

# CONTROL<sup>IN</sup>STEEL

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## General Project Introduction

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1. Introduction
2. Analysis based on semantic tools
3. Results of the Project

## 1. Introduction

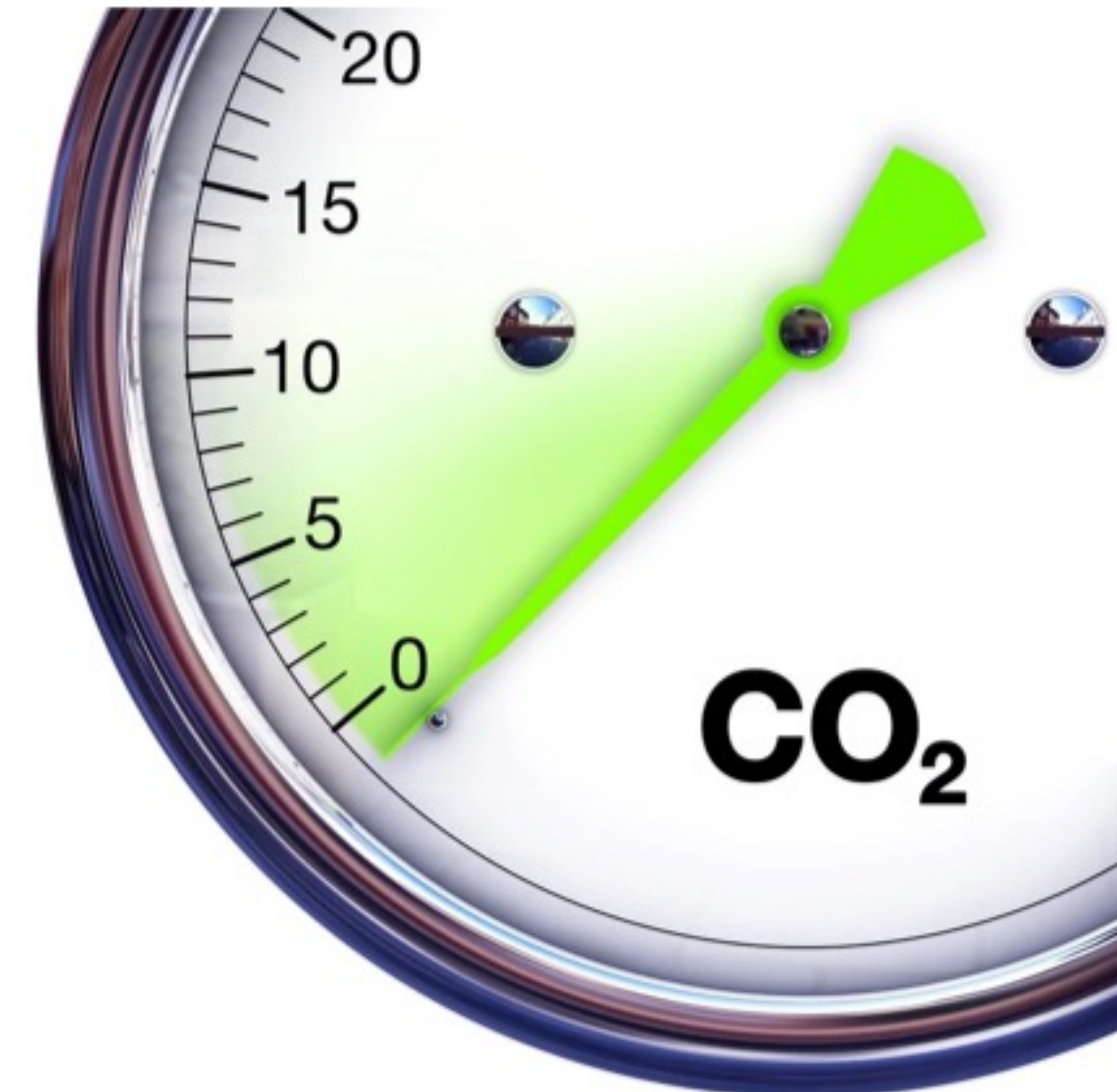
- ControllnSteel is a dissemination activity focusing **advanced automation and control**
  - We selected around **45(+5) former RFCS research projects** for a scientific analysis
- Mission goals
  - 1. Analyze and understand **dynamics** of the **problem-**, **solution-** and **impact space** which also includes **barriers** and **issues**, as well as **physical interaction channels**
  - 2. Perform **dissemination events**, e.g. conference sessions and workshops to effectively distribute knowledge from and about these former projects
  - 3. Provide a **roadmap for future research**



- Scheduling
- Optimization
- Complex process management



- Process control
- Throughput increase
- Product quality improvement



- CO<sub>2</sub> reduction
- Energy optimization
- In general: producing towards ecological KPIs

## 2. Analysis based on semantic tools

*We want to know which **types of problems**, is solved effectively by which **types of solutions**, and generate what **types of impacts**, by overcoming which **type of barriers and issues**.*

*If we know this, we can **maximize the overall impact**.*

- Synonyms
- Taxonomies
- Ontologies  
Relationships

----- Degree of complexity ----->

Synonyms for the word: **GOOD**

- Wonderful

● First-rate

● Fabulous

● Superior

● Superb

● Excellent
- Astounding

● Outstanding

● Magnificent

● Beyond belief

● Stupendous

● Amazing
- Astonishing

● Impressive

● Awesome

● Splendid

● Majestic

● Grand
- Exciting

● Delightful







● Dazzling

● Breathtaking

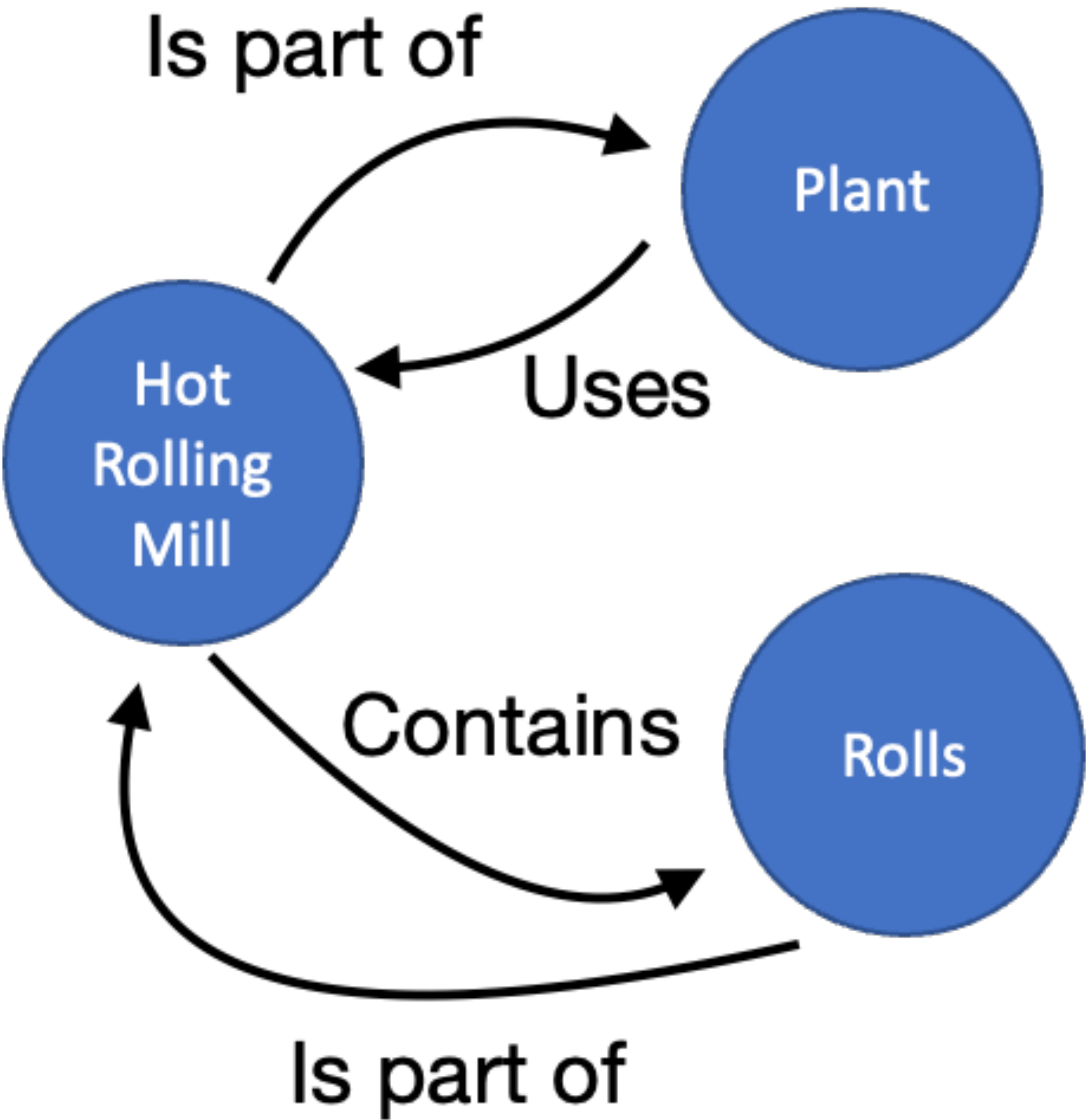
● Glorious

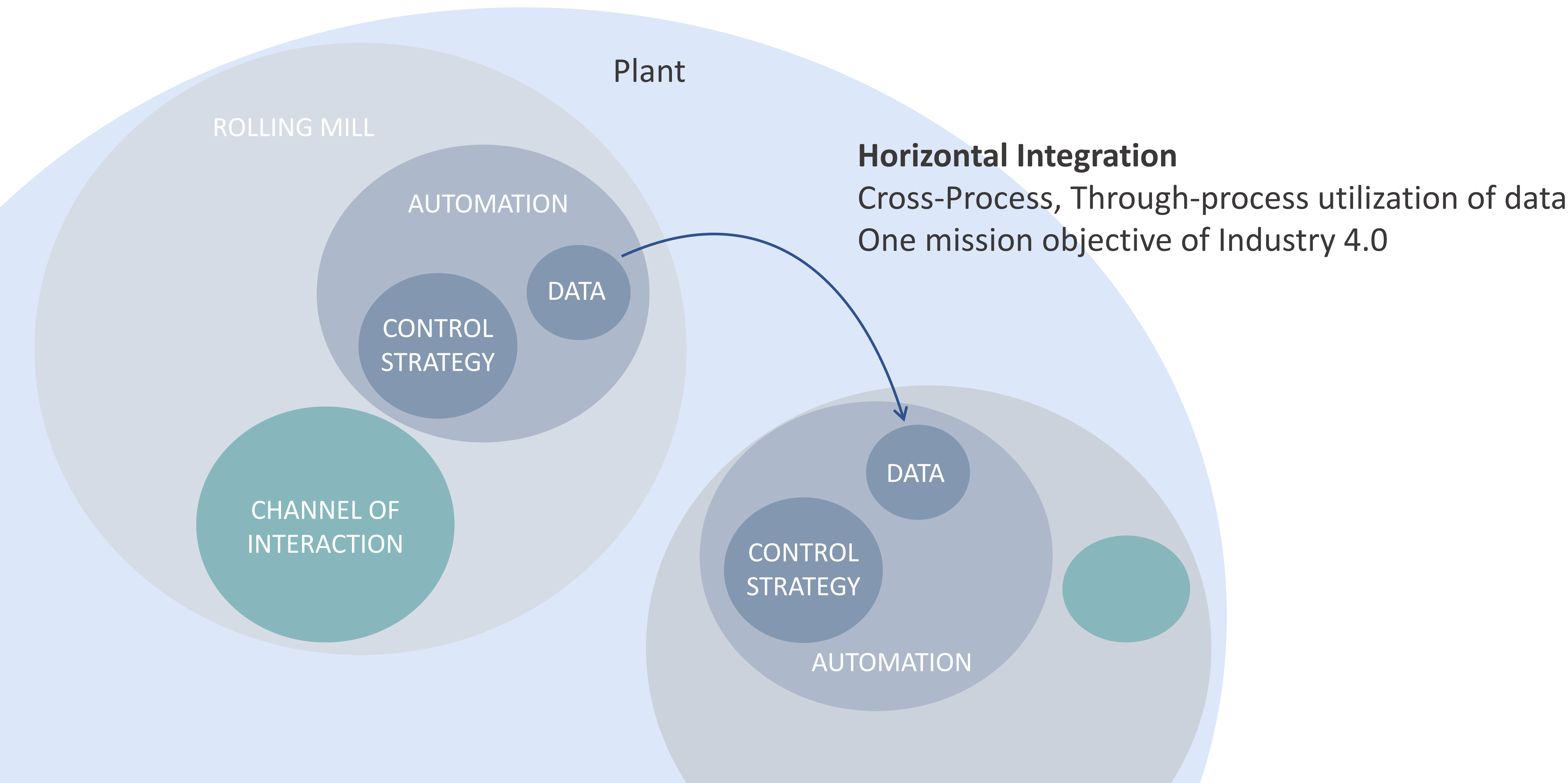
● Incredible

From: ESL Forums, eslforums.com, 2019

BLOOM'S TAXONOMY DIGITAL PLANNING VERBS					
REMEMBERING	UNDERSTANDING	APPLYING	ANALYZING	EVALUATING	CREATING
					
Copying Defining Finding Locating Quoting Listening Googling Repeating Retrieving Outlining Highlighting Memorizing Networking Searching Identifying Selecting Tabulating Duplicating Matching Bookmarking Bullet-pointing	Annotating Tweeting Associating Tagging Summarizing Relating Categorizing Paraphrasing Predicting Comparing Contrasting Commenting Journaling Interpreting Grouping Inferring Estimating Extending Gathering Exemplifying Expressing	Acting out Articulate Reenact Loading Choosing Determining Displaying Judging Executing Examining Implementing Sketching Experimenting Hacking Interviewing Painting Preparing Playing Integrating Presenting Charting	Calculating Categorizing Breaking Down Correlating Deconstructing Linking Mashing Mind-Mapping Organizing Appraising Advertising Dividing Deducing Distinguishing Illustrating Questioning Structuring Integrating Attributing Estimating Explaining	Arguing Validating Testing Scoring Assessing Criticizing Commenting Debating Defending Detecting Experimenting Grading Hypothesizing Measuring Moderating Posting Predicting Rating Reflecting Reviewing Editorializing	Blogging Building Animating Adapting Collaborating Composing Directing Devising Podcasting Wiki Building Writing Filming Programming Simulating Role Playing Solving Mixing Facilitating Managing Negotiating Leading

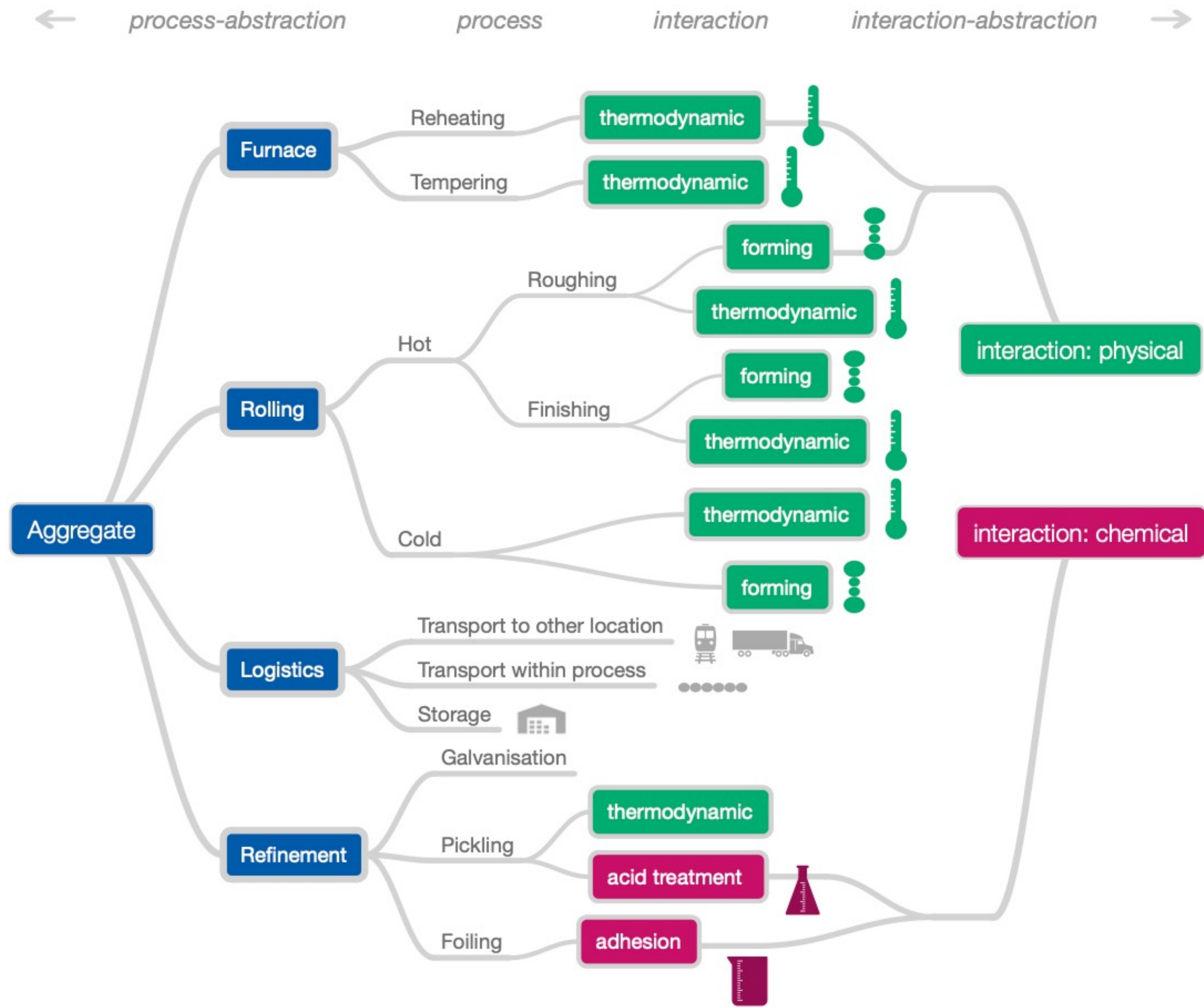
From: Blooms Taxonomy, Terry Heick, 2018

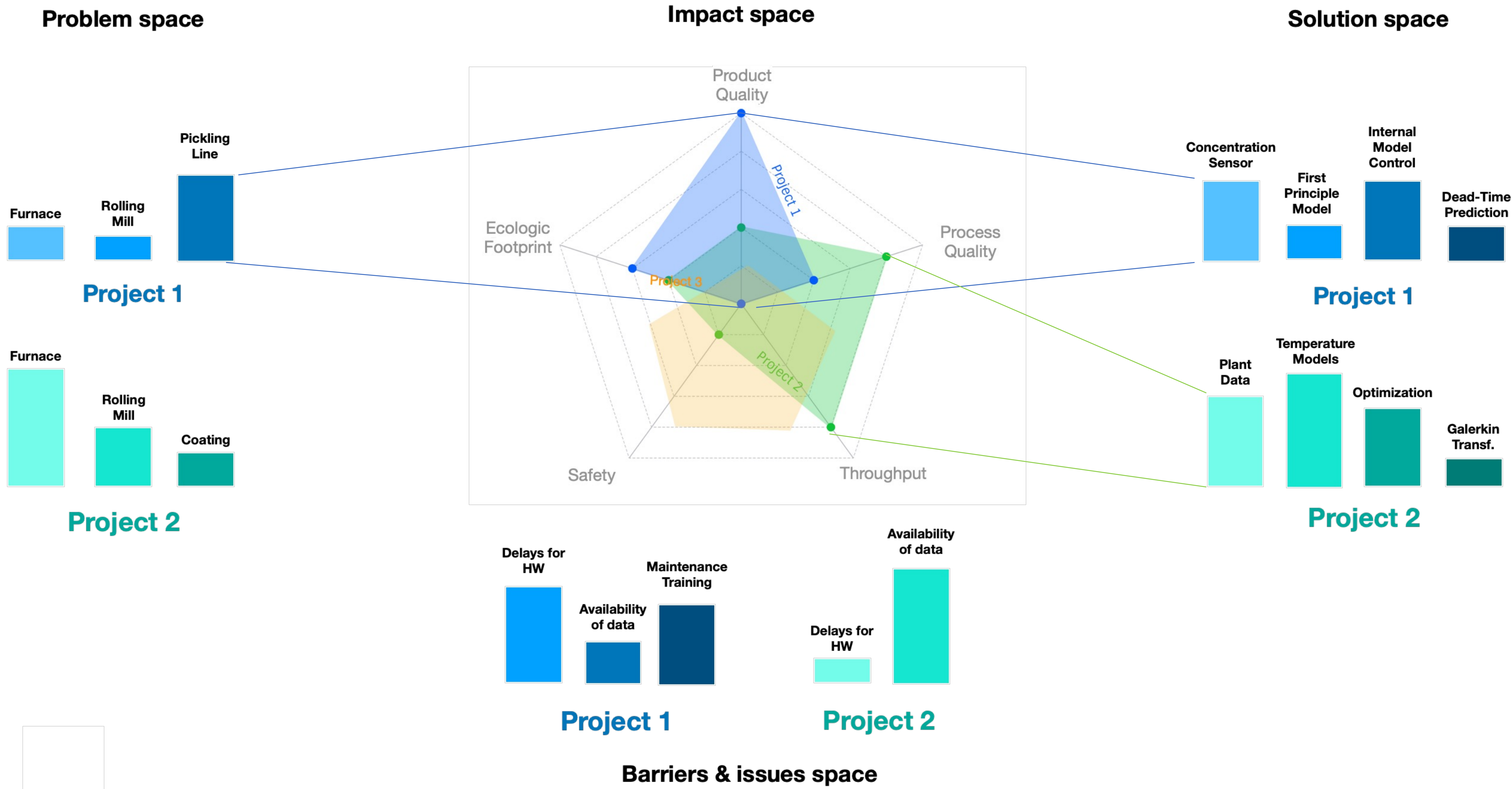




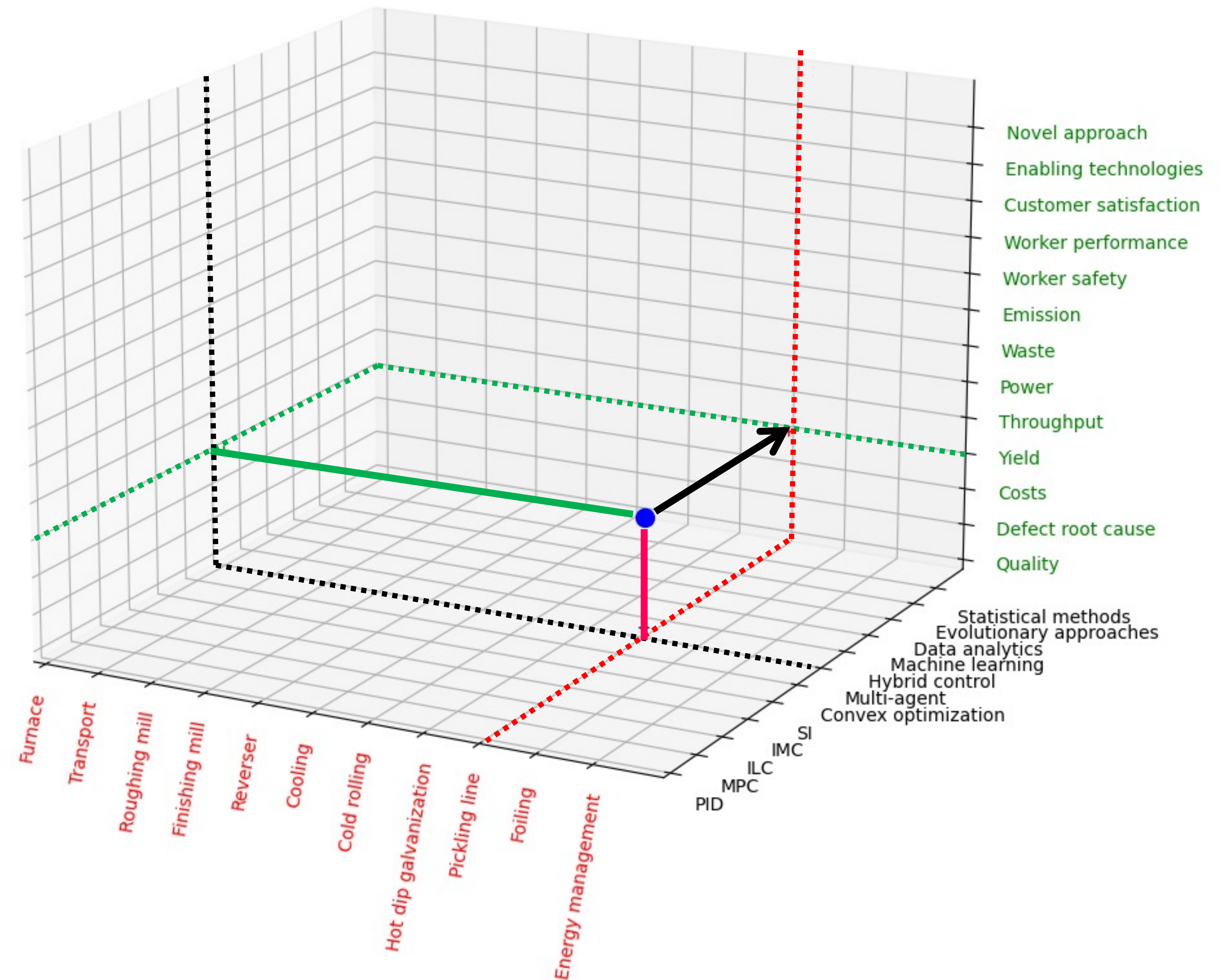
# Taxonomy for problem space

T1) Aggregate	Type	Product	Interaction
Casting	Continuous casting	Slab	physics:thermodynamic
	Furnace	Slab reheating	physics:thermodynamic
	Walking bean reheating	Slab	physics:thermodynamic
Logistics	Billet furnace	Billet	physics:thermodynamic
	Transport	Slab	logistics:displacement
	Continuous annealing	Strip	physics:thermodynamic
Annealing	Bright annealing		physics:thermodynamic
	Batch annealing		physics:thermodynamic
Rolling	Roughing mill	Slab	pyhsics:forming; physics:thermodynamic
	Finishing mill	Strip	pyhsics:forming; physics:thermodynamic
	Cold rolling	Strip	pyhsics:forming; physics:thermodynamic
	Temper rolling	Strip	pyhsics:forming; physics:thermodynamic
	Plate mill		
Cooling	Cooling	Slab, Strip	physics:thermodynamic
Refinement	Hot dip galvanization	Strip	chemical:galvanisation, physics:thermodynamic
	Electro galvanisation	Strip	chemical:galvanisation, physics:thermodynamic
	Pickling mill	Strip	chemical:etching;
	Coating	Strip	chemical: bond; physics:adhesion
	Foiling	Strip	chemical: bond; physics:adhesion
	Skin pass	Strip	physics:cutting;
	Scarfing		
Thru-process	Levelling	Strip	physics:forming;
	Descaling	Slab, Strip	physics:evaporation
	Flatness	Strip	physics:forming
Topical	Quality		
	Long		
	Flat		



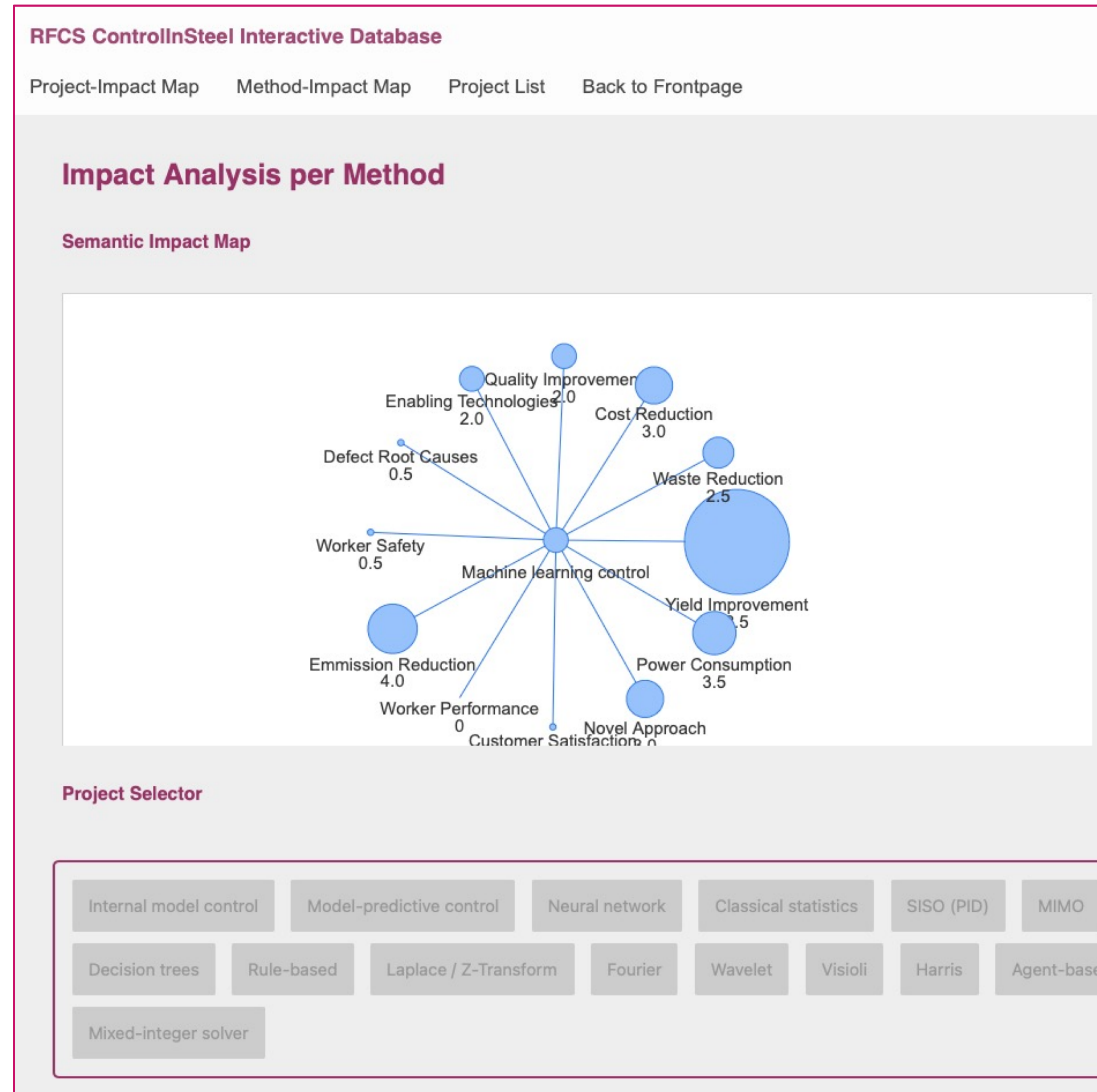


- Example: RFCS SOPROD, because coordinator was the same
- Allows to define project by one or **multiple points (!)**
- Automatic Python code that runs on top of our assessment



# Impact analysis per project

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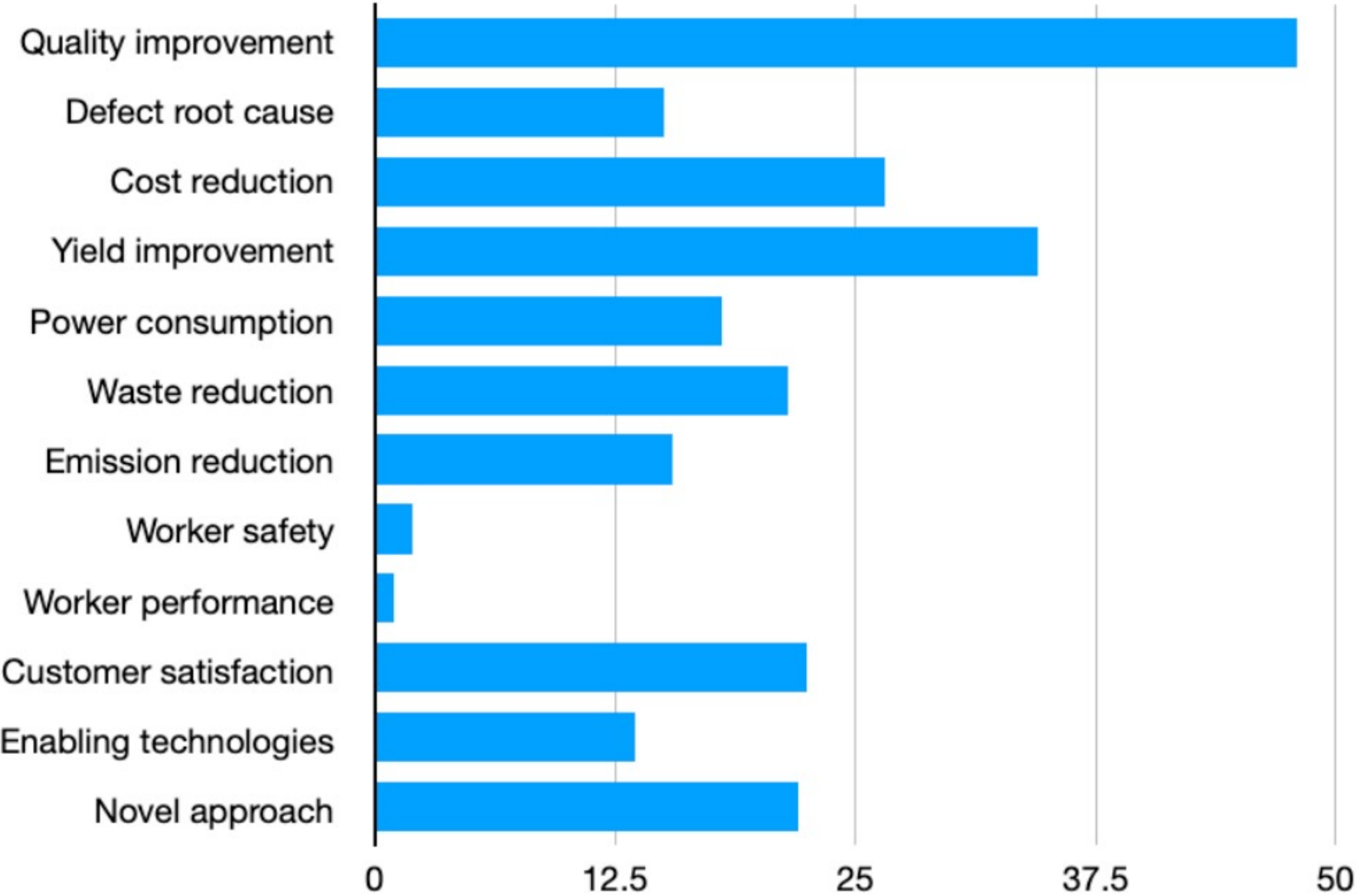
- Project website: [www.controlinsteel.com](http://www.controlinsteel.com)
- Link to interactive result presentation
- Automatic Python code that runs on top of our assessment
- Full compatibility with former dissemination activities like DissI2M (where DissI2M data is currently merged in the CIS database)

### **3.** Project Results

# Result: Impact Categorization and Impact Scores

- Each project could score up to 5 impact points
- Each point could be allocated to either one or multiple impact categories
- Advantage: the analysis is able to fully reproduce the **distribution of impact** of the considered projects

	Quality improvement	Defect root cause	Cost reduction	Yield improvement	Power consumption	Waste reduction	Emission reduction	Worker safety	Worker performance	Customer satisfaction	Enabling technologies	Novel approach
SOFTDETECT	1	2	1	0.5	0	0	0	0	0	0	0	0.5
IMGALVA	2	0	0.5	0.5	0	0.5	0.5	0	0	0.5	0.5	0
SensoCont	1	0	0	0.5	0.5	0.5	0.5	0	0	1	0	1
Smartfire	1	0	0.5	0.5	0.5	0.5	1	0	0	0	0.5	0.5
FinalPlateFlatness	2	0	0.5	0.5	0	0.5	0.5	0	0	1	0	0
Awicco	1	0.5	1	0.5	0	0.5	0	0	0	1	0	0.5
HIGHPICK	1	0	0.5	1	1	0.5	0.5	0	0	0.5	0	0
Linecop	1	0.5	0.5	1	0.5	0.5	0	0	0	0.5	0	0.5

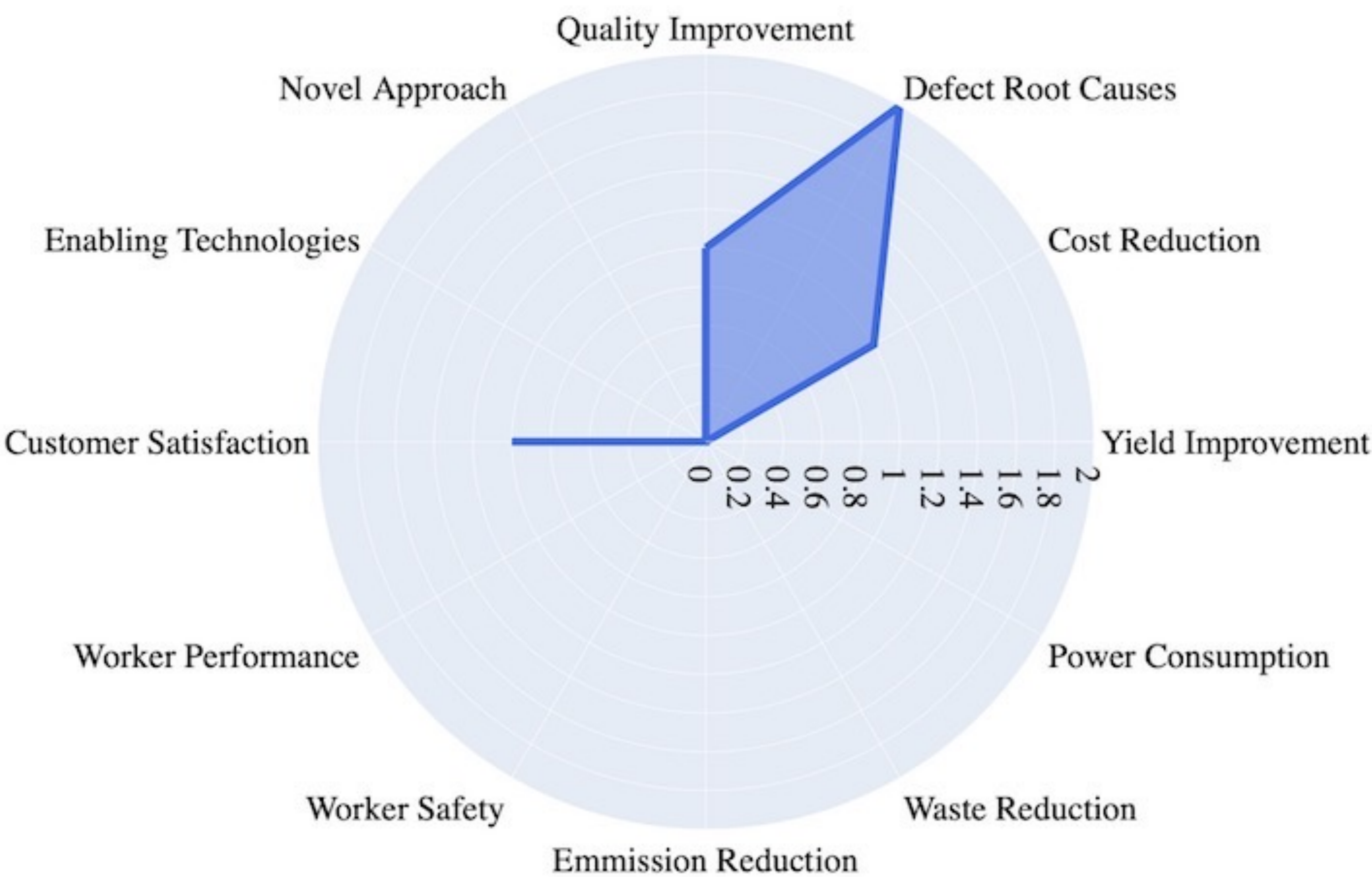


- 0 – no transferability can be expected, not transfer has been reported
- 1 – same aggregate, same plant direct transfer was possible
- 2 – same aggregate, different plant transfer
- 3 – different aggregate, same plant transfer
- 4 – different aggregate, different plant
- 5 – different Industry, similar aggregate
- 6 – different Industry, diverse aggregates

- Each project got an transferability index
- First rigorous assessment of transferability in a quantitative way

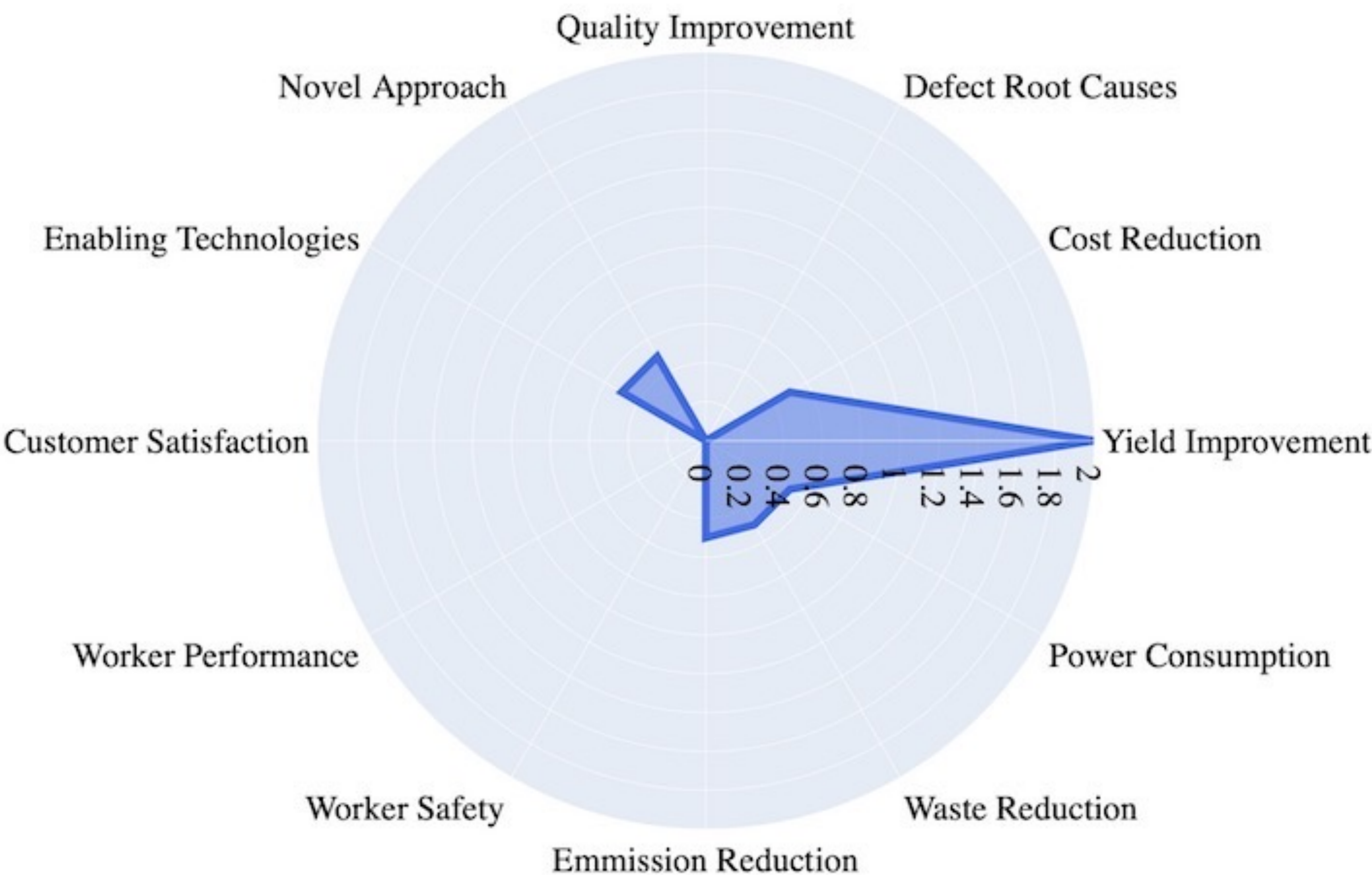
	Primary Transfer Channel	Transferability Index	0	1	2	3	4	5	6
CEFLA	Rolling mill	1							
7210-PR/338	Rolling mill	1							
7210-PR/339	Rolling mill	1							
7215-PP/076	Rolling mill	1							
CASTDESMON	Caster	2							
IPCDS	Rolling mill monitoring system	2							
SHAPEHPM	Rolling mill	1							
AUTOCHECK	Zinc layer thickness control	4							
S5	Strip shape monitoring	2							
GLOBALSHAPECONTROL	Rolling mill	1							
SOFTDETECT	Soft sensor	4							
IMGALVA	Galvanisation	2							
SensoCont	Pickling line operation software	4							
Smartfire	Furnace	3							
FinalPlateFlatness	Rolling mill	2							

SISCON



Example for a surface defect project

SOPROD



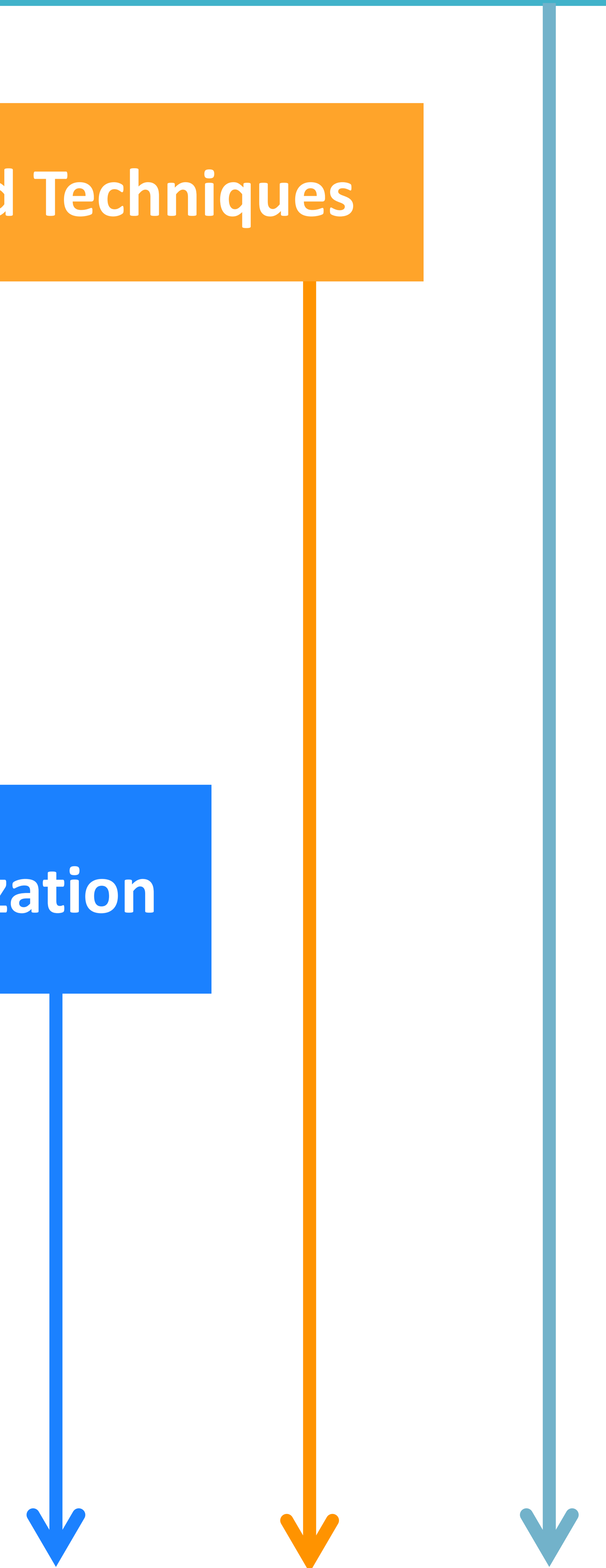
Example for cross-process optimization project

- **1. Single aggregate, control approach optimization**
  - Model-predictive control of hot rolling mill
  - Control performance monitoring
- **2. Process chain optimization**
  - **2a. Cross-process control via distributed, autonomous techniques**
    - Consideration of a part of the production route covering multiple aggregates
    - Use of different model supported types of agent technology or other distributed techniques
  - **2b. Network optimization with novel distributed optimization and control concepts**
    - Identification of optimization problem and formalisation of it
    - Smart interplay of control theoretic approaches (for actuators and sensors) as well as optimization techniques for the overall solution finding













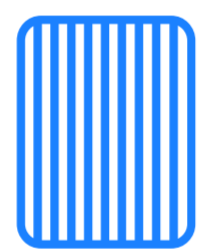



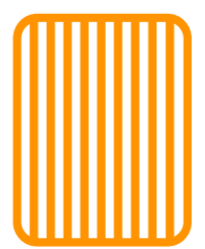

Future Challenges: Machine Learning,  
Quantum Computing, Hyperautomation

Distributed Techniques

Cutting Edge Optimization



- Disseminate at conferences, seminars and events with

- European Steel Technology and Application Days (ESTAD2021)    
- BFI Kolloquium (11.05.2022) 
- EuroSteelMaster (16.05.2022)   
- ESTEP Dissemination Event (22.06.2022) 
- EELISA Digitalisation as Key Driver of Steel Industry (28.06.2022)   
- ControlInSteel Webinar Series 1. **Advanced Control Solutions for Sustainability** 
- ControlInSteel Webinar Series 2. **Distributed Autonomous Control Solutions** 
- ControlInSteel Webinar Series 3. **The Future of Control in the Steel Sector** 
- IFAC COSY 2022 Dedicated Workshop for ControlInSteel   

## Target Audience

-  Steel Industry Stakeholders, Decision makers
-  Researchers in steel research: Optimization
-  Researchers in steel research: Process chain
-  Technologists, researchers, project developers

### ■ Project idea

- Dissemination and impact maximization of various RFCS projects in the field of advanced automation in the downstream process chain
- Taxonomical approach to structure four distinct vocabularies for problems, solutions, impact and barriers
- Systematic analysis of all projects with respect to these vocabularies
- Project ends in June 2022 (with prolongation in Dezember 2022)

### ■ Dissemination

- Upcoming workshops are published at [www.controlinsteel.com](http://www.controlinsteel.com)



Thank you for your interest!

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## Aknowledgments...

... goto **Dr. Alexander Ebel**, who broadly introduced semantic techniques at the BFI and who was inspirational in continuing work in these topics.