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Successful Value Chain Optimization at a Chemical Company

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About me

- 2010 PhD in Logistics and SCM, University of Mannheim

- 2011 joined BASF
  - ▶ Current role: Global Digital Expert
  - ▶ Location: Global Headquarters in Ludwigshafen
  - ▶ Co-creates solutions with internal businesses
  - ▶ Builds web-based prescriptive analytics tools
  - ▶ Leads scalable application frameworks

BASF – We create chemistry

- Our chemistry is used in almost all industries

- We combine economic success, social responsibility and environmental protection

- Sales 2019: €59.3 billion

- EBIT before special items 2019: €4.5 billion

- Employees (as of December 31, 2019): 117,628

- 6 Verbund sites and 361 other production sites

- Around 100,000 customers from various sectors in almost every country in the world

BASF's segments

Chemicals

Petrochemicals

Intermediates

Materials

Performance Materials

Monomers

Industrial Solutions

Dispersions & Pigments

Performance Chemicals

Surface Technologies

Catalysts

Coatings

Nutrition & Care

Nutrition & Health

Care Chemicals

Agricultural Solutions

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BASF worldwide: sites

- Antwerp
- Ludwigshafen
- Florham Park
- Geismar
- Freeport
- Nanjing
- Hong Kong
- Kuantan
- São Paulo

- ● Regional centers
- ● Selected sites
- ● Verbund sites
- ● Selected research and development sites

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Verbund site Ludwigshafen

The world's largest integrated chemical complex owned by a single company

Headquarters

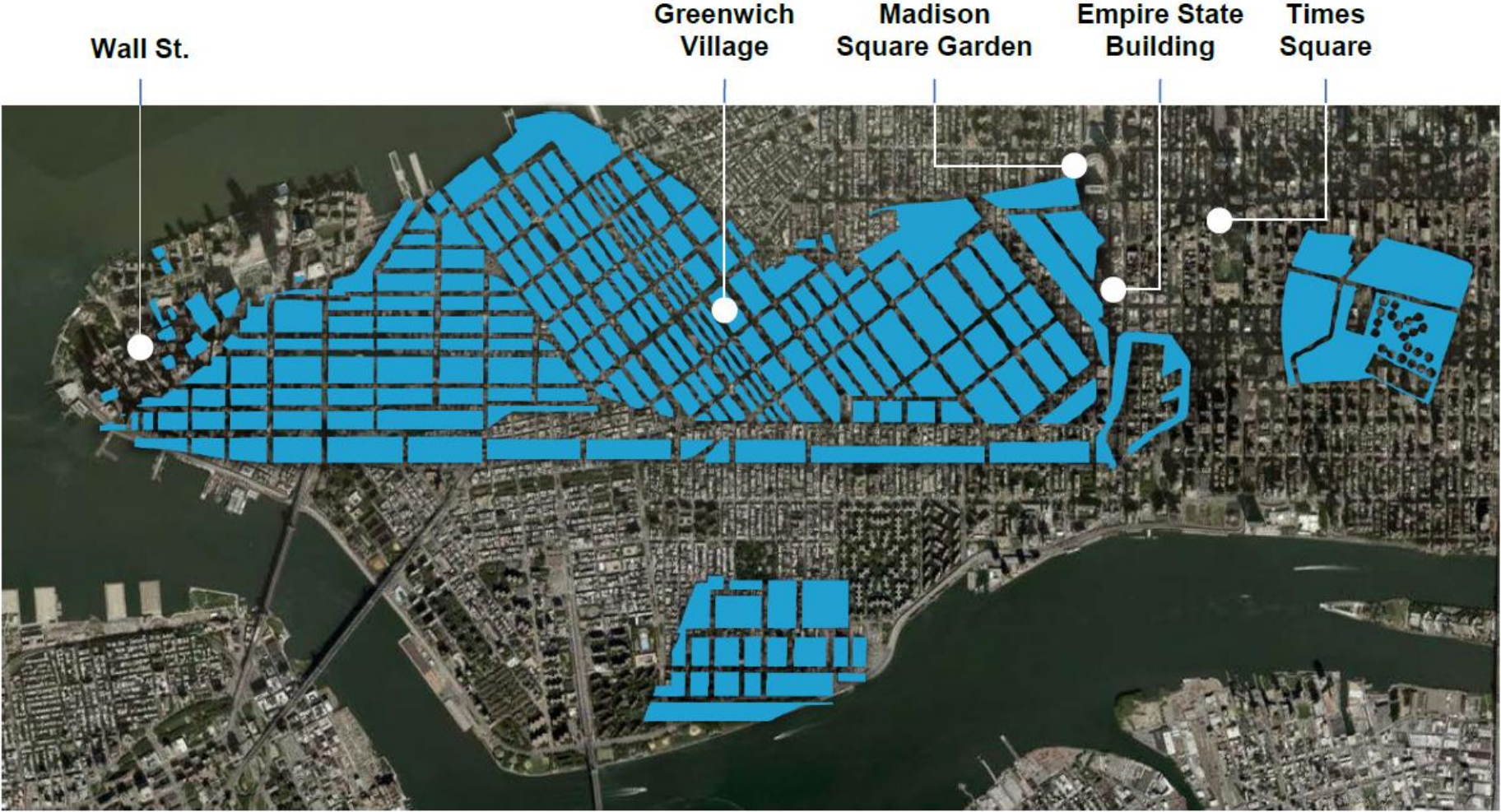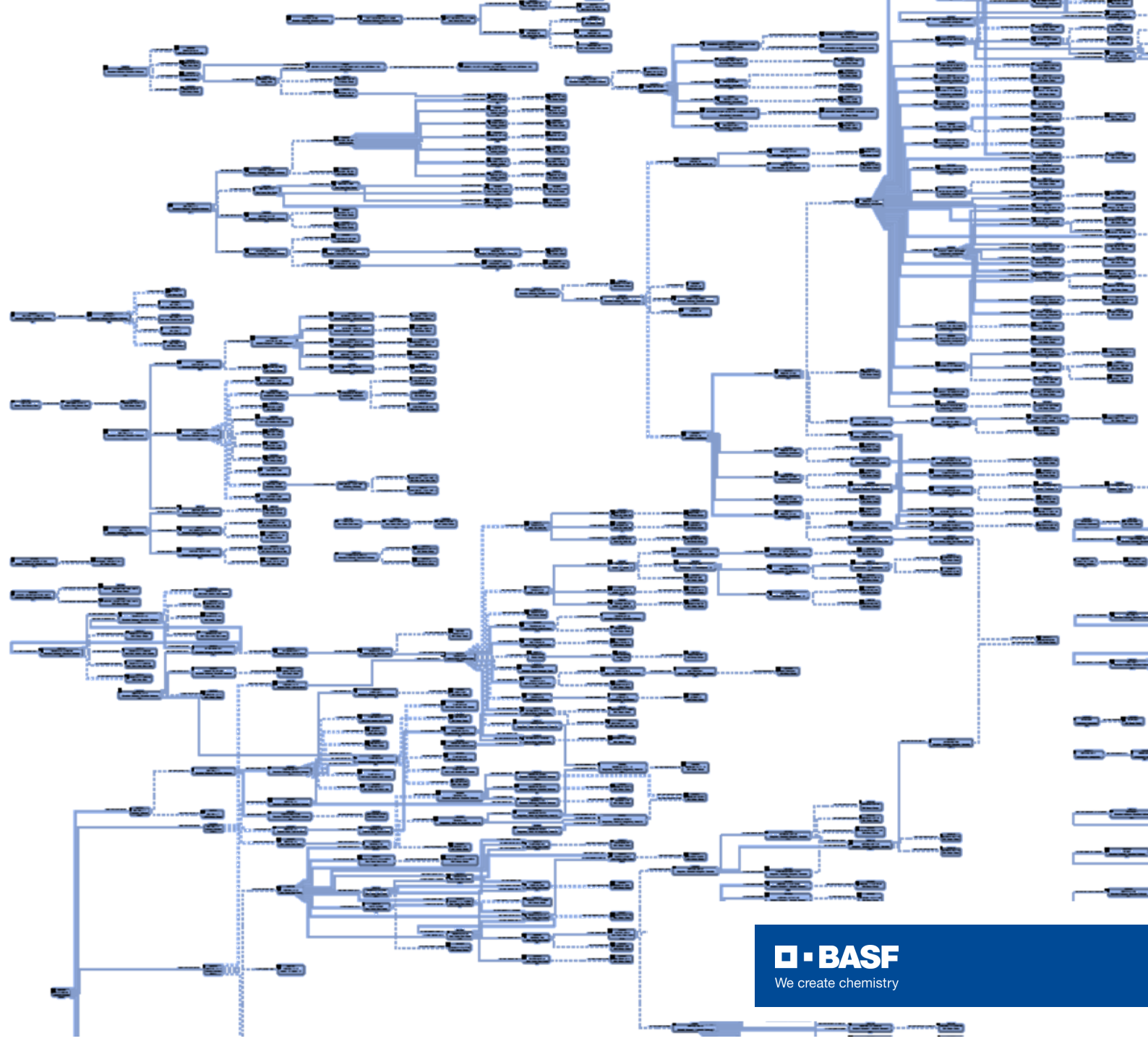|	
Employees BASF SE	34,896*
Site area	10 km²
Sales products**	~ 8.1 million metric tons p.a.
Road	~ 106 km
Rail	~ 230 km
Logistics	
	~ 1,900 trucks daily
	~ 400 railcars daily
	~ 30 fully electric AGV transports daily
	~ 15 ships daily
Pipeline system	~ 2,850 km
Production facilities	~110 production facilities with around 200 production plants

* as of December 31, 2019
** from in-house production

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Verbund site Ludwigshafen – Manhattan, New York City

Wall St.

Greenwich Village

Madison Square Garden

Empire State Building

Times Square

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Complexity drivers

- Multi-stage production across plants worldwide

- Multi-purpose machines

- By-products

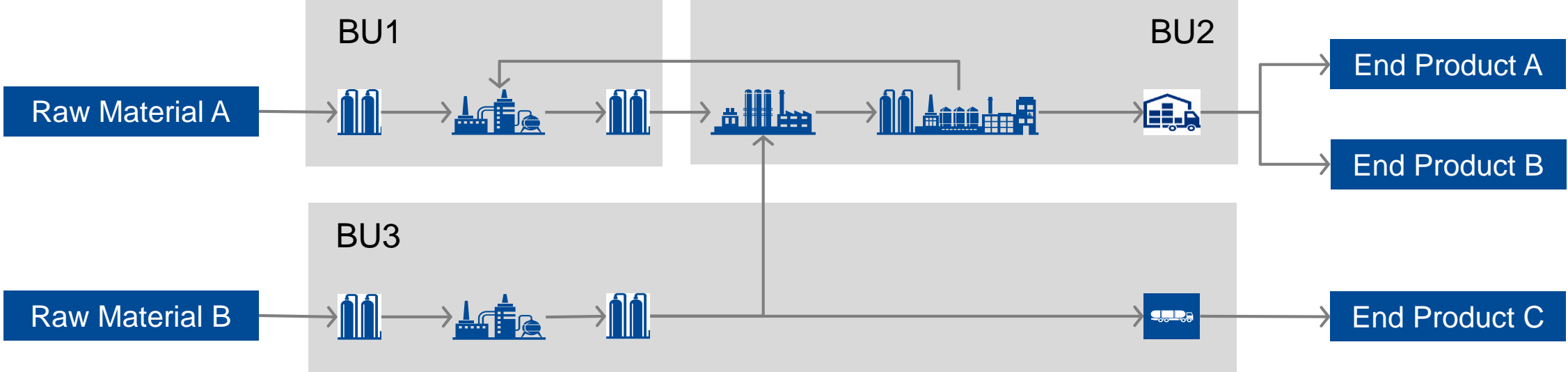- Cyclic product flows

- Diverse target industries

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Complexity management

Investment decision - Challenge

Current bottleneck

Suppliers

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Target industries

BU1

BU3

BU2

Raw Material A

Raw Material B

End Product A

End Product B

End Product C

Future bottleneck
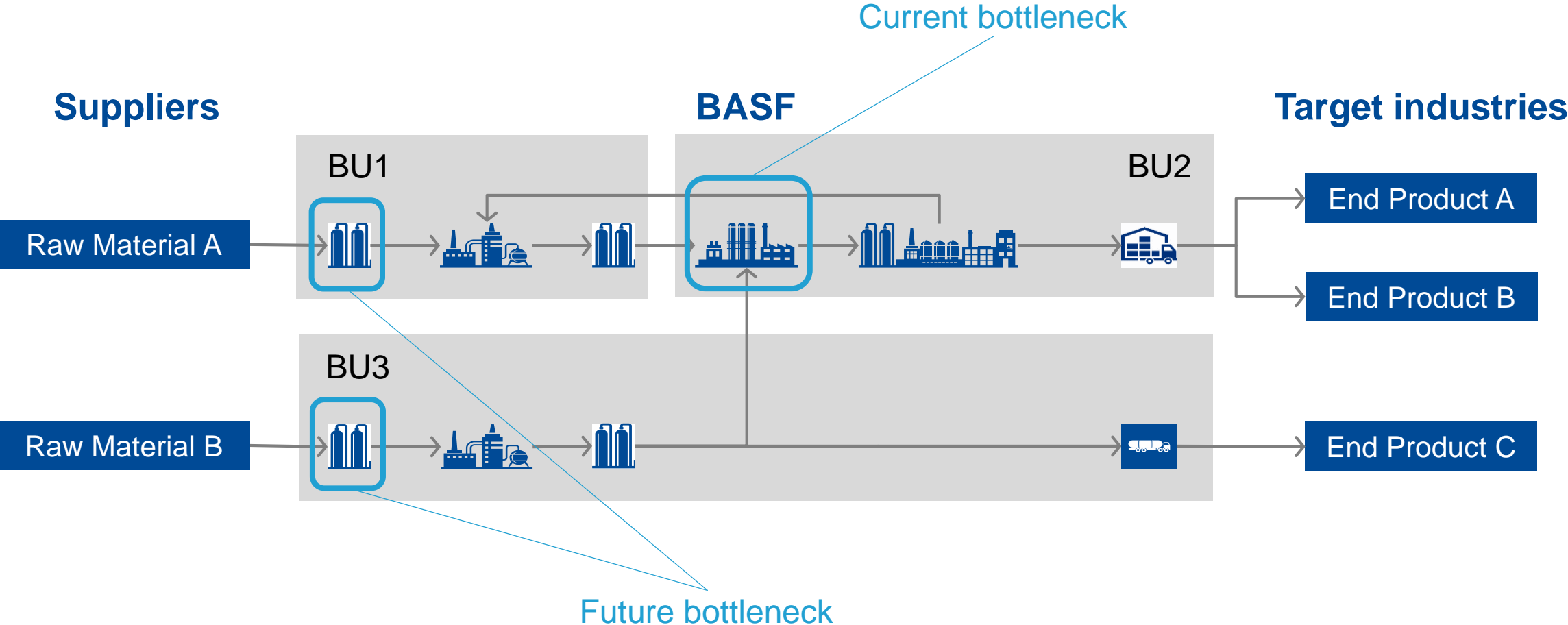
Value chain application: Workflow components

Focus in practice

Effort

Focus in academia

| Pre-processing | Scenario definition | Optimization | Post-processing | Results presentation |

Necessary evil — Order winner — Order qualifier — Trust and continuity
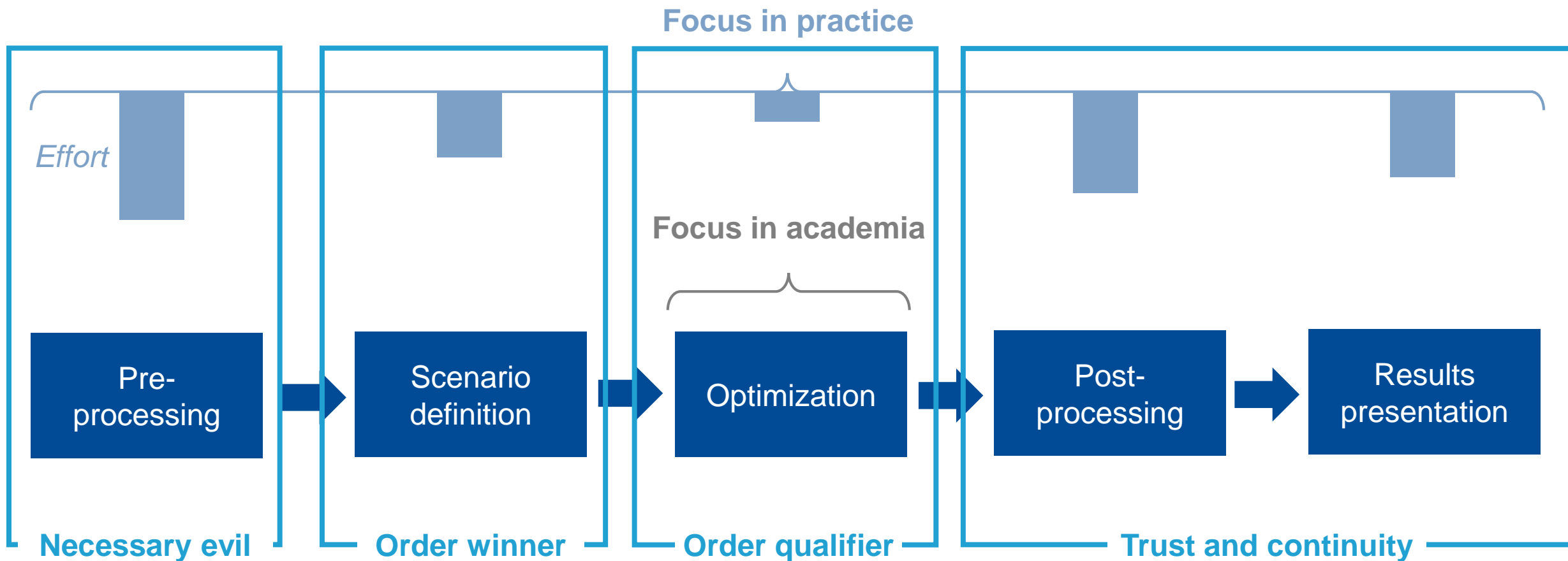
Pre-processing

Automate as much as possible,
allow manual input only where absolutely necessary

Automated

Central source system

- Recipes
- Capacity
- Costs
- Historical demand
- etc.

Manual

Local internal data sources

- Future demand
- Investment options
- Market development
- etc.

Automated / Manual

External data sources

Rule-based

- Merge
- Clean
- Customize
- Detect outliers
- etc.

User manipulation in exceptional cases

Feedback loop with stakeholders

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Scenario definition

Intuitive, flexible, and fast

Success factors

- Easy-to-use interface
- Data manipulation with limited effort
    - ▶ Application-specific
    - ▶ Close collaboration with user
    - ▶ Data consistency checks
    - ▶ Suggestions for default values
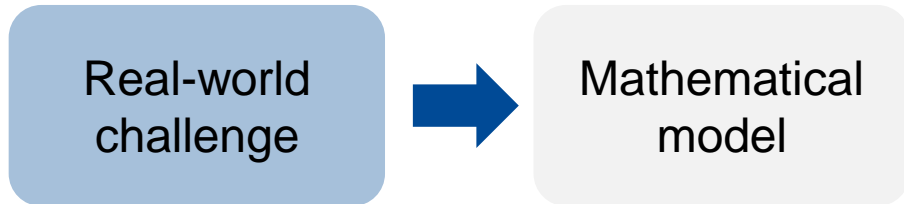- Performance
- Change log

Value chain application example

- Global specification of options (e.g., investment alternatives)

- Grouping of data for manipulation
- Relative growth factors over time
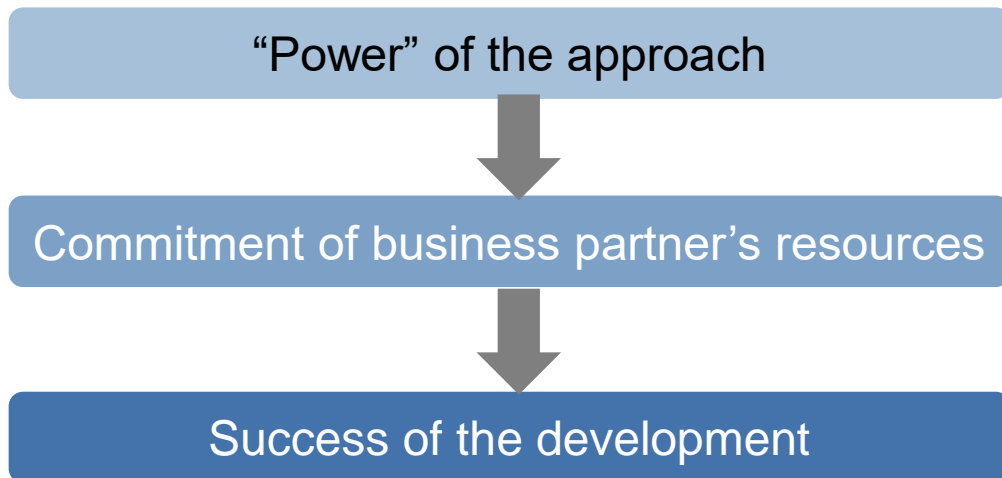
- Validity checks for new data entries

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Optimization

- **Modeling of current challenge**

Real-world challenge	→	Mathematical model

- **Suggestion of additional model variants**

"Power" of the approach

↓

Commitment of business partner's resources

↓

Success of the development

Value chain application example
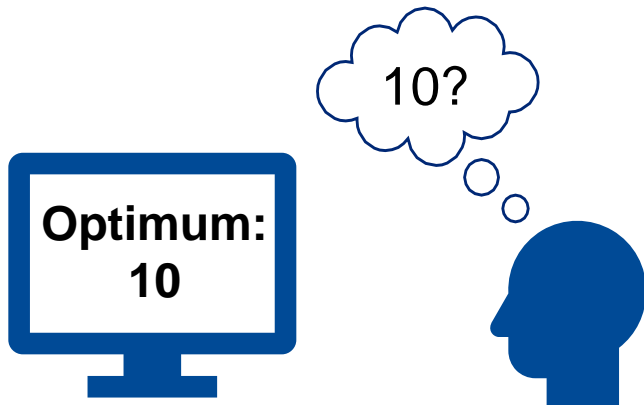
Contribution margin (CM) maximization

- Investments proposals
- Maximize CM while minimizing deviation from historical production plan
- Trade-off between CM and CO_2

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Post-processing

Standard model output

- Optimal objective function value and scenario comparison by this KPI
- Production and sales quantities
- etc.

10?

Optimum: 10

Additional solution insights

through a series of post-processing steps

- Detailed cost allocation per product
- Contribution margin estimate per product
- Raw material share per product
- Lost sales analysis
- Additional capacity requirement
- etc.

Additional mathematical programs and custom algorithms

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Detailed cost allocation per product

General approach

1. Optimize contribution margin — LP

Sourcing, production & transportation quantities

2. Detailed cost allocation — NLP

Variable costs | Fixed costs

Accumulated costs per category

3. KPI calculations: margin per product

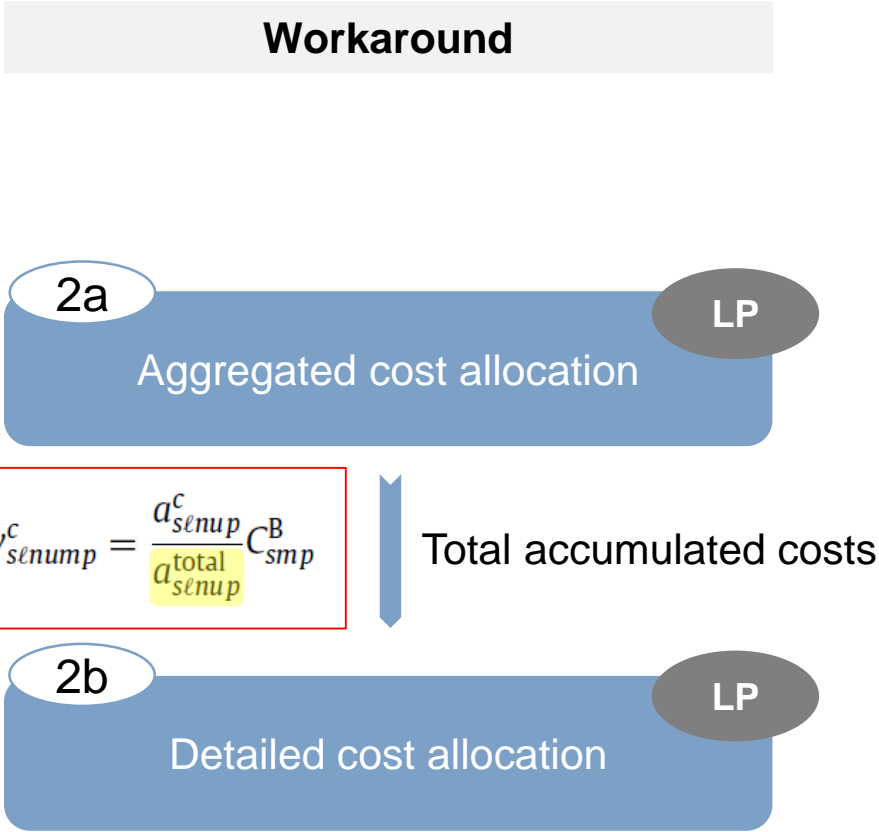**Constraints and inputs**

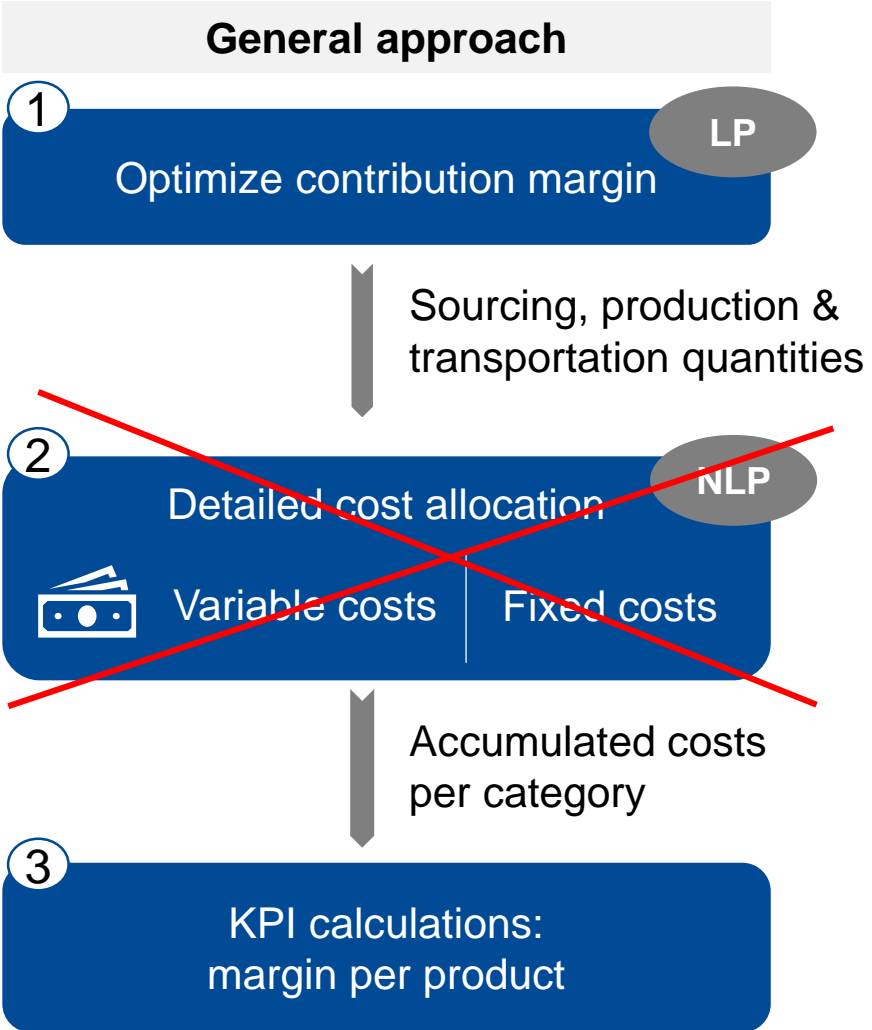Marketing

Production

Transportation

Cost allocation rules

$$w^c_{s\ell nump} = \frac{a^c_{s\ell nup}}{a^{\text{total}}_{s\ell nup}} C^{\text{B}}_{smp} \quad \text{due to by-products}$$

Legend
LP – Linear program
NLP – Non-linear program

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Detailed cost allocation per product

General approach

1 Optimize contribution margin — *LP*

↓ Sourcing, production & transportation quantities

2 Detailed cost allocation — *NLP*

Variable costs | Fixed costs

↓ Accumulated costs per category

3 KPI calculations: margin per product

Workaround

2a Aggregated cost allocation — *LP*

$$w^{c}_{s\ell nump} = \frac{a^{c}_{s\ell nup}}{a^{\text{total}}_{s\ell nup}} C^{B}_{smp}$$

Total accumulated costs

2b Detailed cost allocation — *LP*

Legend
LP – Linear program
NLP – Non-linear program

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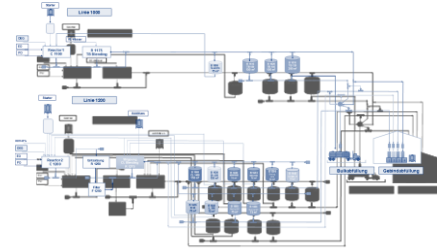# Results presentation

Accommodate various stakeholder perspectives

Interactive dashboards

- Different perspectives per scenario
  - ▶ Production (overall)
  - ▶ Demand
  - ▶ Production line
  - ▶ Lost sales analysis
  - ▶ Comparison over time
- Scenario comparison

Interactive network graph visualization

- Different levels of aggregation
  - ▶ Global
  - ▶ Site
  - ▶ Plant
  - ▶ Production line
- Bottleneck visualization
- etc.

Excel

→ Feedback loop with stakeholders

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Successful value chain applications
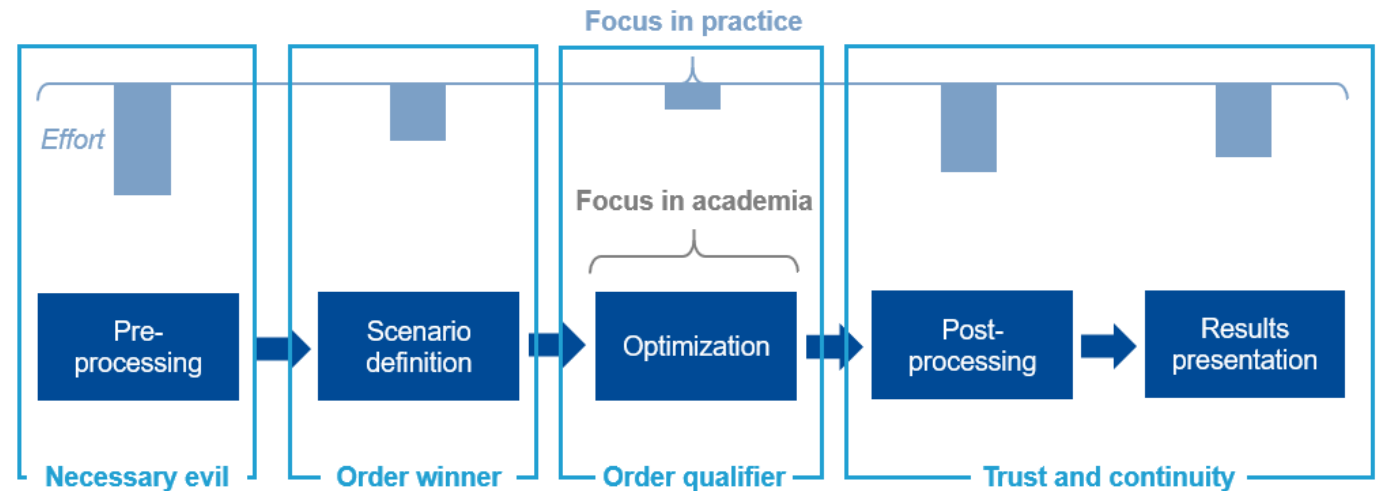
- **Strategic**
  - ▶ Long-term investment planning
  - ▶ One-time analyses
  - ▶ Value chain strategy development
- **Tactical**
  - ▶ Mid-term production planning
  - ▶ Regular (monthly) usage
  - ▶ S&OP meeting support
- **Operational**
  - ▶ Short-term scheduling
  - ▶ Highly integrated into ERP and execution system

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