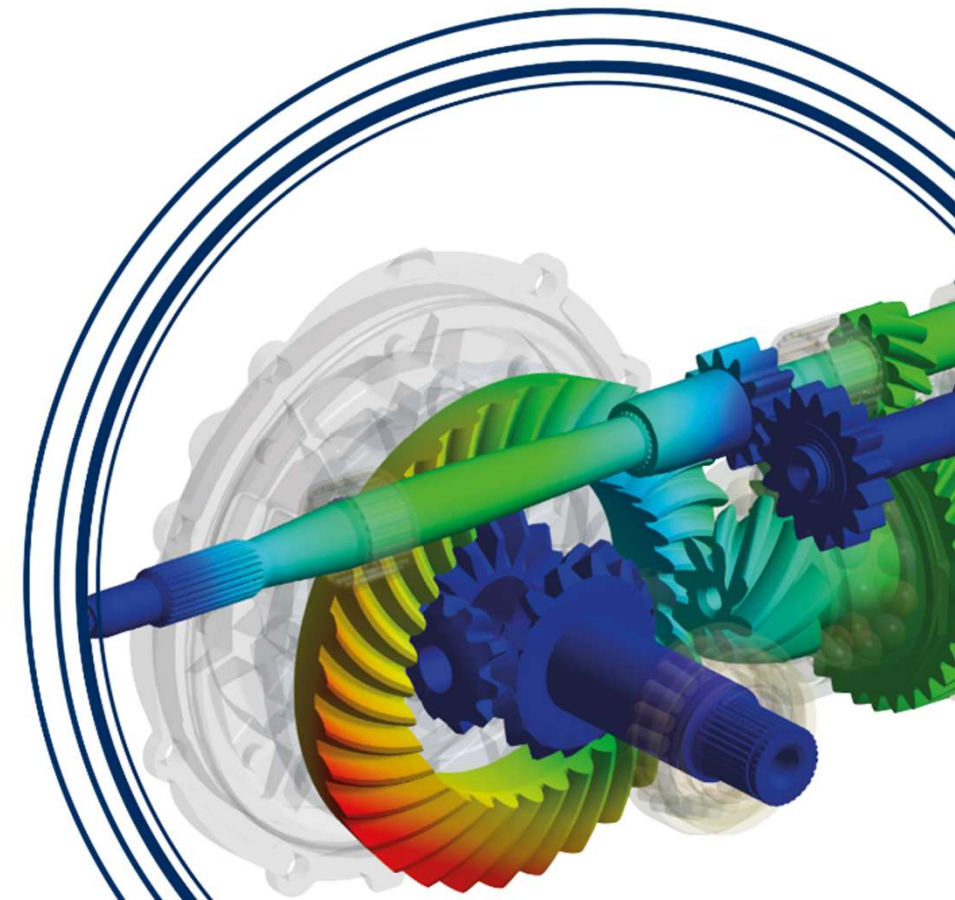


Sustainable product insight with optiSLang and Granta

20th Weimar Optimization and
Stochastic Days 2023

Jessica Sastre,

Dr.-Ing. Cord Steinbeck-Behrens,
Dipl.-Ing. (FH) Andreas Veiz



CADFEM[®]

Ansys / ELITE
CHANNEL PARTNER

Customer interviews:

Development priority:

Product optimization & CO2 Reduction

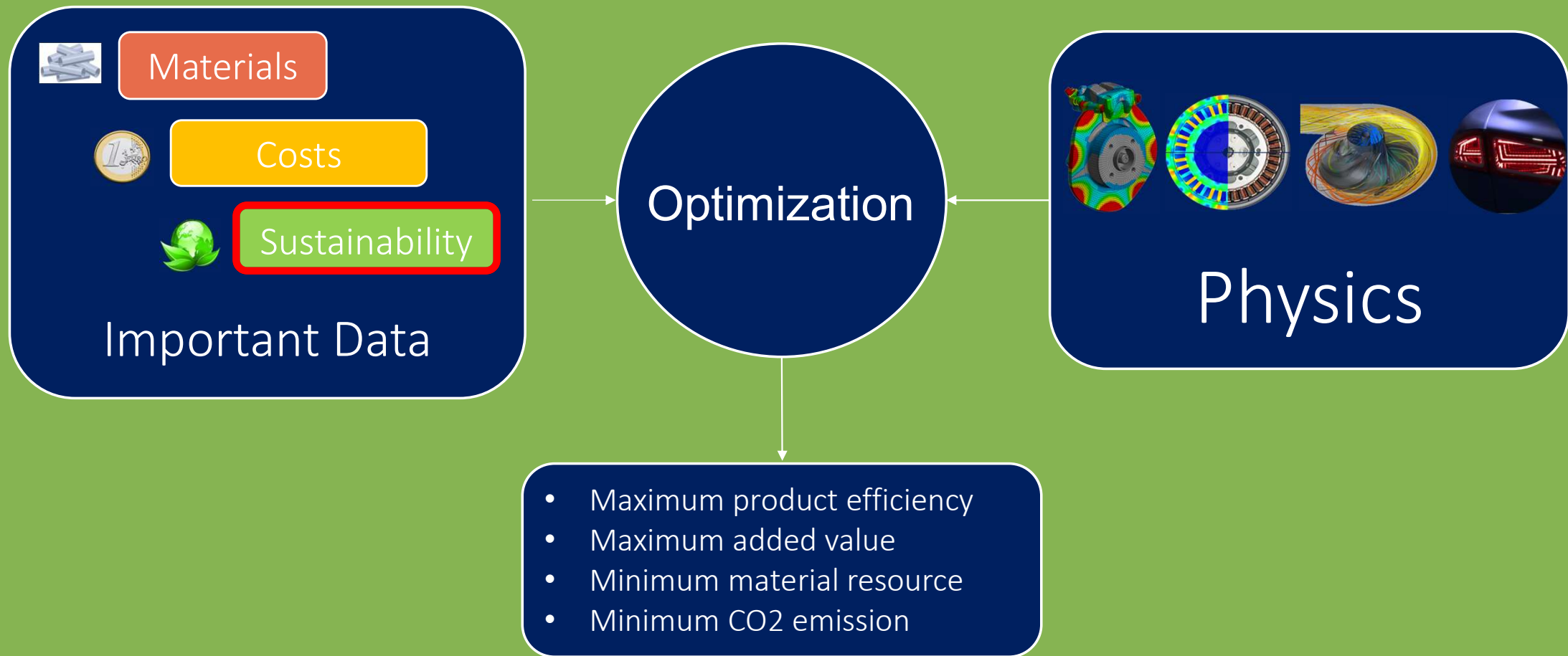


Complexity

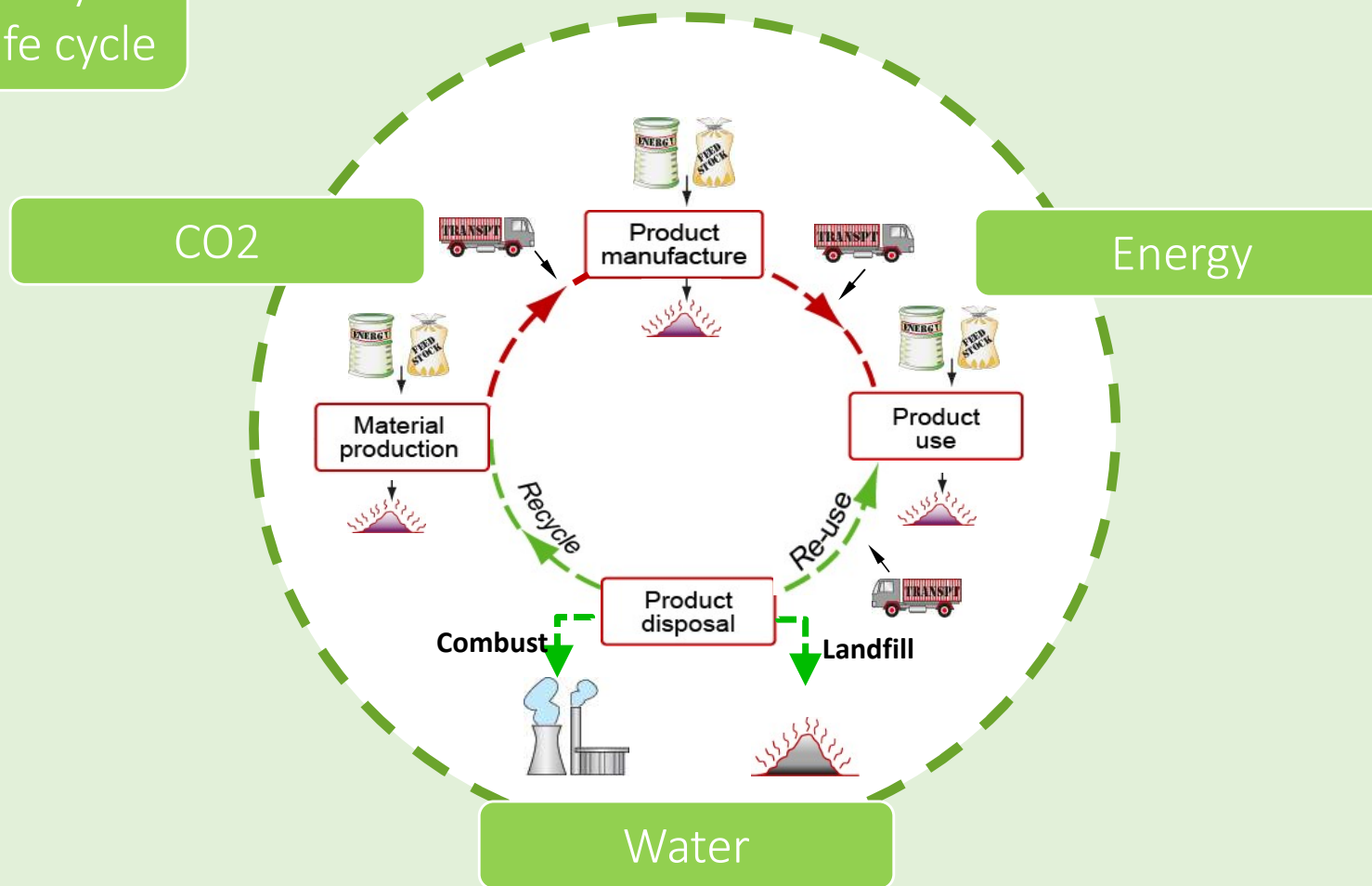


Sustainability

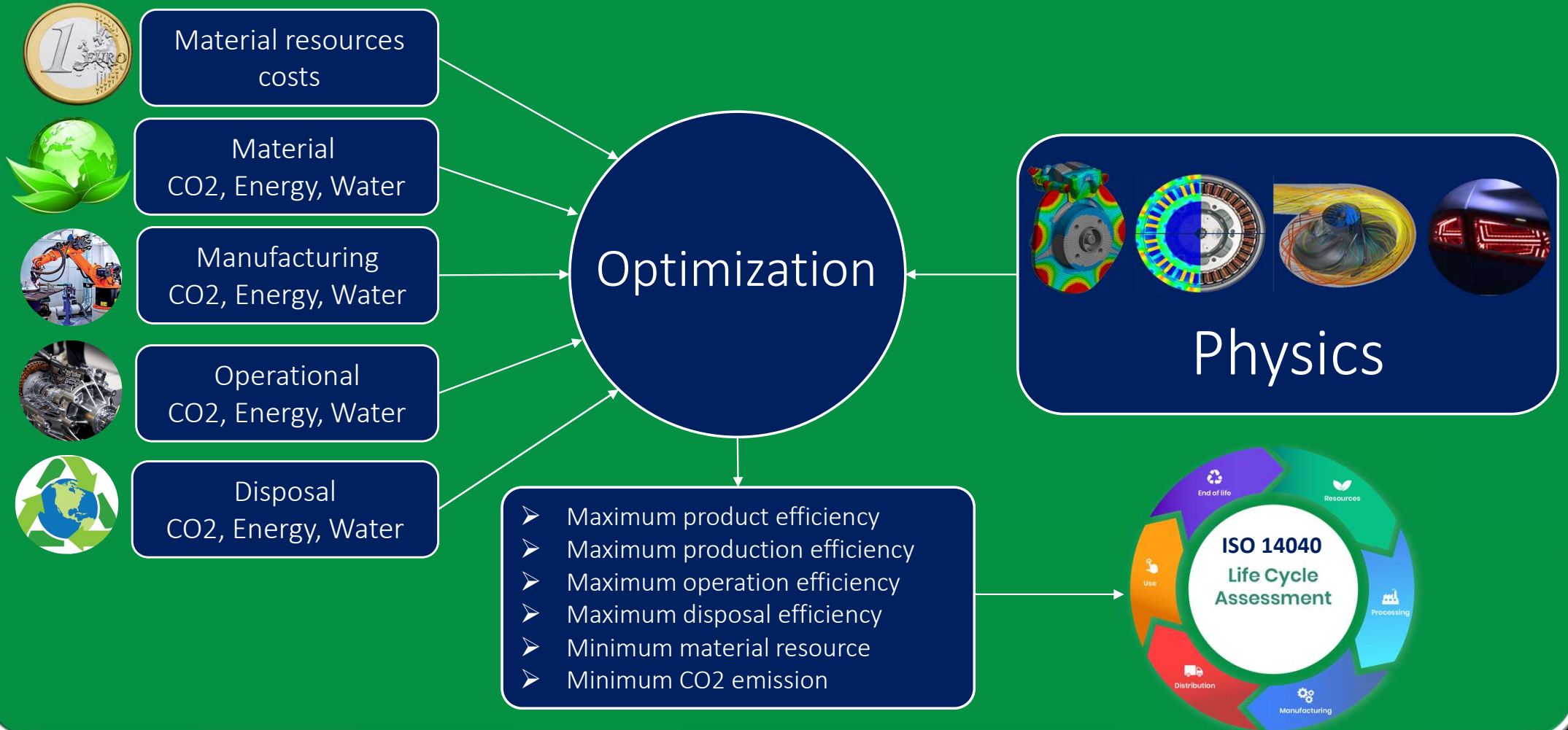
Innovation and sustainability through product insight



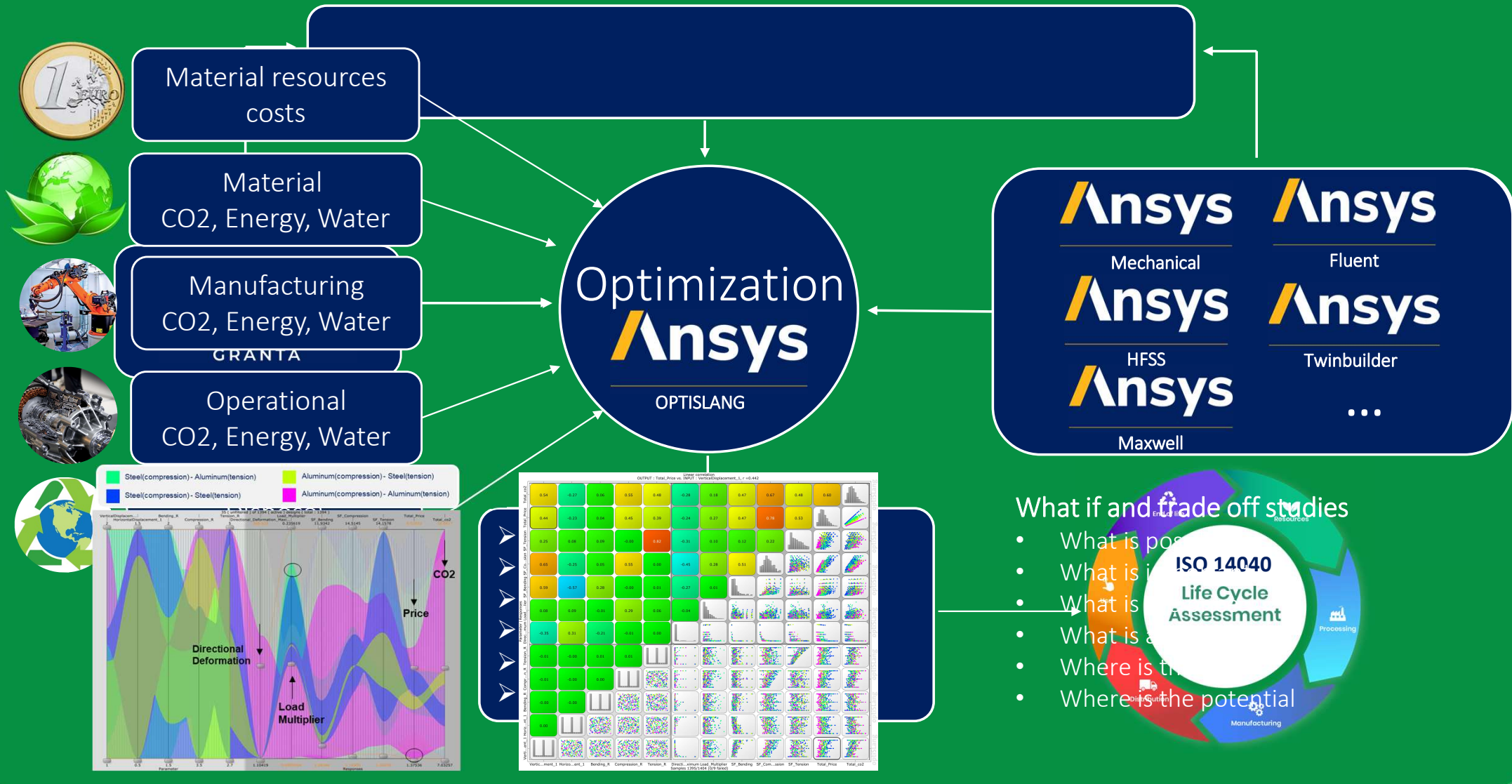
Sustainability in product life cycle



Simulation Process Data Management



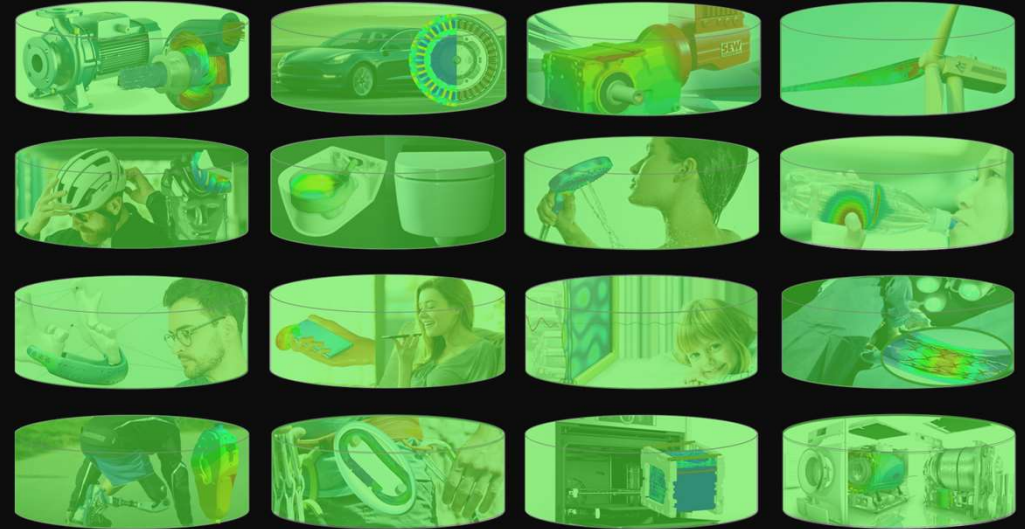
CADFEM Workflow



Innovative products today



Sustainable Products tomorrow

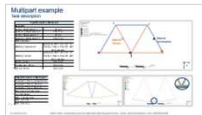


Innovation and sustainability through product insight

Simple parametric system in OptiSLang

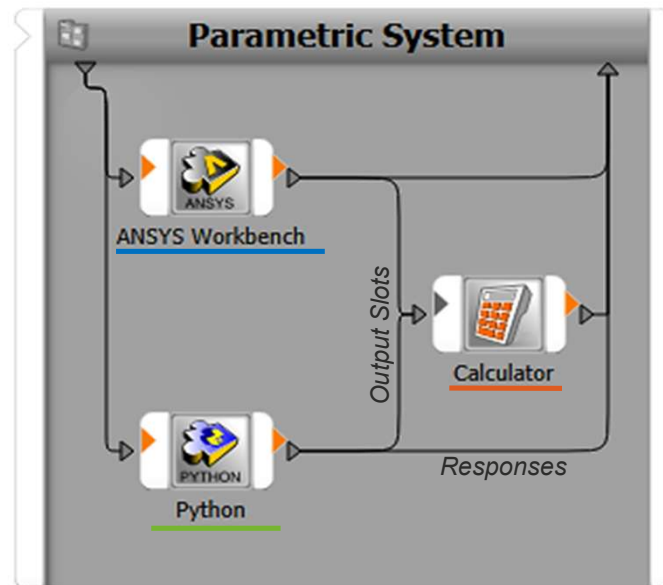
- **Materials name**
- Geometry parameters
- Mass of the part
- Evaluations: Max equivalent stress, Load Multiplier

Ansys / MECHANICAL



- **Materials Name**
- CO2/kg per Material
- Price/kg per Material
- Yield strength per Material

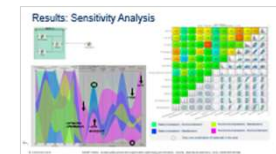
Ansys / GRANTA



Results for sensitivity analysis and optimization:

- $Total_Price = Mass * Price$
- $Total_co2 = Mass * CO2$
- $SF = Yield\ strength / Equivalent_stress$

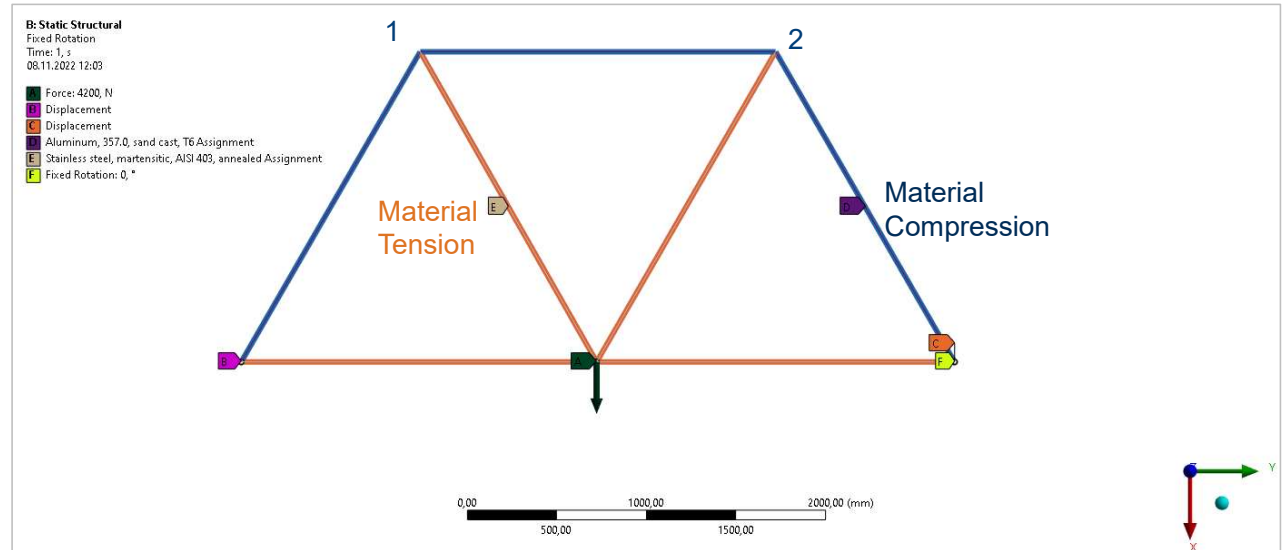
Ansys / OPTISLANG



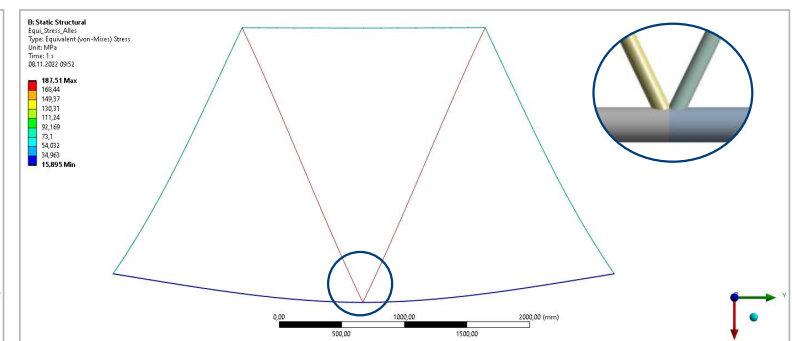
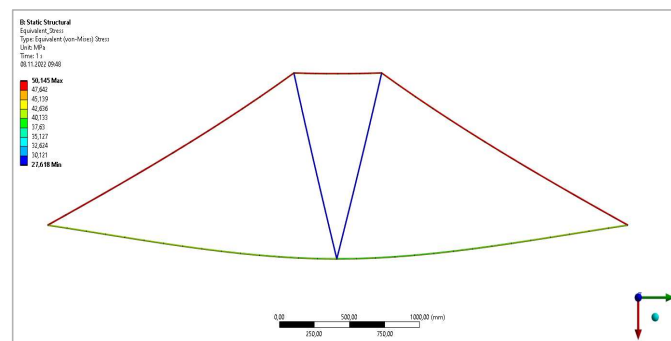
Multipart example

Task description

Input Parameters-Mechanical	
Geometry	
Vertical_Displacement_1	1m-2m
Horizontal_Displacement_1	0.5m-1.5m
Vertical_Displacement_2	1m-2m
Horizontal_Displacement_2	0.5m-1.5m
Static Structural	
Material_Compression	Aluminum,357.0, sand cast, T6 - Stainless steel, martensitic, AISI 403, annealed
Material_Tension	Aluminum,357.0, sand cast, T6 - Stainless steel, martensitic, AISI 403, annealed
Bending_Radius	1mm-6mm
Compression_Radius	1mm-6mm
Tension_Radius	1mm-6mm



Output Parameters-Mechanical
Equivalent_Stress_Compression
Equivalent_Stress_Tension
Equivalent_Stress_Bending
Directional_Deformation
Load Multiplier
Mass_Compression
Mass_Tension
Mass_Bending

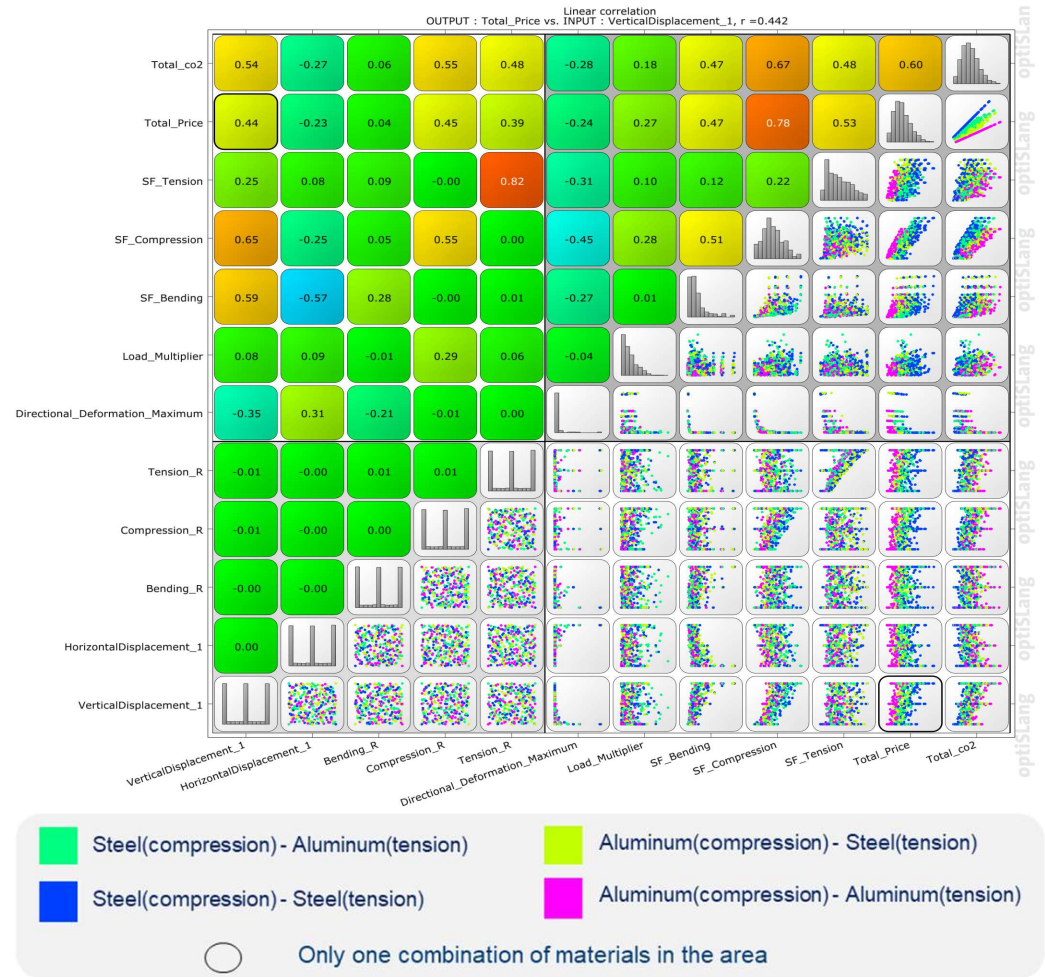
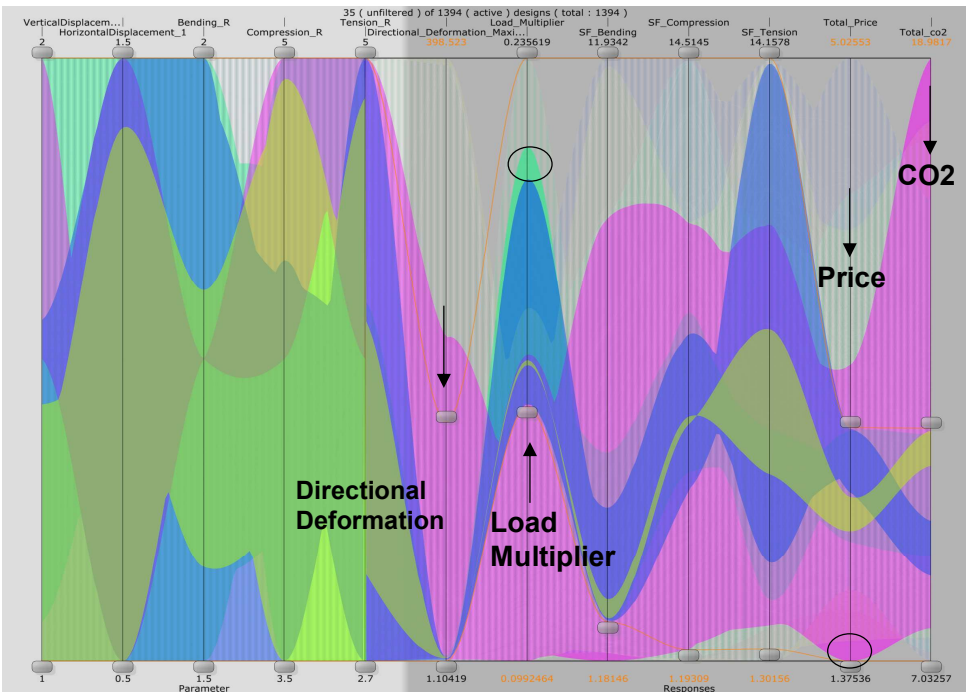
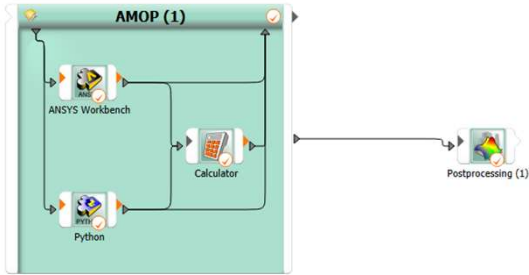


Material data

Stainless steel, ferritic, AISI 409, annealed	
Datasheet view: All attributes	Aluminum, 357.0, sand cast, T6
Processing properties	Datasheet view: All attributes Show/Hide Find Similar
Metal casting	
Metal cold forming	Stress corrosion cracking ⓘ Slightly susceptible Notes Rated in chloride; Other susceptible environments: Halide, water
Metal hot forming	
Metal press forming	
Metal deep drawing	Primary production energy, CO2 and water
Machining speed	Embodied energy, primary production (virgin grade) ⓘ * 181 - 199 MJ/kg Sources Estimated from sources including Institute for Prospective Technological Studies, 2005; Heekert, 2000; Norgate, Jahanshahi, Rankin, 2007; Hammond and Jones, 2008; Ecoinvent v3.7.1; Dhringra, Overly, Davis, 1999; Williams, Ayres, Heller, 2002; Boustead, 2002
Weldability	Embodied energy, primary production (typical grade) ⓘ * 110 - 129 MJ/kg
Weldability - MIG	CO2 footprint, primary production (virgin grade) ⓘ * 13 - 14,3 kg/kg
Weldability - plasma	Sources Estimated from sources including Voet, van der and Oers, van, 2003; Hammond and Jones, 2008; Ecoinvent v3.7.1; Tharumarajah and Koltun, 2007
Weldability - SAW	CO2 footprint, primary production (typical grade) ⓘ * 8,02 - 9,37 kg/kg
Weldability - TIG	
Brazeability	Water usage ⓘ * 1,06e3 - 1,17e3 l/kg
Carbon equivalency	Processing energy, CO2 footprint & water
Durability	Casting energy ⓘ * 10,8 - 12 MJ/kg
Water (fresh)	Casting CO2 ⓘ * 0,65 - 0,718 kg/kg
Water (salt)	Casting water ⓘ * 20,5 - 30,8 l/kg
Weak acids	Vaporization energy ⓘ * 1,55e4 - 1,71e4 MJ/kg
Strong acids	Vaporization CO2 ⓘ * 930 - 1,03e3 kg/kg
Weak alkalis	Vaporization water ⓘ * 6,45e3 - 9,68e3 l/kg
Strong alkalis	Coarse machining energy (per unit wt removed) ⓘ * 0,877 - 0,969 MJ/kg
Organic solvents	Coarse machining CO2 (per unit wt removed) ⓘ * 0,0526 - 0,0581 kg/kg
Oxidation at 500C	Fine machining energy (per unit wt removed) ⓘ * 4,49 - 4,97 MJ/kg
UV radiation (sunlight)	Fine machining CO2 (per unit wt removed) ⓘ * 0,27 - 0,298 kg/kg
Galling resistance (adhesive)	Grinding energy (per unit wt removed) ⓘ * 8,51 - 9,41 MJ/kg
Notes Aluminum bronze is the m	Grinding CO2 (per unit wt removed) ⓘ * 0,511 - 0,564 kg/kg
Flammability	Non-conventional machining energy (per unit wt removed) ⓘ * 155 - 171 MJ/kg
	Non-conventional machining CO2 (per unit wt removed) ⓘ * 9,3 - 10,3 kg/kg
Corrosion resistance	Recycling and end of life
Pitting resistance equivalent	Recycle ⓘ ✓
Pitting and crevice corrosion	Embodied energy, recycling ⓘ 31,1 - 34,4 MJ/kg
Stress corrosion cracking	CO2 footprint, recycling ⓘ 2,45 - 2,7 kg/kg
Notes	Recycle fraction in current supply ⓘ 42,8 - 47,3 %
	Downcycle ⓘ ✓
	Combust for energy recovery ⓘ ✗
	Landfill ⓘ ✓
	Biodegrade ⓘ ✗



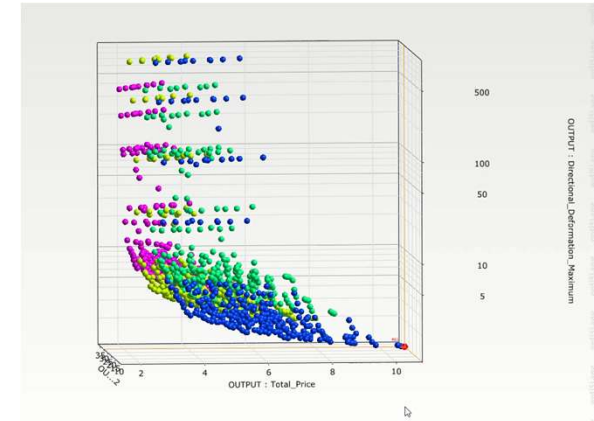
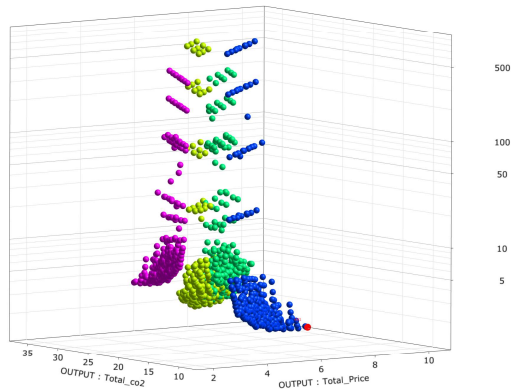
Results: Sensitivity Analysis



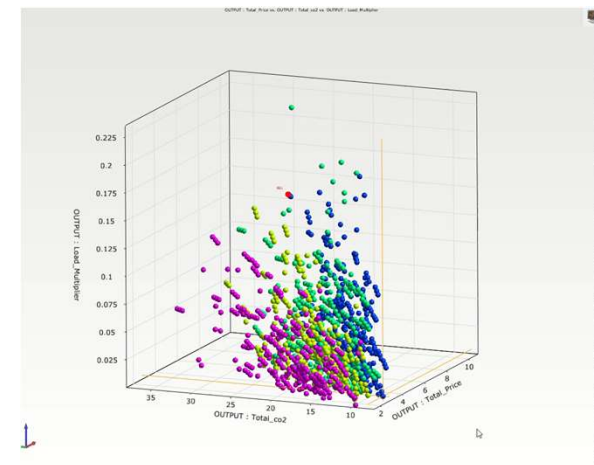
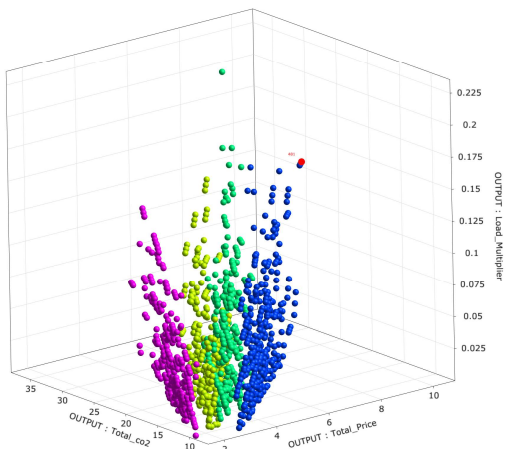
Results: Sensitivity Analysis

Total Price vs. Total CO2 vs.
Directional Deformation Max

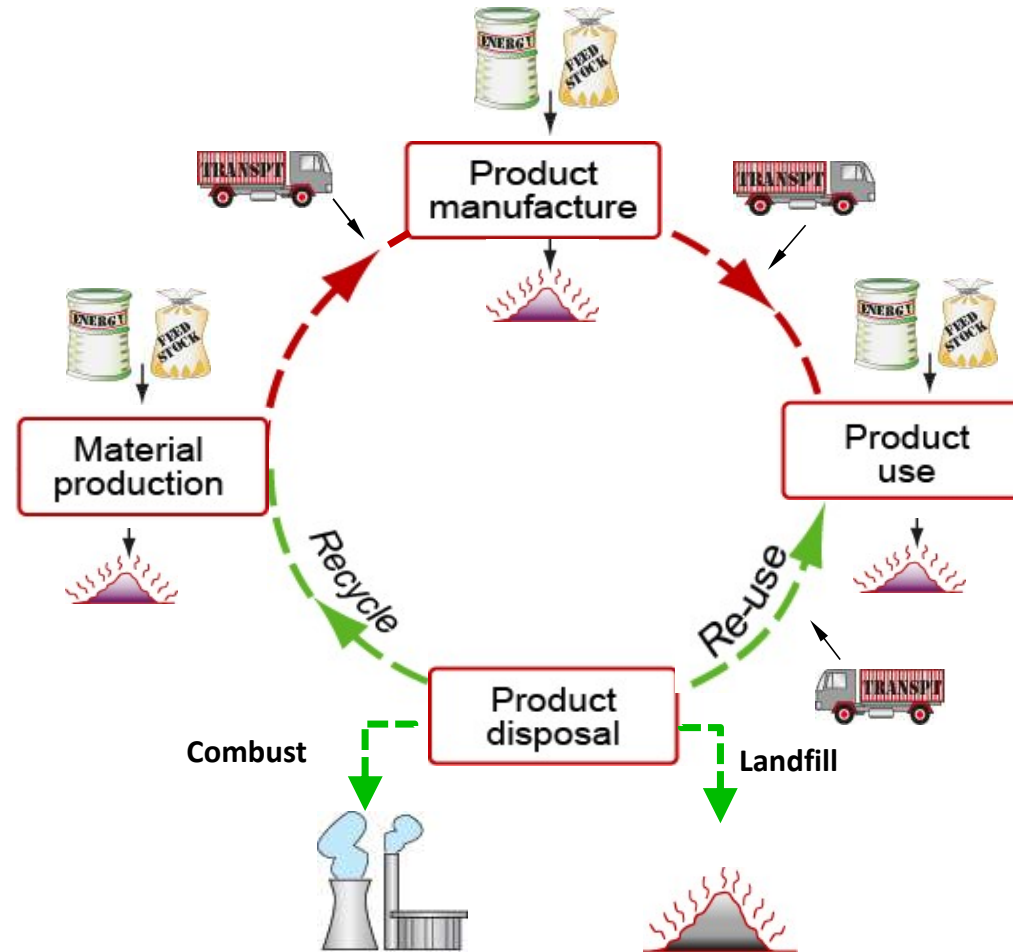
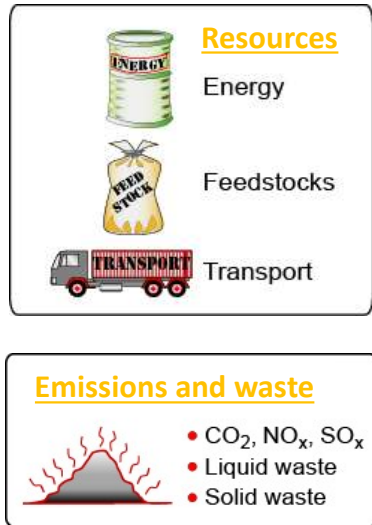
- Steel(compression) - Aluminum(tension)
- Steel(compression) - Steel(tension)
- Aluminum(compression) - Steel(tension)
- Aluminum(compression) - Aluminum(tension)



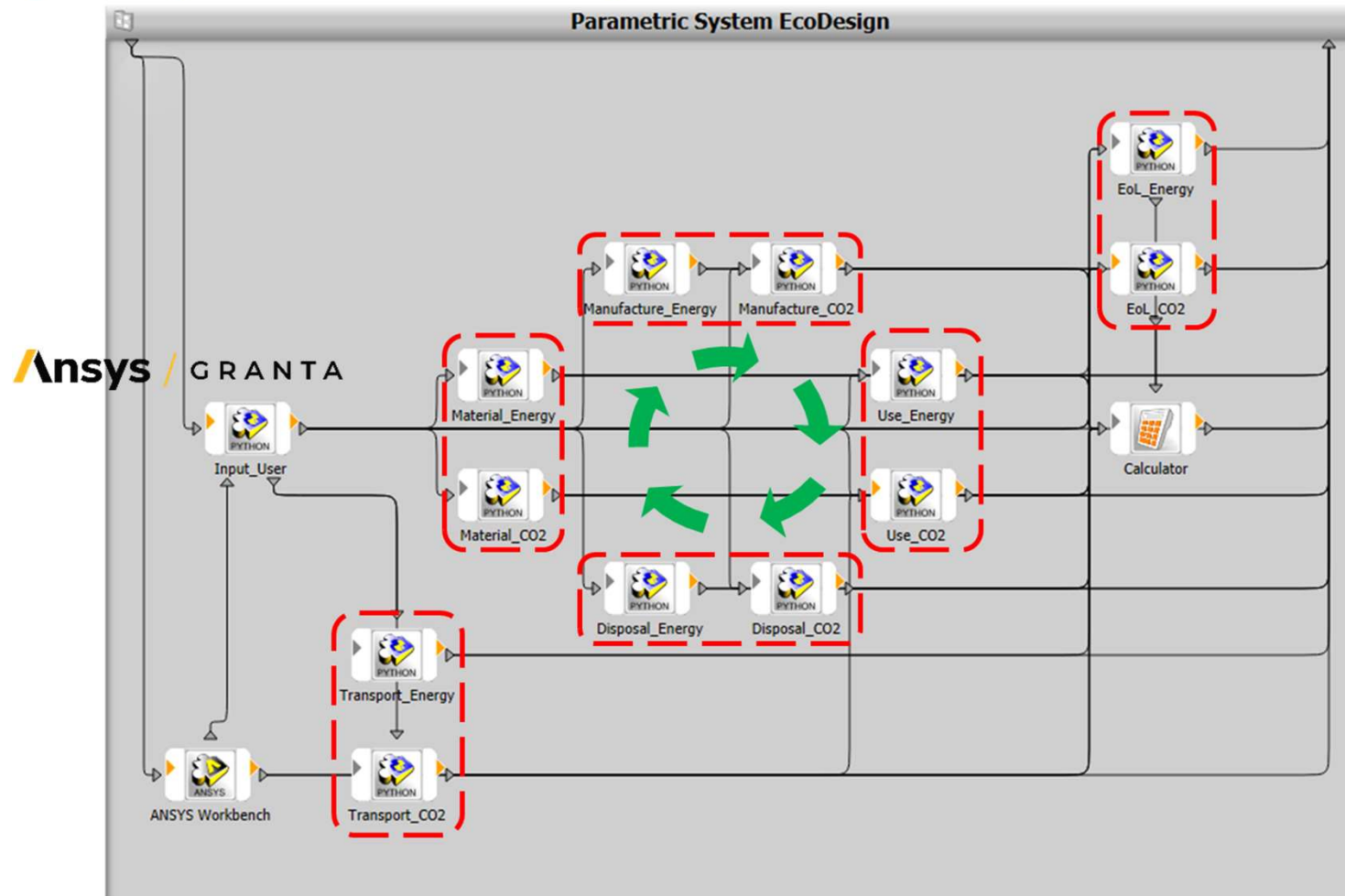
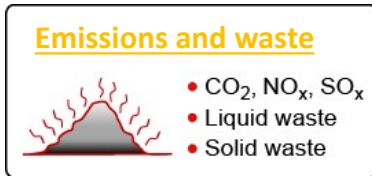
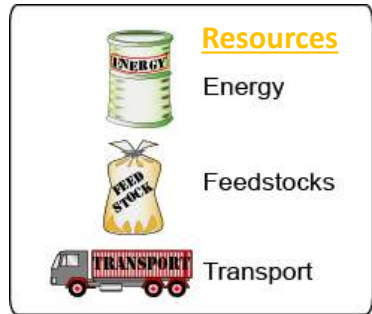
Total Price vs. Total CO2 vs.
Load Multiplier



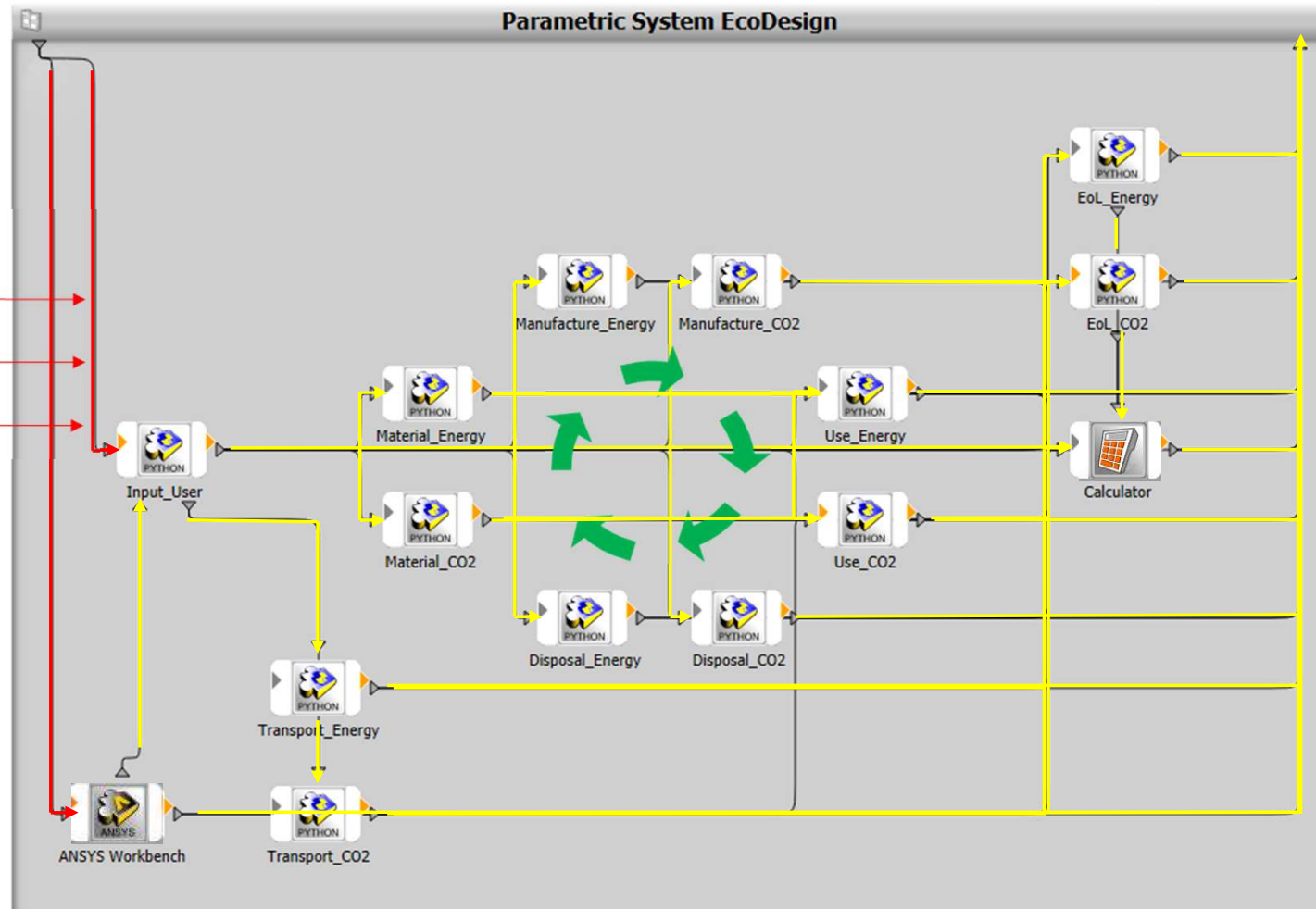
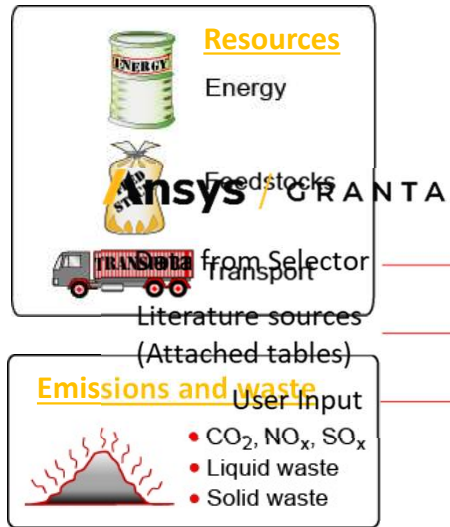
Sustainability in product life cycle



Sustainability in product life cycle



Sustainability in product life cycle



Streamlined LCA with Eco Audit tool

Item	Material	Quantity	Unit	Energy	CO2	NOx	SOx	Other
...

Streamlined LCA with Eco Audit tool

Eco Audit Project

Product definition Report

ECO AUDIT PRODUCT INSIGHT

Material, manufacture and end of life							Joining and finishing	
Material name	Recycled content	Primary process	Secondary process	% removed	End of life	% recovered	Joining and finishing process	Amount in m
Stainless steel, martensitic, AISI 410, hard temper	virgin	Roll forming, forging	Fine machining (per unit wt removed)	50	Recycle	100	Joining: Welding, electric	0.02
Aluminum, 6061, T4	virgin	Roll forming, forging	Coarse machining (per unit wt removed)	50	Recycle	100	Joining: Welding, electric	0.02
Aluminum, 6061, T6	virgin	Roll forming, forging	Fine machining (per unit wt removed)	50	Recycle	100	Joining: Welding, electric	0.02
Stainless steel, ferritic, AISI 409, annealed	virgin	Roll forming, forging	Grinding (per unit wt removed)	50	Recycle	100	Joining: Welding, electric	0.02
			Non-conventional machining (per unit wt removed)	50	Recycle	100	Joining: Welding, electric	0.02

Transport		
Material name	Transport type	Distance (km)
Stainless steel, martensitic, AISI 410, hard temper	32 tonne (4 axle) truck	500
Aluminum, 6061, T4	32 tonne (4 axle) truck	500
Aluminum, 6061, T6	32 tonne (4 axle) truck	500
Stainless steel, ferritic, AISI 409, annealed	32 tonne (4 axle) truck	500

Use				Static mode			Mobile mode		
Material name	Product life in years	Country of use	mode	Energy input and output	Days per year	Hours per day	Fuel and mobility type	Days per year2	Km per day
Stainless steel, martensitic, AISI 410, hard temper	30	Germany	static	Electric to thermal	100	24		0	0
Aluminum, 6061, T4	30	Germany	static	Electric to thermal	100	24		0	0
Aluminum, 6061, T6	30	Germany	static	Electric to thermal	100	24		0	0
Stainless steel, ferritic, AISI 409, annealed	30	Germany	static	Electric to thermal	100	24		0	0

Please fill the cells according to the selected mode

Report

Summary chart

Detailed report

Image: Note:

Browse...

Clear

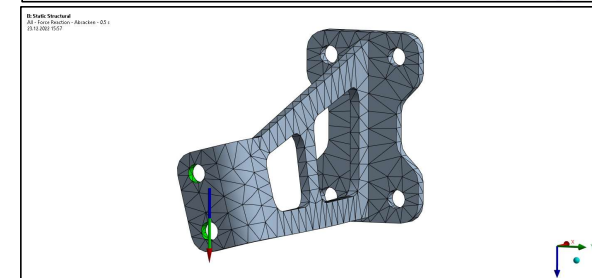
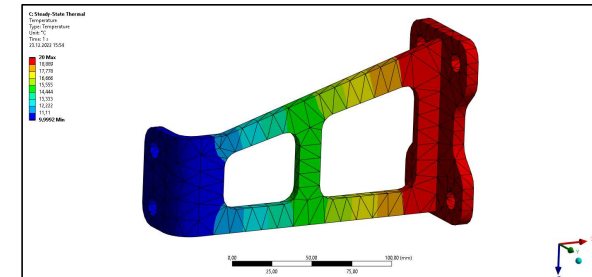
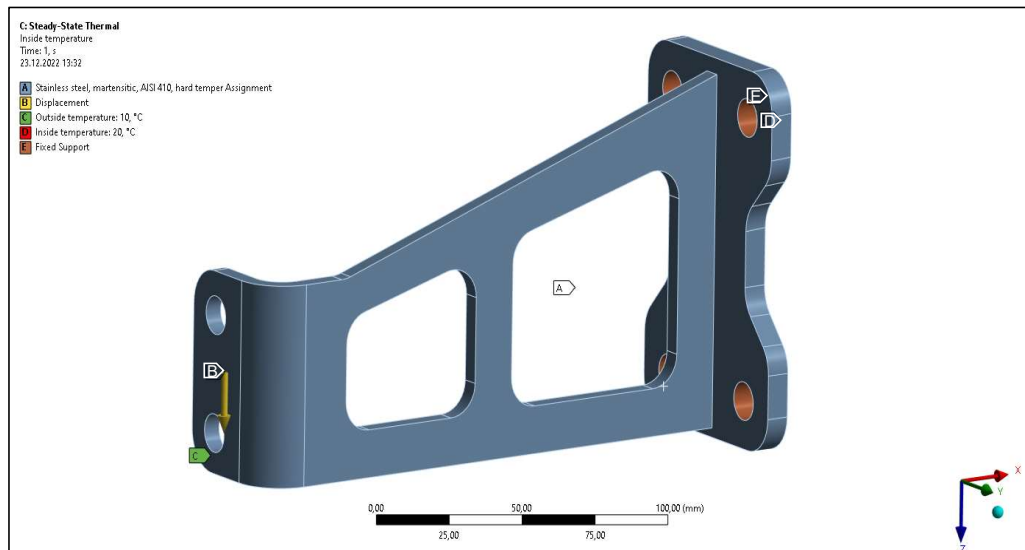
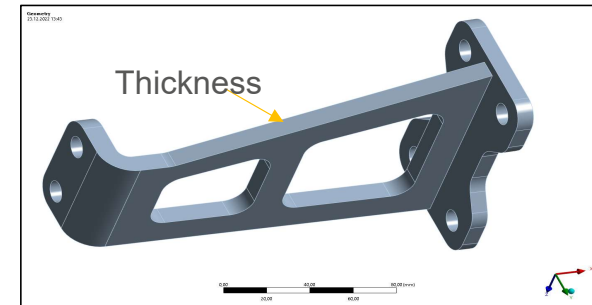


Single part example

Task description

Input Parameters	
Geometry	
Thickness	5mm-10mm
Static structural	
Material	Stainless steel, martensitic, AISI 410, hard temper
	Stainless steel, ferritic, AISI 409, annealed
	Aluminum, 6061, T4
	Aluminum, 6061, T6

Output Parameters
Heat [w]
Mass [kg]
Force reaction-0.5s-Z axis [N]
Force reaction-1s-Z axis [N]
Load increase [N]
Load increase percent



Additional calculations

- Direct output per part from mechanical node

Force reaction 0.5s Z Axis

- Direct output per part from product cycle

Material energy
Material CO2
Material cost
Transport energy
Transport CO2
Manufacture energy
Manufacture CO2
Use energy
Use CO2
Use cost
EoL energy
EoL CO2
Disposal energy
Disposal CO2



- Indirect outputs per part

Total energy full cycle
Total CO2 full cycle
Total cost (material+use)

- Indirect outputs per design performance

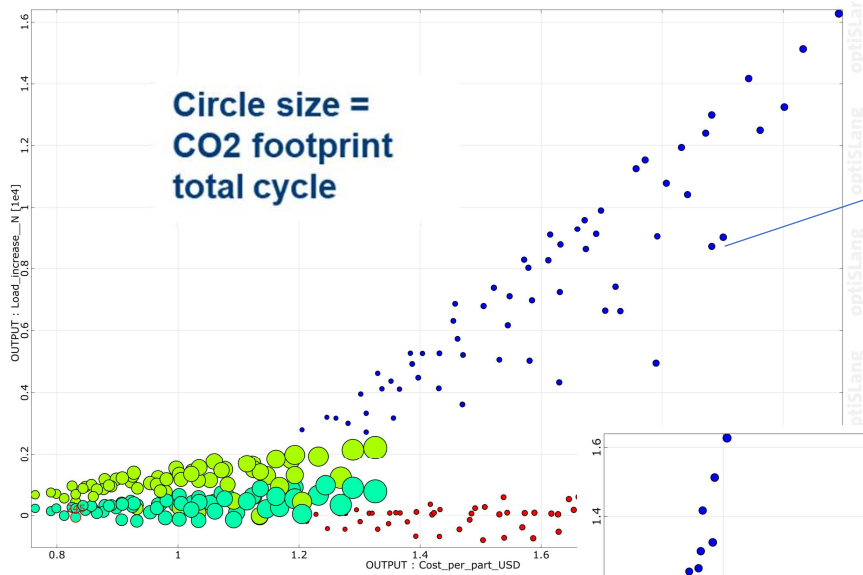
Performance per load capacity
Material energy
Material CO2
Material cost
Use energy
Use CO2
Use cost
Total energy
Total CO2
Total cost

- Indirect outputs for all required parts

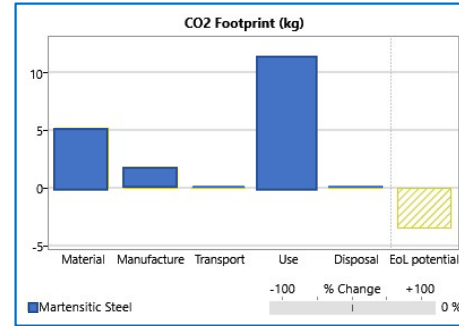
Total cost (material+use)
Number of parts



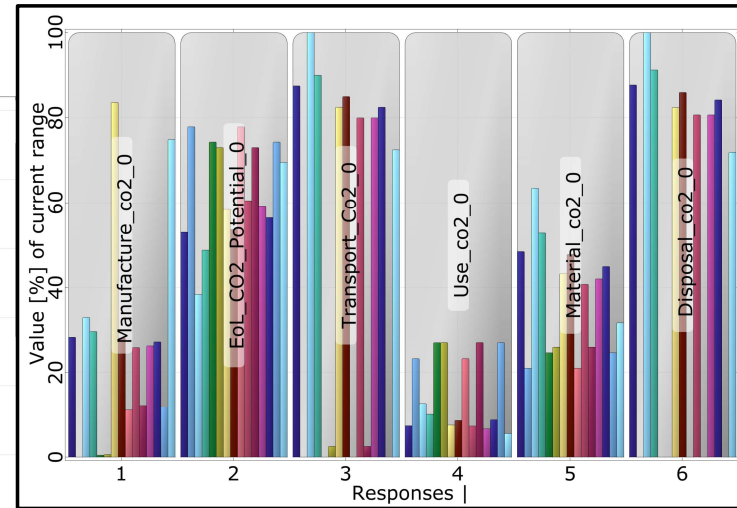
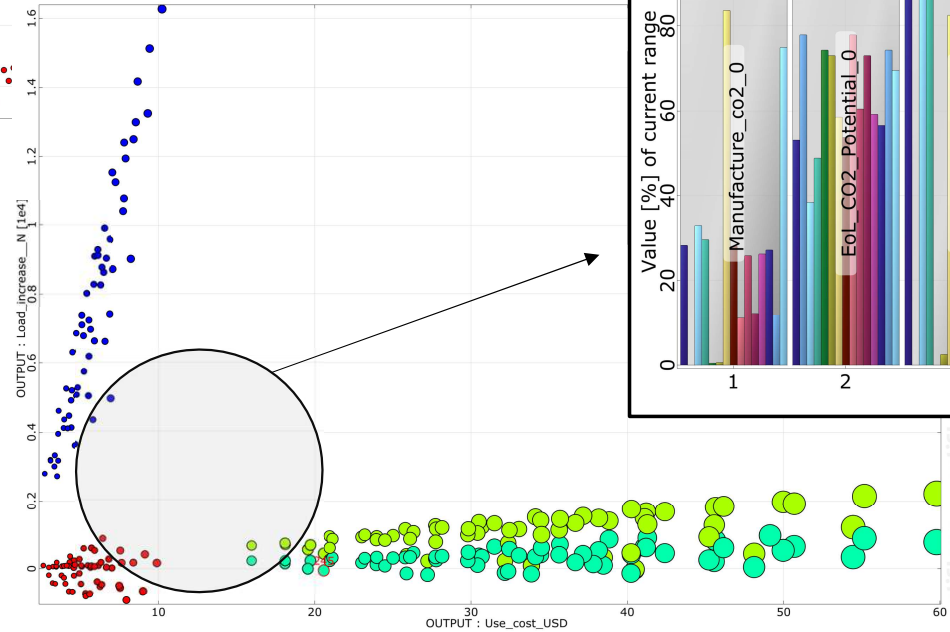
Results: Sensitivity Analysis



- Martensitic steel
- Ferritic steel
- Aluminium T6
- Aluminium T4

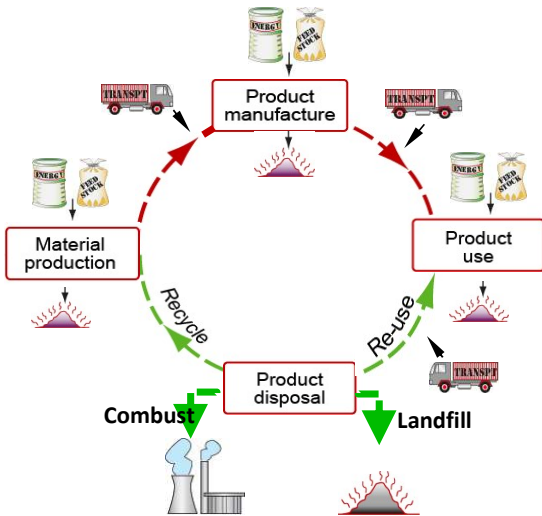


Eco Audit inside Granta



Eco Audit inside OptiSLang

Tool comparison and conclusion



	Concept assessment	Sustainability insight	Full LCA
Design phase	● Early ○ Late	● Early ● Late	○ Early ● Late
Time needed	● Day ○ Months	○ Day ● Months	○ Day ● Months
Environmental expertise	● Low ○ High	○ Low ● High	○ Low ● High
Analysis' costs	● Low ○ High	○ Low ● High	○ Low ● High
Ecodesign opportunities	○ Low ● High	○ Low ● High	● Low ○ High
Environmental indicators	○ 1 ○ > 20	○ 1 ● > 20	○ 1 ● > 20
Physics simulation	n.a.	○ Low ● High	n.a.
Costs estimate	n.a.	● Early ○ Late	○ Early ● Late
Design optimization	n.a.	○ Low ● High	n.a.
Tool used	Granta Eco Audit	Granta + OptiSLang + Physics	Full LCA software

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Simulation is more than Software

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