A Planning Tool for a Municipal Utility Company

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Session WC-22: Real-world applications of mathematical optimization - Opportunities and Challenges
OR in industry, software applications, modeling languages
Wednesday, 13:30-15:00 Room: G-209

Agenda

- Introduction
- Optimization Models Types
- Case Study
- Conclusion

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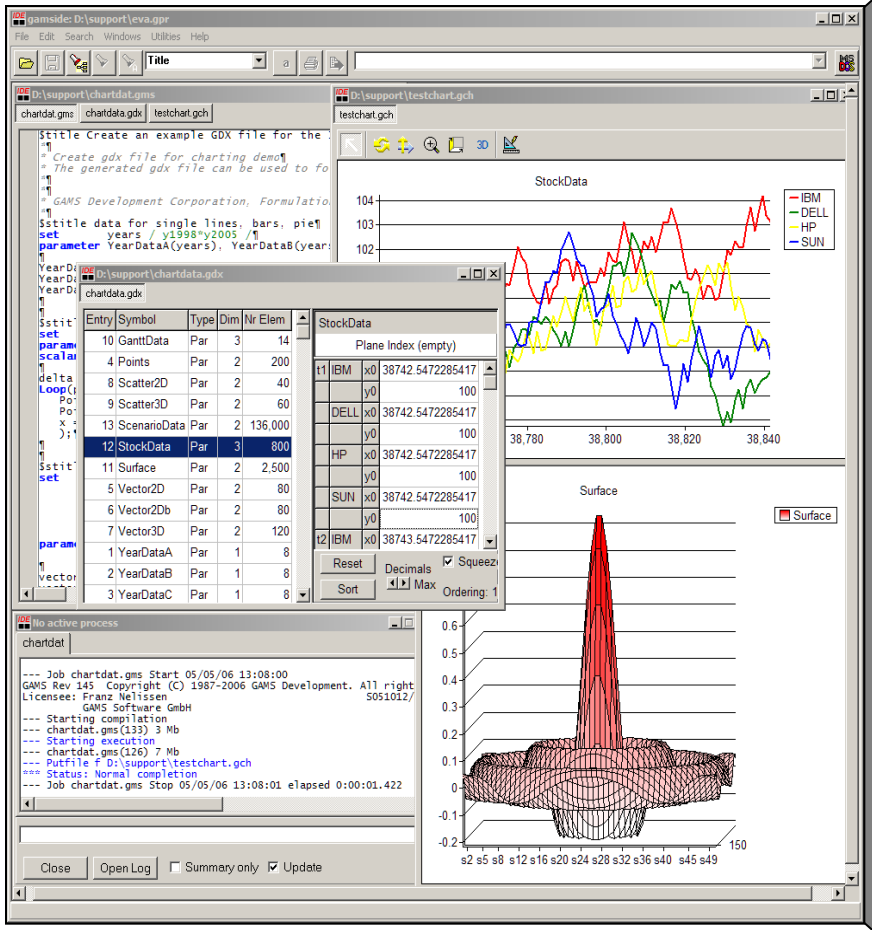
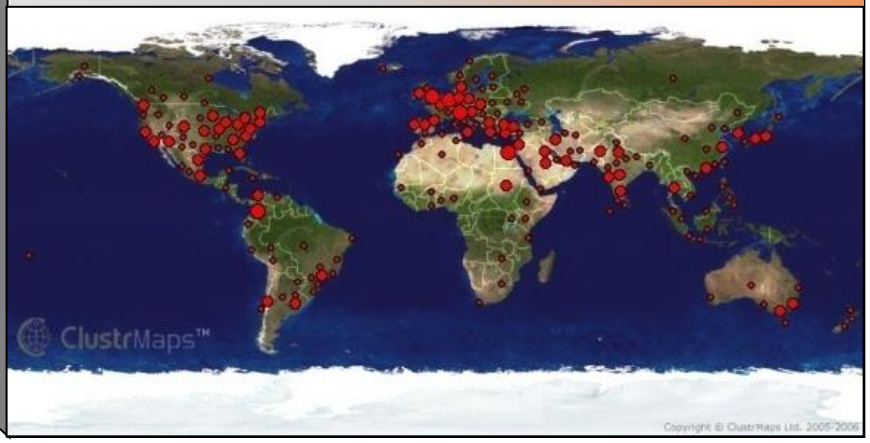
GAMS at a Glance



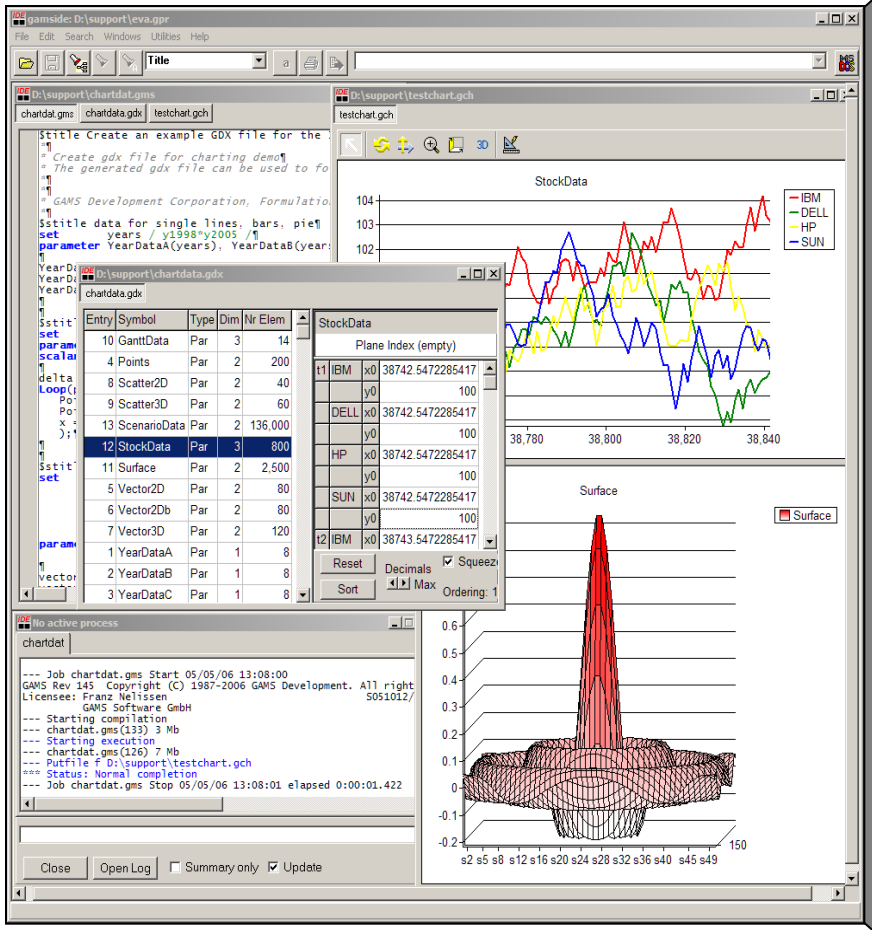
General **A**lgebraic **M**odeling **S**ystem

- Roots: World Bank, 1976
- Went commercial in 1987
- GAMS Development Corp.
- GAMS Software GmbH

- Broad academic & commercial user community and network



GAMS at a Glance



General **A**lgebraic **M**odeling **S**ystem

- Algebraic Modeling Language
- 25+ Integrated Solvers
- 10+ Supported MP classes
- 10+ Supported Platforms
- Connectivity- & Productivity Tools
  - IDE
  - Model Libraries
  - GDX, Interfaces & Tools
  - Grid Computing
  - Benchmarking
  - Compression & Encryption
  - Deployment System
  - …

Change in Focus

Computation **Past**	*Model* **Now**	*Application* **Future**
▪ **Algorithm limits application** ▪ Problem representation low priority ▪ Large expensive projects ▪ Long development times ▪ Centralized expert groups ▪ High computational costs → **Users left out**	▪ **Modeling skill limits applications** ▪ Algebraic model representation ▪ Smaller projects and rapid development ▪ Decentralized modeling teams ▪ Machine independence → **Users involved**	▪ **Domain expertise limits application** ▪ Off-the-shelf GUI ▪ Models embedded in business applications ▪ Links to other types of models ▪ Internet/Web →**Users hardly aware of model**

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What is a Model?

- List of Equations
  - *Mathematical Programming (MP) Model*
- Collection of several intertwined (MP) Models
  - Data Preparation and Calibration
  - "*Solution*" Module
  - Reporting Module
- Categorization of Models by answering:
  - Who is the *User* of a Model?

Who is the *User* of a Model?

- (Academic) Researcher
  - One time use (Research Paper)
- Domain&Model Expert
  - Model Results used for Consulting
- Black Box User
  - Model integrated in Application
- Each Category has its own needs
  - Development & Deployment

Consulting Models

- *Model* is Tool for Problem Analysis
- 10% of Model Source is (Equation) Algebra
- User: Domain & Modeling Expert (not necessary the same person)
- *Living* Model (changes with the problem)
  - Lifecycle: At least 10 years
  - Technology Change (Platform, Solver, …)

Black Box Model

- *Innocent* User
- Bulletproof Optimization Application
  - No *failures*: e.g. No Infeasible Models
- Model embedded in larger System:

Optimization

- **Takes longer than one is willing to wait**
- **It will eventually fail**

Application

- **Real Time**
- **Always need a *Solution* to Problem**

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Planning at KVV (Strategic and Tactic)

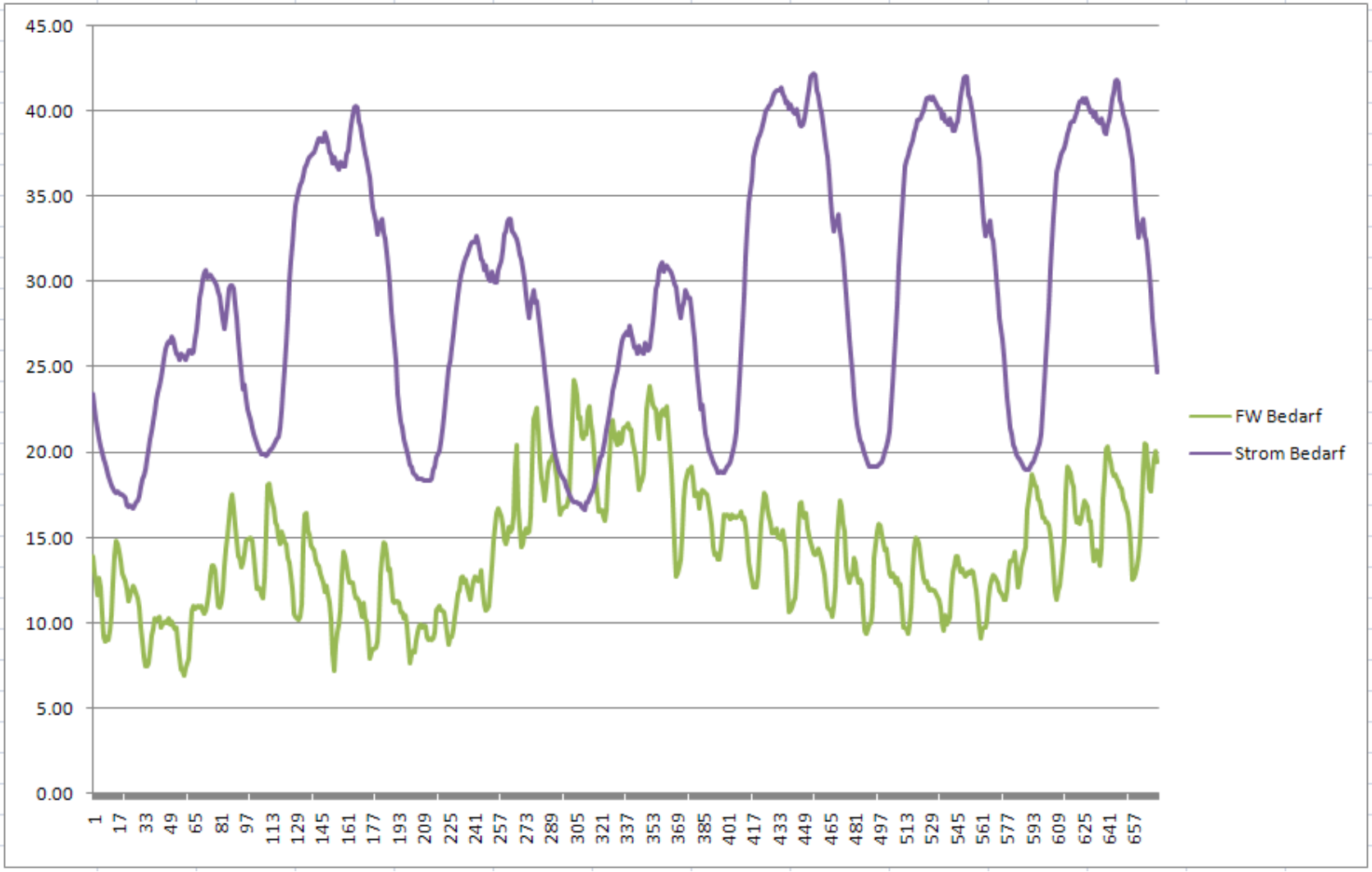
- 2007: New guy at KVV (Kassler Verkehrs- und Versorgungs GmbH) needs a tool to support decision making process from a pure **economic** point of view
- Shopping for available tools:
  - Too operational
  - Combined Heat and Power Generation (Kraft-Wärme-Kopplung) not well reflected in available tools (subsidies for co-generation)
  - Don’t use the tool of the *antagonist* (production)

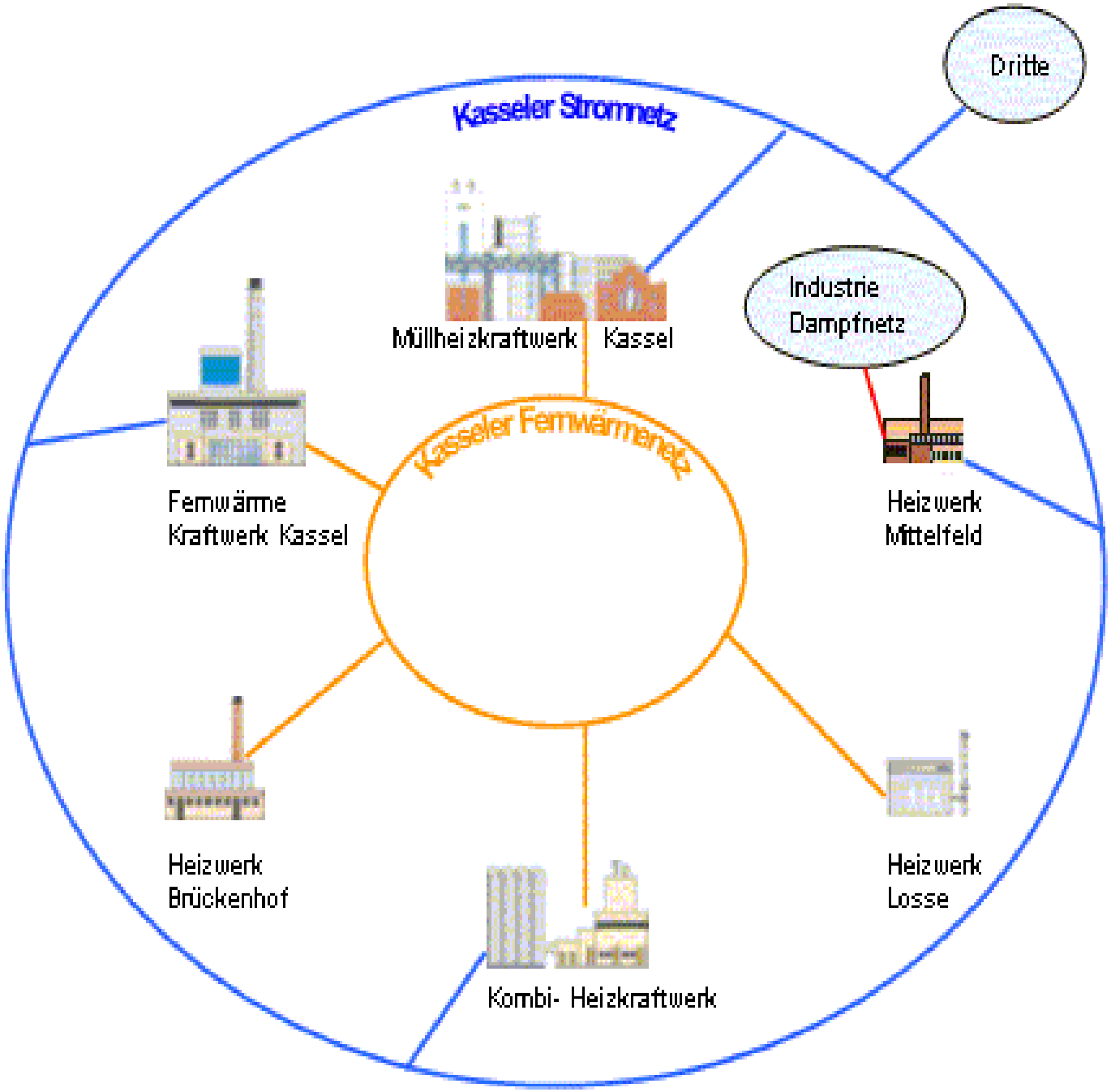
- Build an optimization tool from scratch tailored to their specific requirements

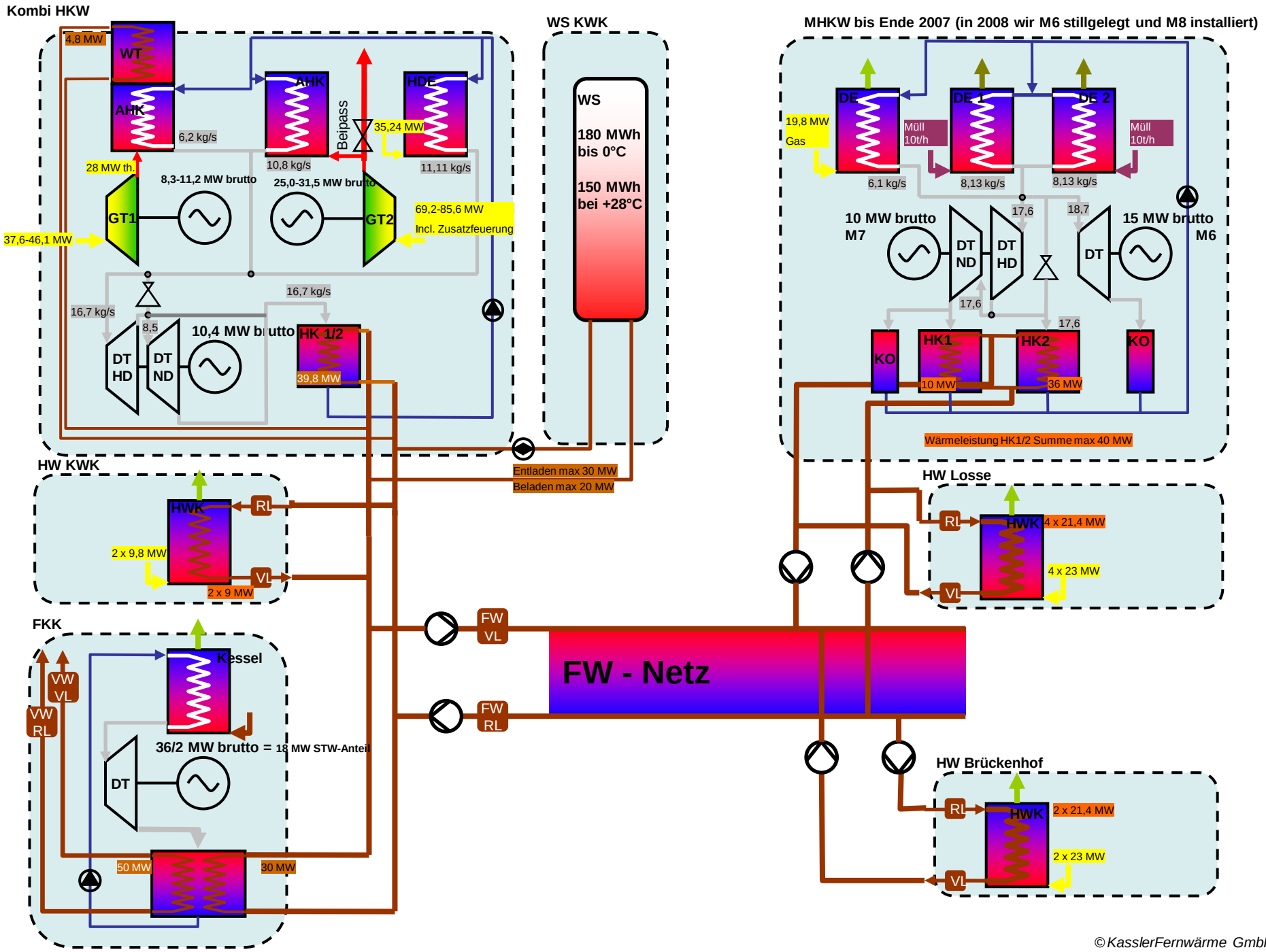
Modeling Task (Simplified)

- Supply (Make or Buy):
  - Heat & Power Generation units
  - Contracts/EEX for Power
- Transportation: Heat Network, Storage
- Demand: Heat & Power
- Objective: Minimize total cost
- Time resolution: 1 hour, Horizon: 1 year
- Modeling of generation units: down to process level

Demand Electricity/Heat

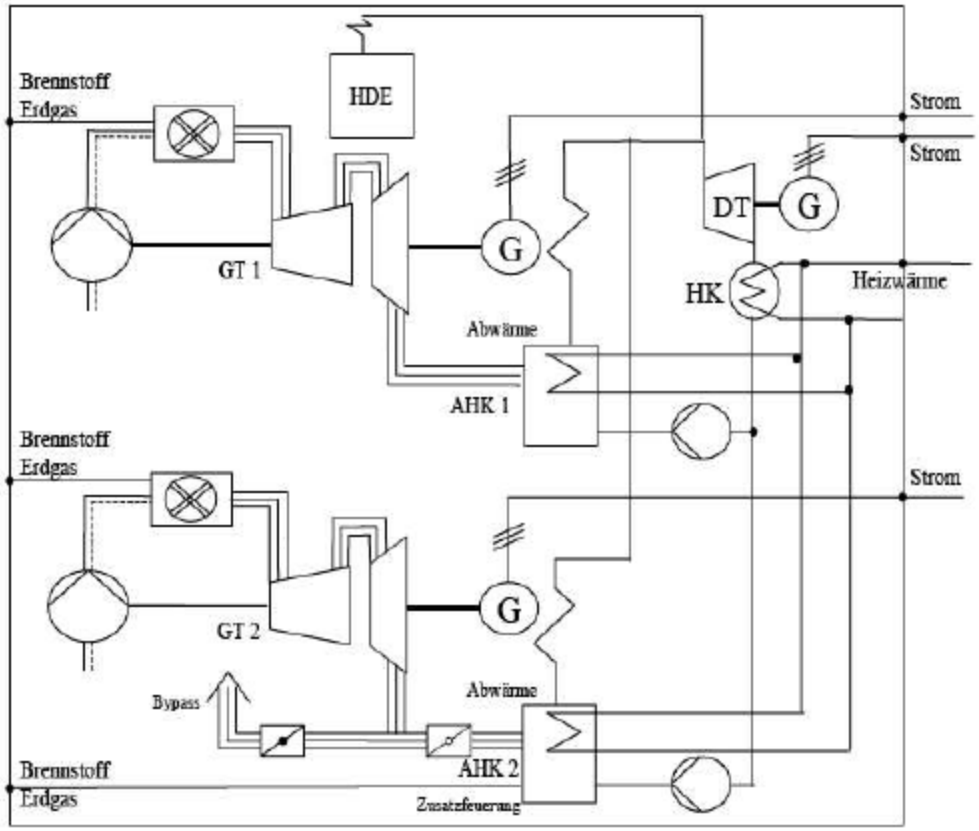


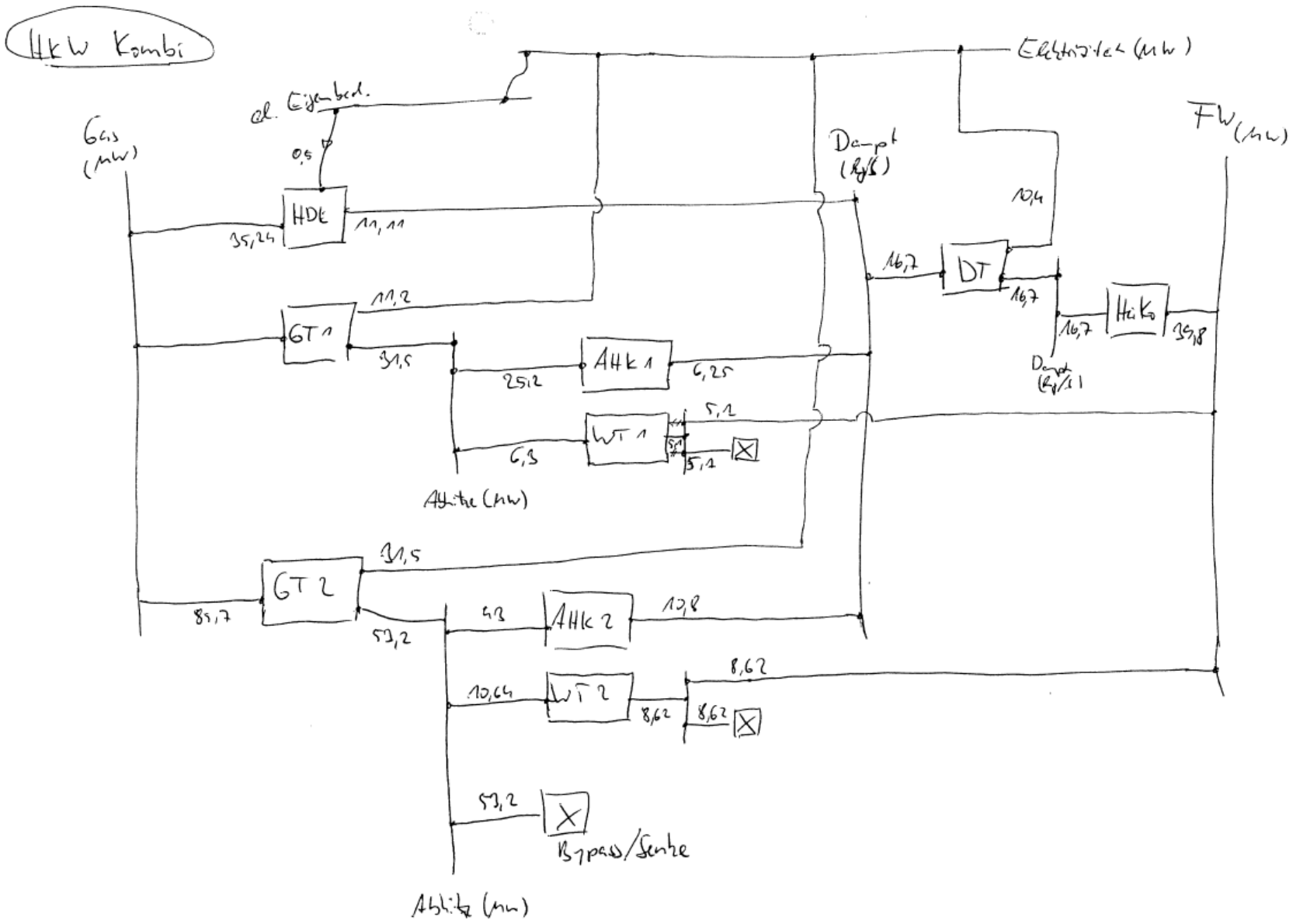

Dritte
Kasseler Stromnetz
Müllheizkraftwerk Kassel
Industrie Dampfnetz
Kasseler Fernwärmenetz
Fernwärme Kraftwerk Kassel
Heizwerk Mittelfeld
Heizwerk Brückenhof
Heizwerk Losse
Kombi- Heizkraftwerk



KFW Kasseler Fernwärme GmbH

Schaltbild erweitertes Kombi – Heizkraftwerk




HKW Kombi
Gas (MW)
el. Eigenbed.
0,5
HDE
35,24
11,11
GT 1
11,2
31,5
AHK 1
25,2
6,25
WT 1
5,1
6,3
5,1
Abhitze (MW)
GT 2
11,5
85,7
57,2
AHK 2
43
10,8
WT 2
10,64
8,62
8,62
57,2
X
Bypass/Senke
Abhitze (MW)
Elektrizität (MW)
Dampf (Kg/s)
10,4
16,7
DT
16,7
16,7
HeiKo
35,18
Dampf (Kg/s)
FW (MW)

Modeling of Processes

- IO Table (Inputs, Output, Intermediates)
- Temperature dependent IO Table
- Monitor start of process
- Processes with minimum level of operation

	A	B	C	D	E	F	G	H	I	J	K	L
1		HWK	HWK	GT	GT	AHK	WT	DT	HEIKO			
2		0	1	0	1	1	1	1	1			
3	Gas	0	-39.6	-54.69	-85.67							MWh
4	Kohle											MWh
5	Abhitze			36.43	53.2	-42.56	-10.64					MWh
6	Dampf					10.72		-16.7				kg/s
7	Abdampf							16.7	-16.7			kg/s
8	Waerme	0	18				8.6184		39.84			MWh
9	Strom			13.77	29.55			10.39				MWh

Model Realization

- Tight Budget
- Selection of Partners & Software Tools
  - Excel 
  - Energy Consultant
  - GAMS
- Front/Backend: Excel
  - Data storage
  - Simple scenario management (batch runs)
  - VBA to drive GAMS (< 300 SLOC)
  - Development/Deployment/Maintenance

Timeline

- Preliminaries
  - Understanding what optimization can do
  - Data available
  - Skills: Economist, Engineer, Modeler/Optimizer
- 3 Weeks intensive prototype development
  - Data, model, reports
- 3 Day training course
- Agreement that no further packaging is needed
- Since then:
  - Build of trust and confidence in the tool
  - Help with explanation of *inexplicable* results
    - 95% data issues, 5% bugs in model
  - Minor adjustments and enhancements

Use of the Model at KVV

- New investment in infrastructure:
  - Biofuel plant
  - New gas turbine
- Change in operation
  - Provide economic base for renegotiation for turbine maintenance contract (more starts)
- Complex ownership structures
  - Negotiation of changes in co-ownership
- Contract Negotiations
  - Supply of power
  - New big clients

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Conclusion

- Working prototype is sometimes sufficient
- Use tools/software systems already in place
- Don’t overprotect knowledgeable users from complexity of optimization model
- Protect user from optimization pitfalls
- Let users take ownership and pride in *their* optimization application

Thank you!

USA

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