

Applying Mathematical Optimization to Sourcing

Arne Andersson

Retired from

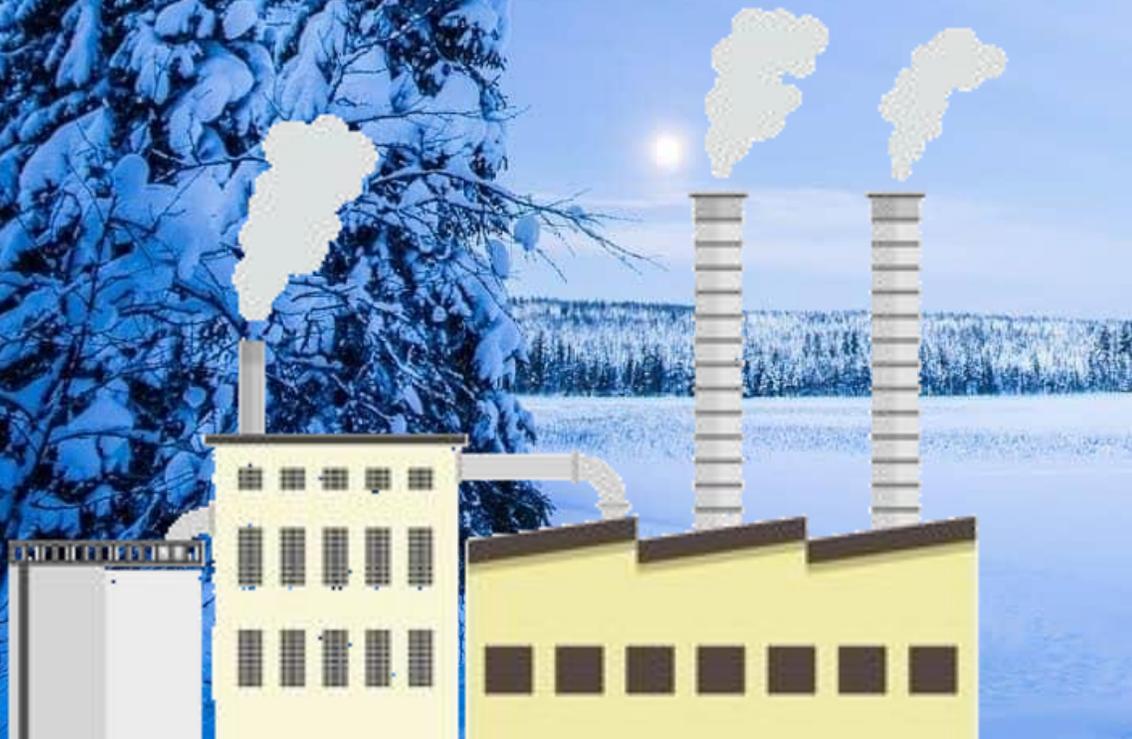
Uppsala University / Coupa Software



Background

- Late 1990s: academic research on algorithms, optimization and electronic markets (AA-trees, World's fastest sortign algorithm, etc ...)
- June 2000: Trade Extensions was founded, based on research on markets for electric power
- April 2017: Coupa Software acquires Trade Extensions

**Cold winter morning.
Factories are starting up.
Water heaters are running.**



Electricity Prices in Uppsala (SE3) 2026-02-17

Day-ahead

- Prices
- Price indices
- System price & turnover
- Volumes
- Capacities
- Flows
- Scheduled physical flows
- Flow-based constraints
- Aggregated Bidding Curves

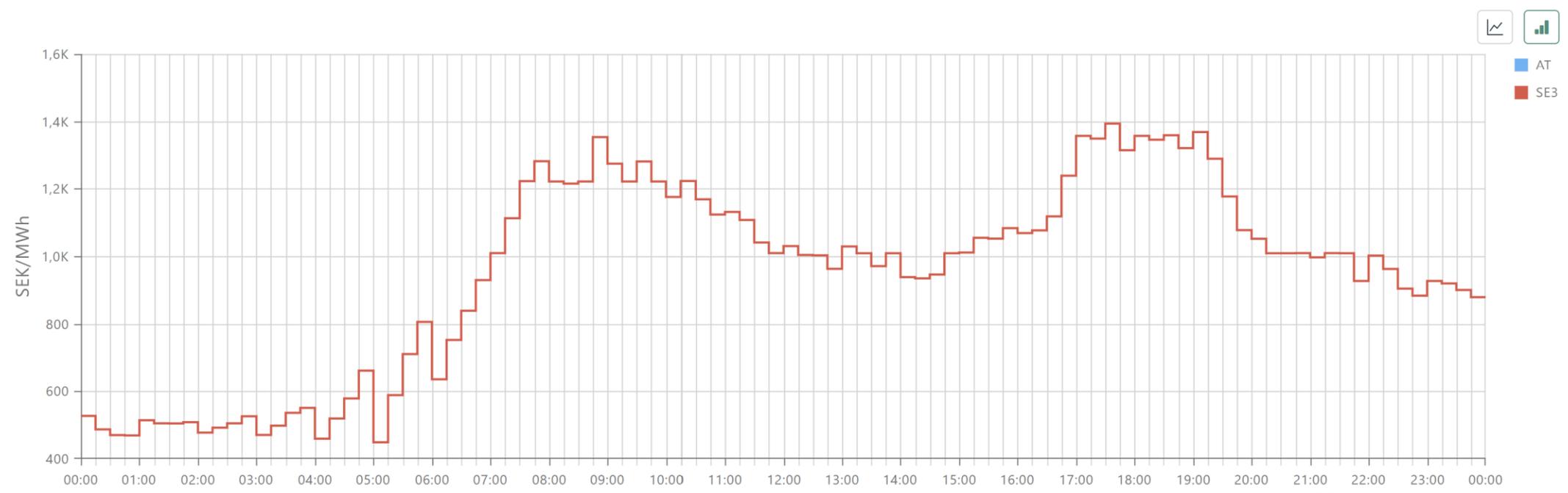
Prices

Transition to 15-minute MTU 

◀ 17.02.2026  ▶ Time interval: Delivery Period Currency: SEK Filters  Hide Graph

Areas: **Baltic** EE LT LV **CWE** **AT** BE FR GER NL PL **Nordic** DK1 DK2 FI N01 N02 N03 N04 N05 SE1 SE2 **SE3** SE4

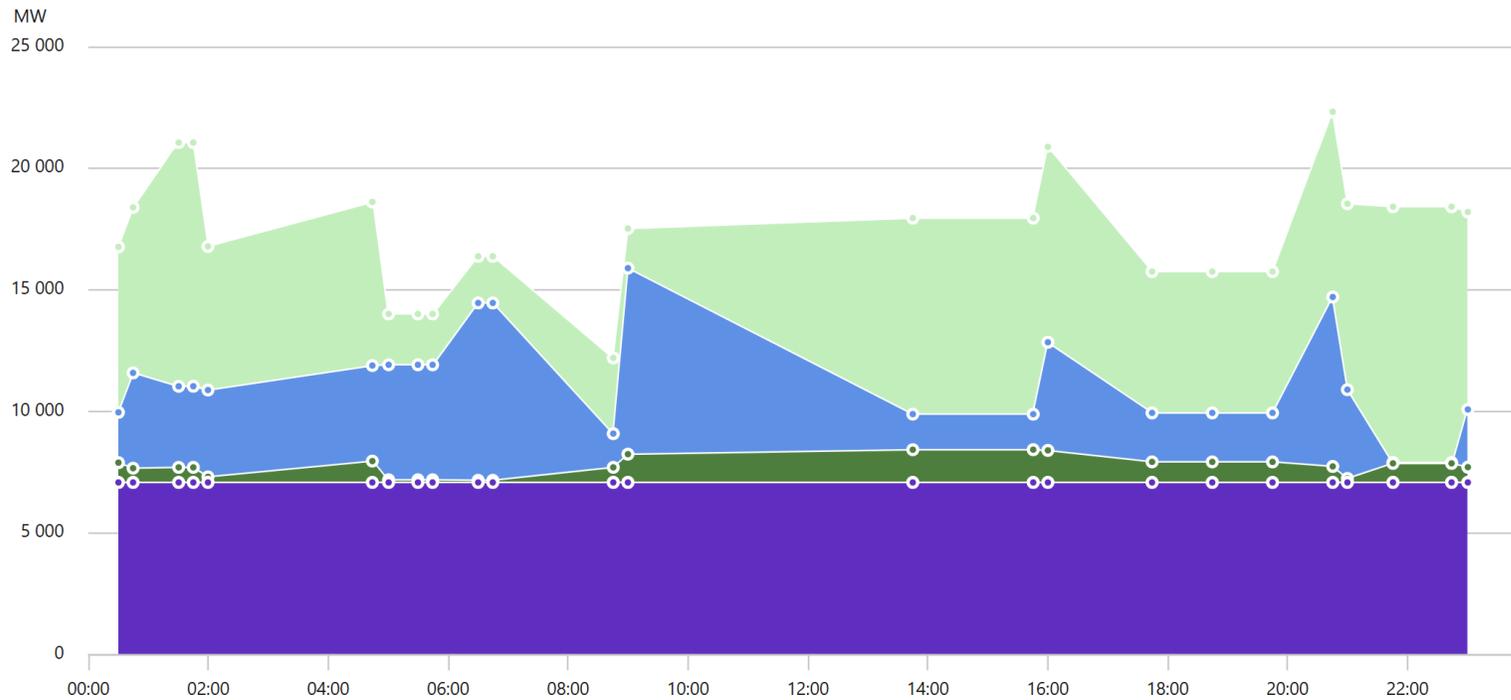
SEE BG TEL **System** SYS



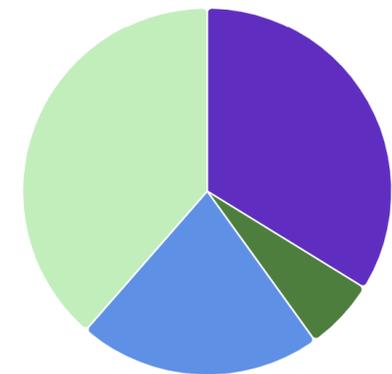
< 2026-02-16 📅 >

- Sverige
- Danmark
- Norge
- Finland
- Estland
- Lettland
- Litauen
- Totalt

✓ Graf 📄 Tabell

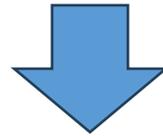


Kraftfördelning klockan 23:00



- Kärnkraft: 33,8%
- Värmekraft: 0%
- Ospecificerat: 6,3%
- Vattenkraft: 21,3%
- Vindkraft: 38,6%

Complex Market



Combinatorial bidding



Optimization

What we do

- Large-scale and complex negotiations between companies.
- Optimization-based resource allocation.
- Handling lots of data, millions of bids, and advanced constraints
- "I give you a better price if I get A, B, and C together"
- "I want at most three suppliers in France"

Some facts

- A few billion USD sourced weekly.
- Several Fortune 10 clients. Majority of clients are large multi-national companies. Plus consultancy firms.
- Frequently projects at several 100 million USD.
- Largest sourcing project was around 8 billion USD.

- What we compute has large real-world consequences. Fantastic and scary.



The Optimization Problem

Minimize
Cost

Given

Items

Bids

Supplier constraints

Buyer constraints

Solution

A set of allocated bids.

Negotiations add complexity to optimization





IKEA®

\$39⁹⁹ / 3pcs

ALVINEKVIST full/queen duvet cover set
Includes full/queen duvet cover and two
queen pillows, 100% cotton, Imported.
White/gray 201.596.35 Available in other sizes.
Prices vary.

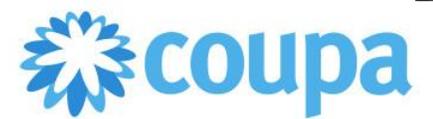
**Where the
everyday begins**

THE PRICES IN THIS CATALOG CAN ONLY GET LOWER UNTIL JUNE 2015, NEVER HIGHER.



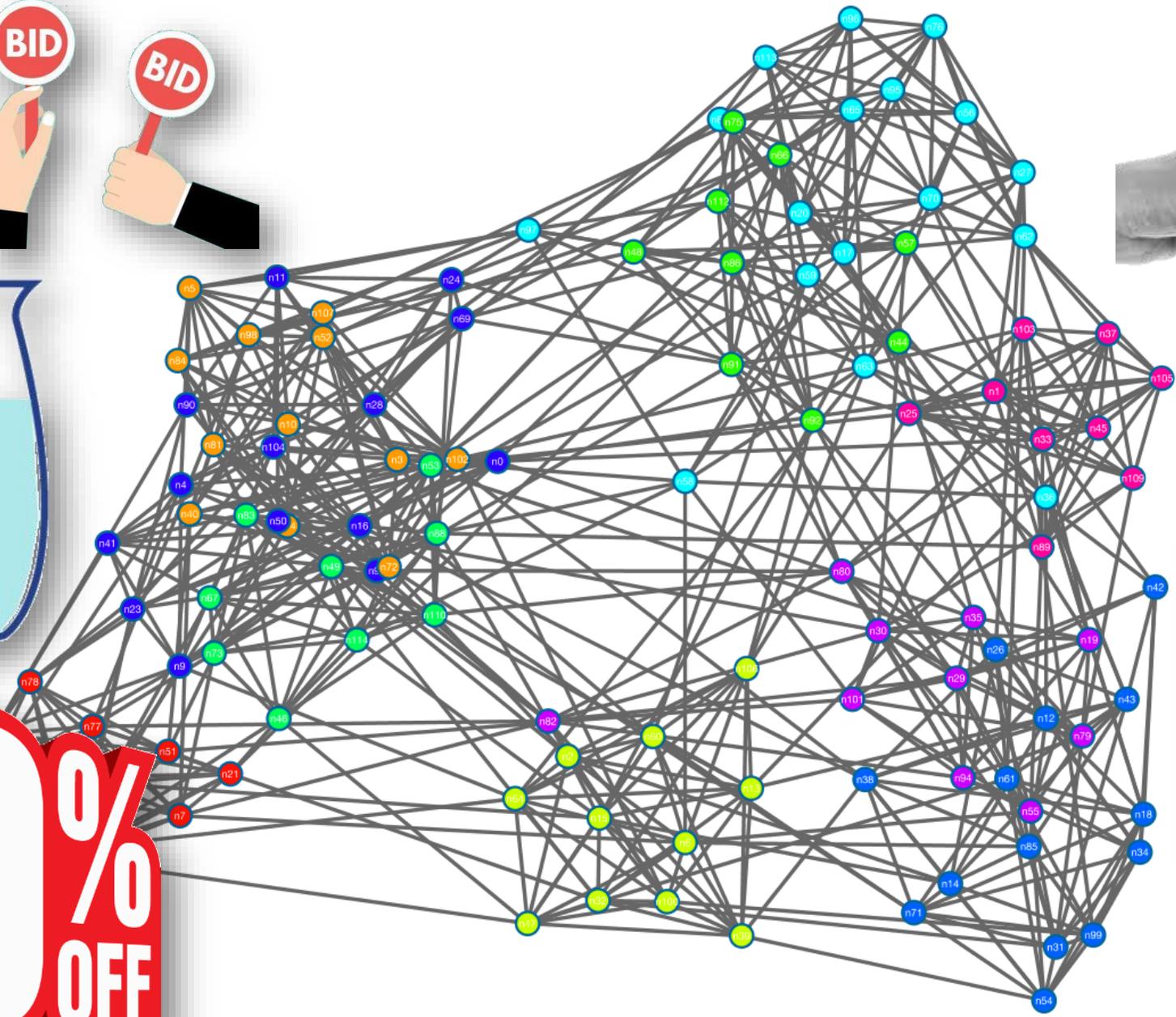


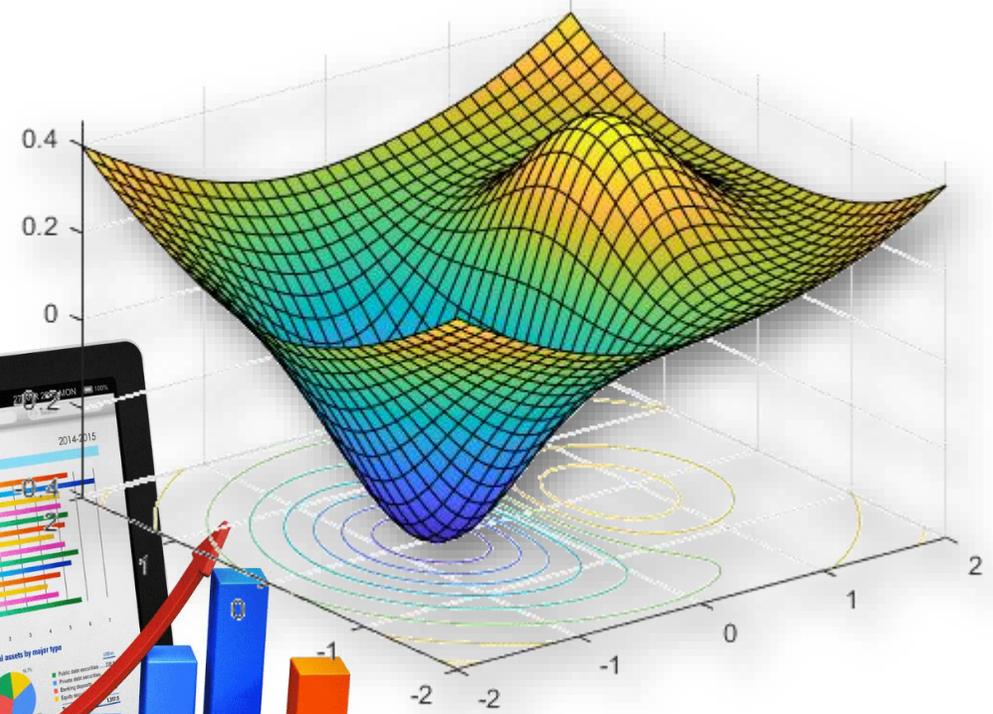
© Rolf Nyström/www.rolfsbild.se





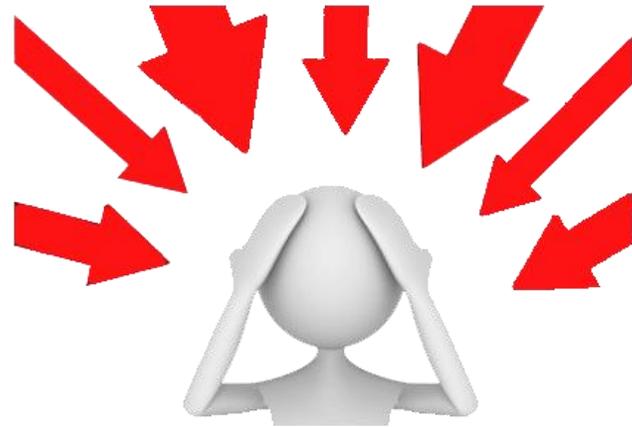
10% OFF







Buyer



The
mathematical
world



Bulk Paint - 2017

- Scenarios
- Scenario Dashboard
- Rule List
- Scenario Settings
- Selection Sheets
- Filters

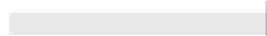
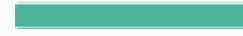
Scenarios

Create scenario 📄 Solve all 🔍 Filter scenarios
Phase: Round 2 ☰ ☰ Hints 🔔

Name	Payment	Savings	Allocation	Winners	Rules
3. Max 3 Winners 🔔 3 Solved 5 months ago	USD 5,037,389.14	59% USD 7,254,180.86	100%	<div style="width: 100%; height: 10px; background-color: #28a745;"></div>	3
4. Incumbents Only, reject BluesCO 🔔 3 Solved 5 months ago	USD 5,214,673.11	51% USD 5,380,719.46	87%	<div style="width: 87%; height: 10px; background-color: #28a745;"></div>	2
5. Select BluesCO as Sole Source Vendor 🔔 2 Solved 5 months ago	USD 8,051,252.34	34% USD 4,240,317.66	100%	<div style="width: 100%; height: 10px; background-color: #28a745;"></div>	1
6. 2 Winners per Paint Class 🔔 3 Solved 5 months ago	USD 5,534,201.64	55% USD 6,757,368.36	100%	<div style="width: 100%; height: 10px; background-color: #28a745;"></div>	4
7. Batch Size Delivery Capability 🔔 3 Solved 5 months ago	USD 4,997,818.11	58% USD 6,903,211.14	97%	<div style="width: 97%; height: 10px; background-color: #28a745;"></div>	5
8. Limit New Supplier 🔔 3 Solved 5 months ago	USD 5,372,461.35	56% USD 6,919,108.65	100%	<div style="width: 100%; height: 10px; background-color: #28a745;"></div>	3

Double-click to view scenario in a separate tab
 Click to select, CTRL-click to select multiple, SHIFT-click to select interval.
 Right click for options.


Solve all ▾
Filter scenarios ▾

Name			Savings	Allocation
 3. Max 3 Winners Solved 5 months ago	Optimisation value (USD) Adjusted payment 5,214,673.11 Rule violation penalty 0.00 + Non-allocated volume penalty 490,589,621.94	389.14	59% 	USD 7,254,180.86 
 4. Incumbents Only Solved 5 months ago	Computed cost USD 495,804,295.05	673.11	51% 	USD 5,380,719.46 
 5. Select BluesCO a Solved 5 months ago	Solve time Preparation 00s Creation 00s Computation 00s + Storing 00s Total Solve Time 01s	252.34	34% 	USD 4,240,317.66 
 6. 2 Winners per Pa Solved 5 months ago		201.64	55% 	USD 6,757,368.36 
 7. Batch Size Delivery Capability ⓘ 3 Solved 5 months ago		USD 4,997,818.11	58% 	USD 6,903,211.14 
		USD 5,372,461.35	56% 	USD 6,919,108.65 

Buyer-defined scenarios: Typical constraints

- At most 50 winners in total.
- At most 10 winners per factory.
- No more than 5% of suppliers turnover in award.
- No more than 25% to new suppliers
- Suppliers discounts:
 - If I get these five lanes in combination I can offer a different transit time.
 - I offer 30% discount on backhauls.
 - If I get more than 3MUSD of business I offer a 5% discount.

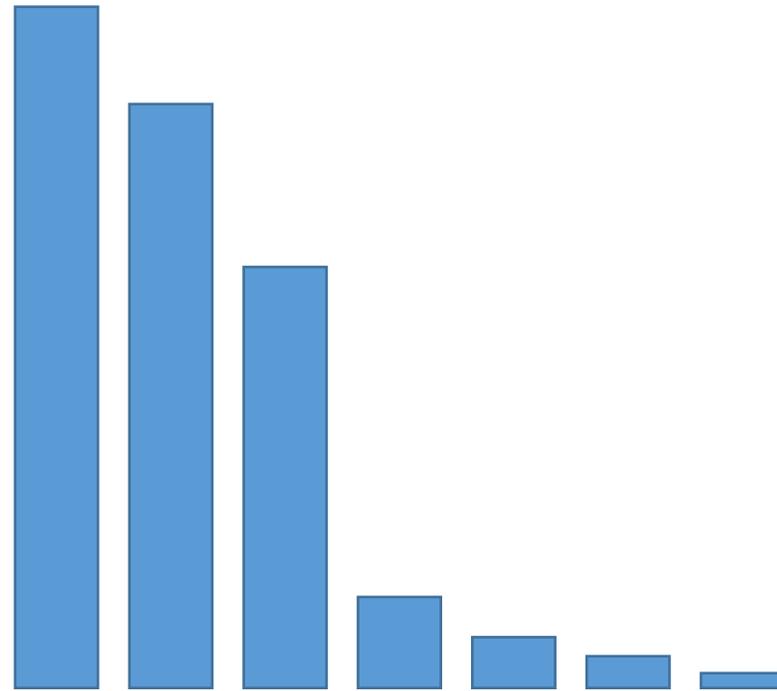
Our task: Helping buyers to easily set-up such rules, solve the optimization problems, and provide means for quickly and in detail compare different scenarios of allocation. (What is the impact by factory if changing from 45 to 50 suppliers in total?)

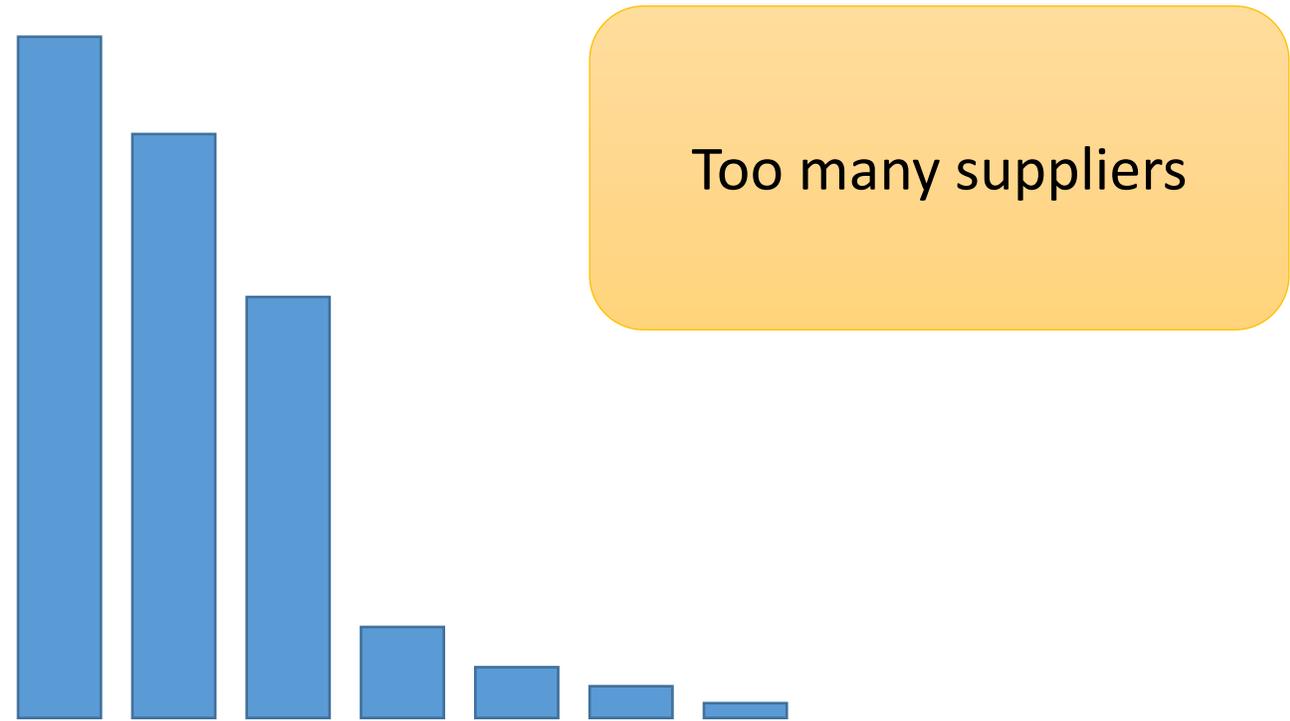
Example 1: Understanding Reserve Cost

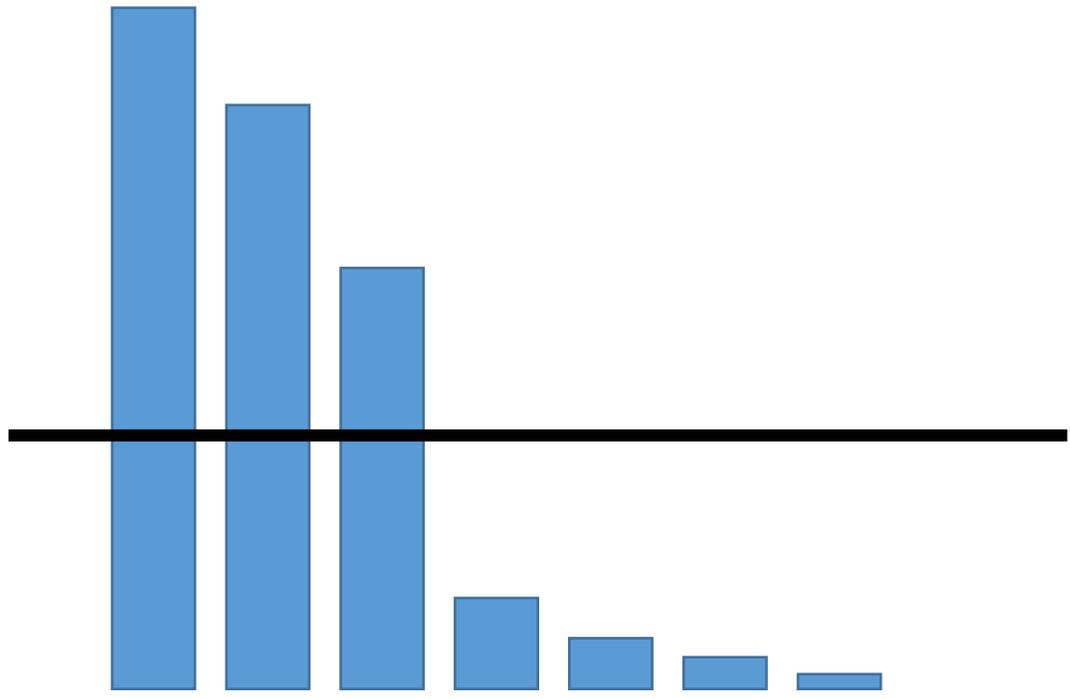
- Constraint: At most one winner

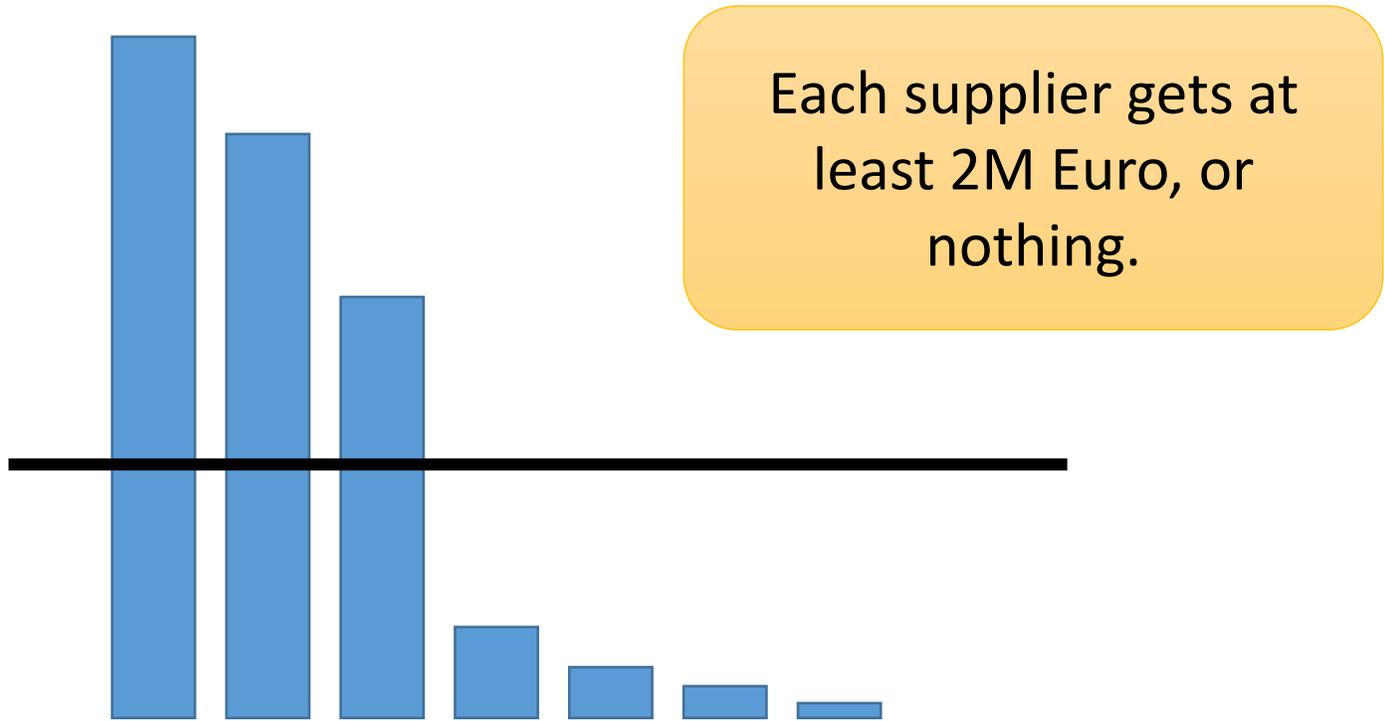
Lane	Supreme Transport	Mediocre Transport
Berlin – Hamburg	1 000 000	1 200 000
Hamburg – Salzburg	1 500 000	1 700 000
Gothenburg – Uppsala	400 000	600 000
Rotterdam – Amsterdam	2 000 000	2 300 000
Bern – Innsbruck	300 000	400 000
Paris – London	3 000 000	3 400 00
Tranemo – Svenljunga		50 000

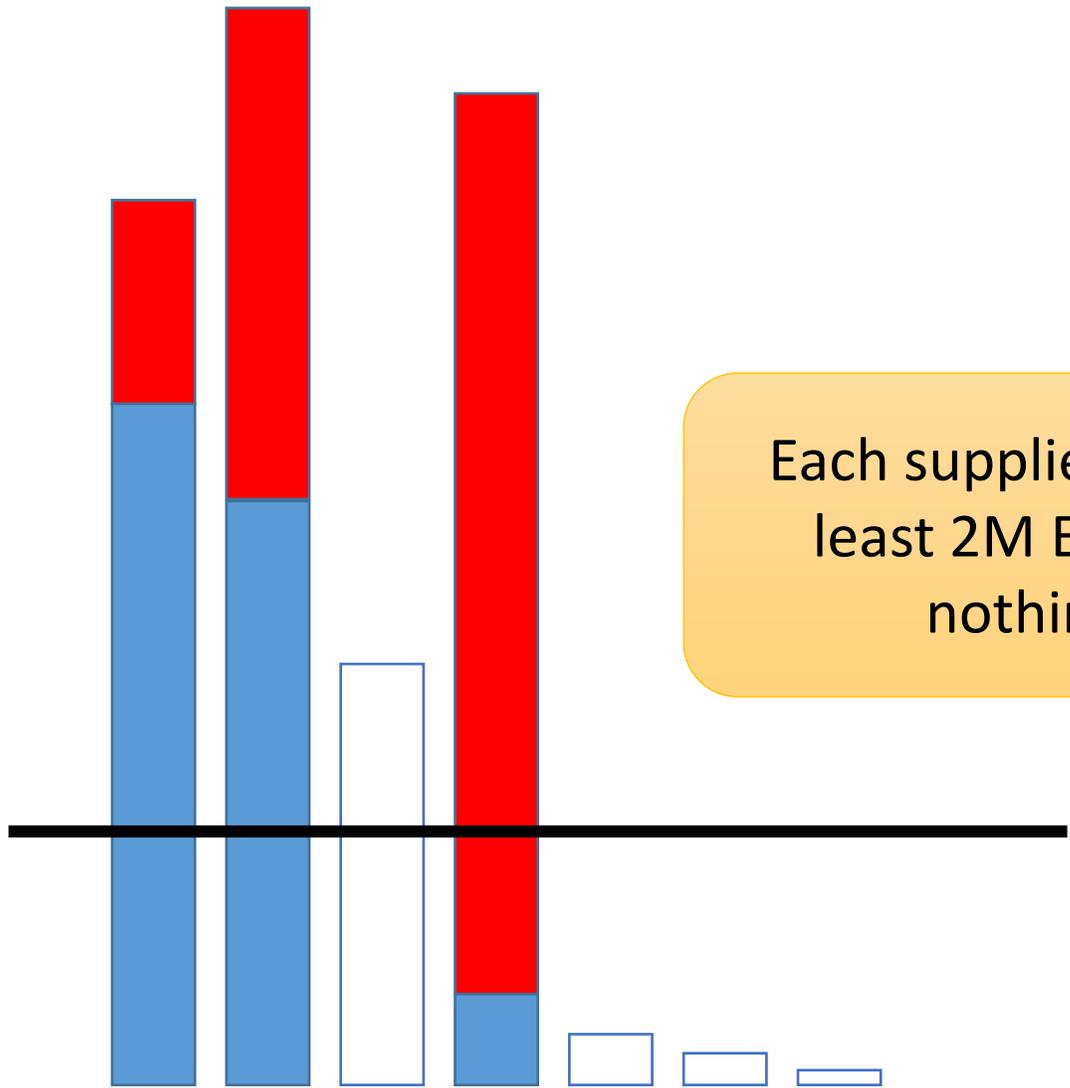
Example 2: Pick the right constraint



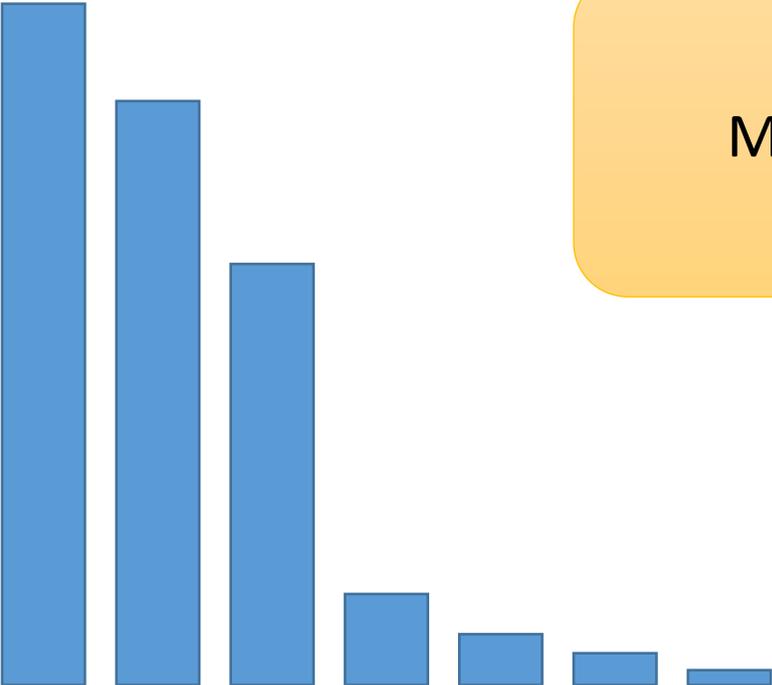




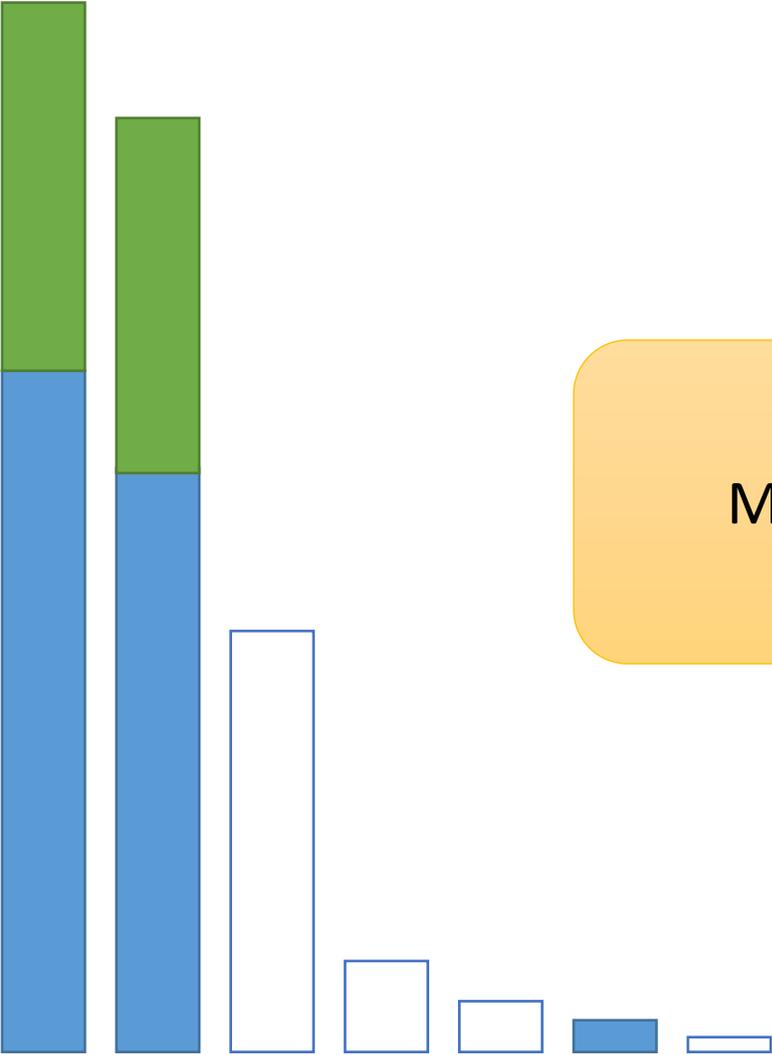




Each supplier gets at least 2M Euro, or nothing.



Max 3 winners.



Max 3 winners.

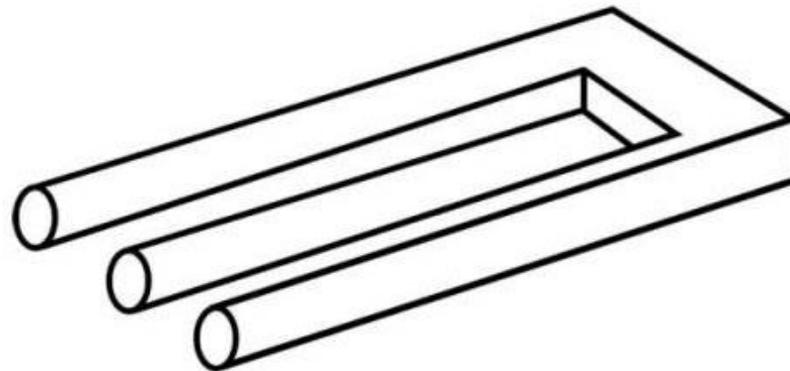
Example 3: Rounding

Supplier	Number of weekly containers awarded
Supreme Transport	134.5
Mediocre Transport	34.1
Splendid Transport	100.4
Transporting Hipsters	22

Example 4: "2nd best solution"



Example 5: infeasibility



Example 6: Automated User Guidance



Max 3 winners.

Example 6: Automated User Guidance



Max 3 winners.



Max 3 winners per
Country.

Example 6: Automated User Guidance



Max 3 winners.

Max 3 winners per
Country.

Max 3 winners per
country except France.

Summary

- Bringing optimization to the real world
- Large Data Sets
- Many challenges



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