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material flows and software.

Analysing Material (and Energy Flows) in SME – a practical approach

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ifu Institut für Umweltinformatik Hamburg GmbH

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- Software, Training & Coaching
- Team of 40 employees
- >5000 clients world wide

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Visual Flows
Sankey Diagrams

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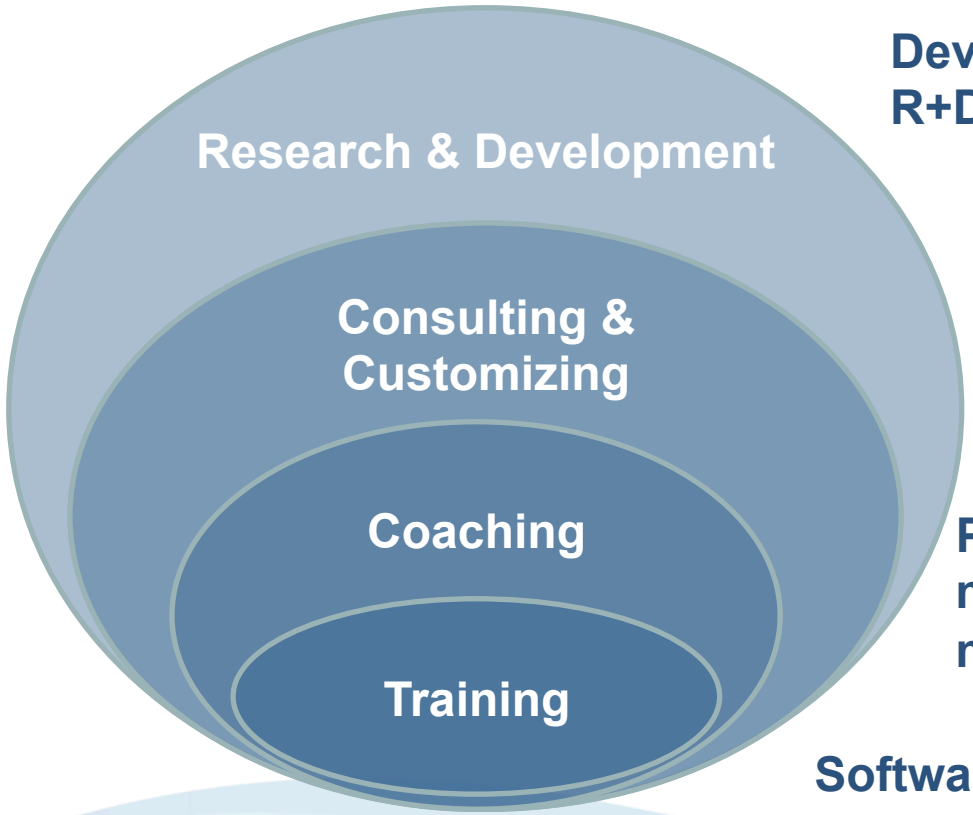

Development of new solutions
R+D Partner e.g. in funded projects

Complete project handling,
IT integration, Customizing

Project planning and expert monitoring, modeling data research model review, interpretation

Software-Tools & Methods

Analysing Resource Efficiency

Means to us:

Analyzing Material Flows + Energy Flows

= Taking a wholistic systems approach

„... to reach a ressource efficienct production system a compreheinsive system understanding is the basis...“

What does that mean in practice?

… a case of a German SME will help us to understand better...

SWU
Quality right from the start.

SWU Spinnweberei Uhingen GmbH

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Quality right from the start.

	Spinning mill	Weaving mill
Foundation	1860	1894
Location	Waldkirch (close to Freiburg)	Uhingen (close to Stuttgart)
Employees	55	45
Production technology	~11600 spindles ~2400 t/a yarn 5-6 days, 24h	42 weaving machines ~8‘700‘000 m² fabrics 5-6 days, 24h
Main products	Cotton-based yarn (carded, combed, twisted)	Industry fabrics (abrasives, print, etc.)

In 2009...

CEO of SWU:

„We are efficient already, if not, we were already out of business!“

... But still participated in the BMBF funded project Enhipro „Energy and Auxiliaries improved production“ (www.enhipro.de).

There was one measure the CEO knew

Energy use:
>10 GWh per year

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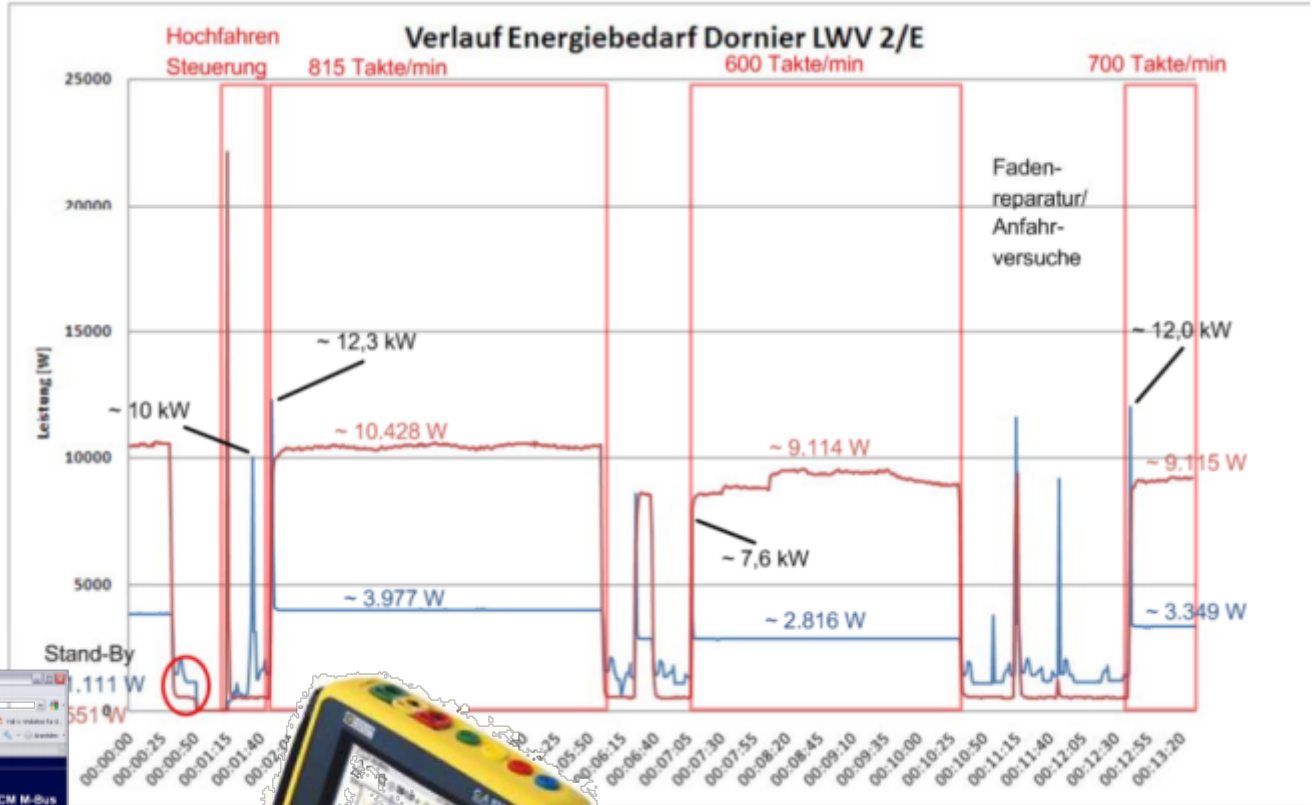
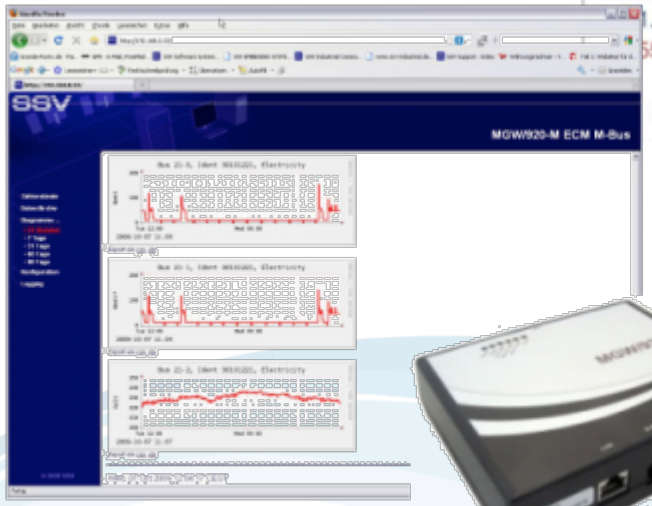
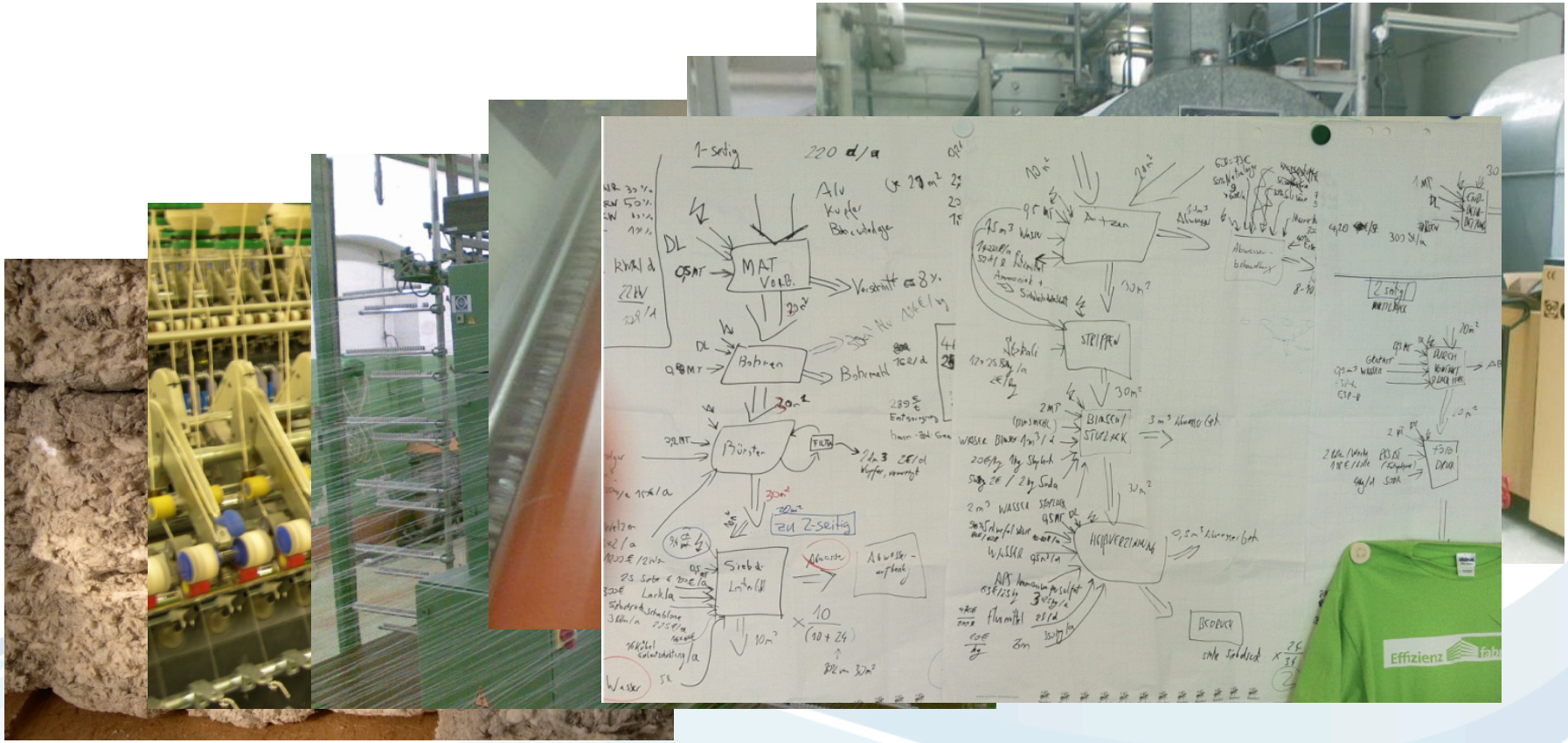
Measuring (ad hoc and permanent)



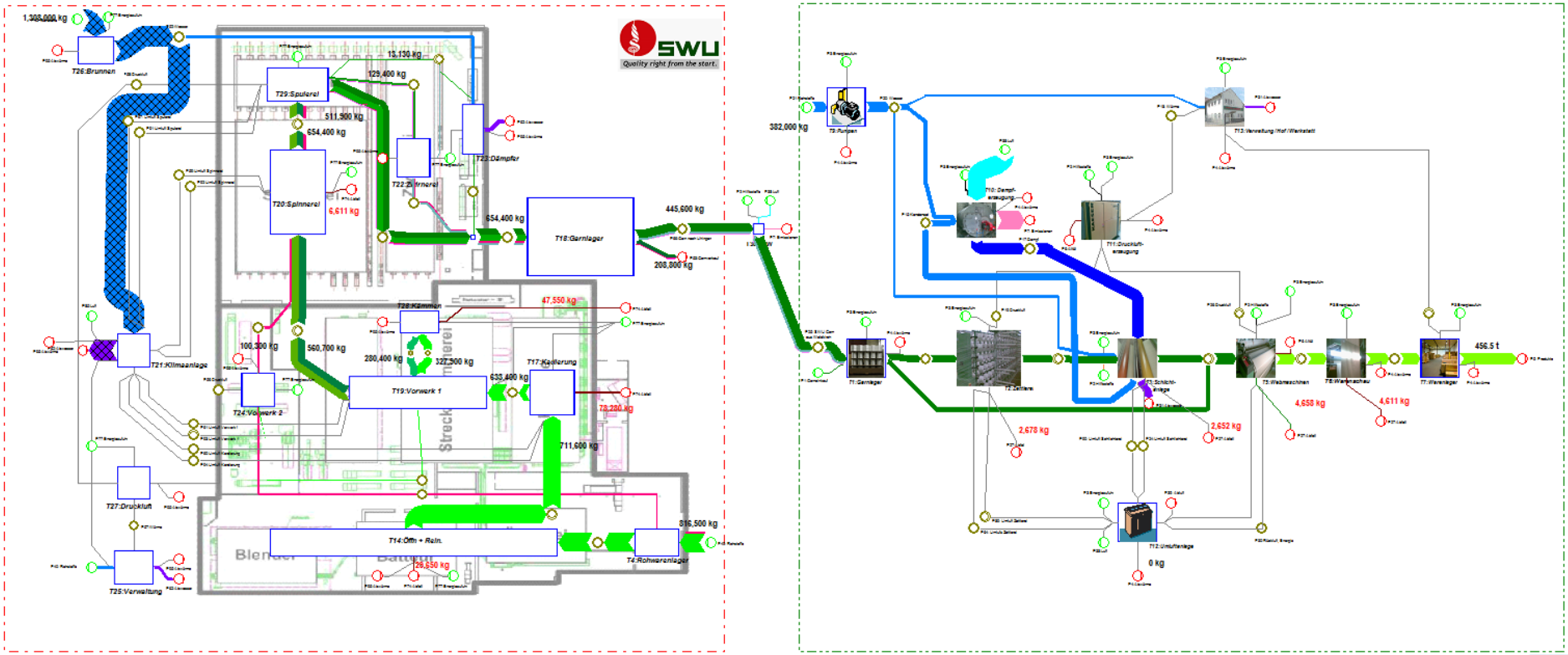


Modeling and Analysing

- Initial 2-day workshop on material and energy flow accounting and costing (flipcharts)
- Modeling and analysis in the software tool Umberto
- Continuous improvement, refinement, data update, discussion of results



Modeling and visualization



Umberto model of SWU (both sites and transport)

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Modeling of a process

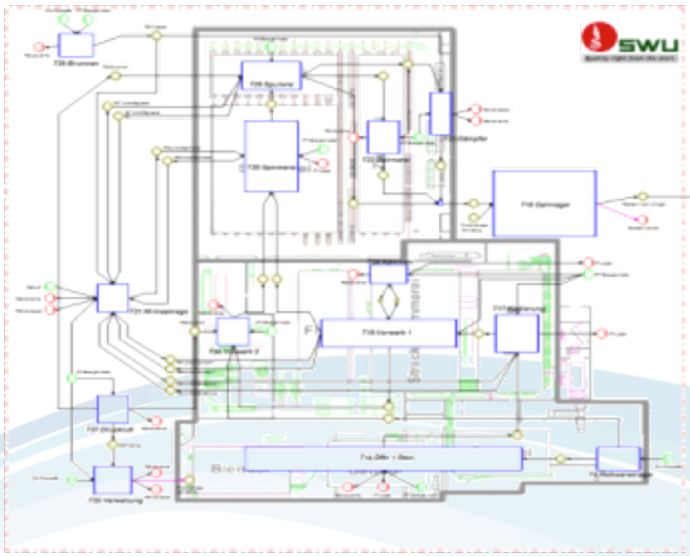
Transition Specifications T5 - Input/Output Relations

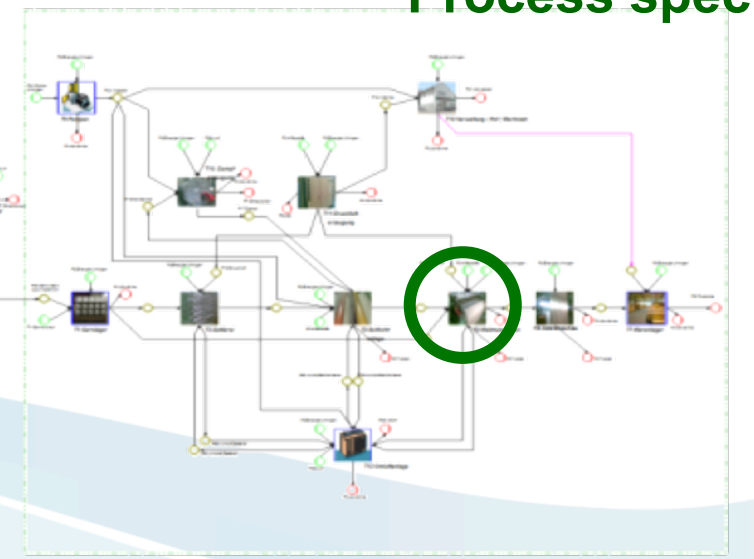
Input / Output | Allocation Rules | Cost Center Costs | Cost Drivers | Constraints

Var	Place	Material	Coefficient	B. Unit
X00	P13	Garn (webfertig)	1000	kg
X01	P9	Schussfaden	200	kg
X02	P3	Energie, el. (Prozess)	1800000	kJ
X03	P3	Energie, el. (Licht etc.)	36000	kJ
X04	P24	Energie, Kühlung	1440000	kJ
X07	P2	Schmieröl	0.1	kg
X09	P19	Energie, Druckluft	134000	kJ
X10	P19	Druckluft	5000	m3

Var	Place	Material	Coefficient	B. Unit
Y00	P14	Gewebe (Websaal)	1180	kg
Y01	P6	Garn (Abfall)	20	kg
Y02	P6	Schmieröl (Abfall)	0.1	kg
Y03	P8	Abwärme	34100000	kJ

Example Weaving hall - simple Input/Output Process specification





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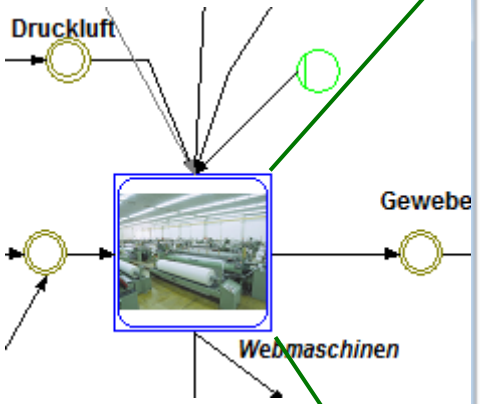
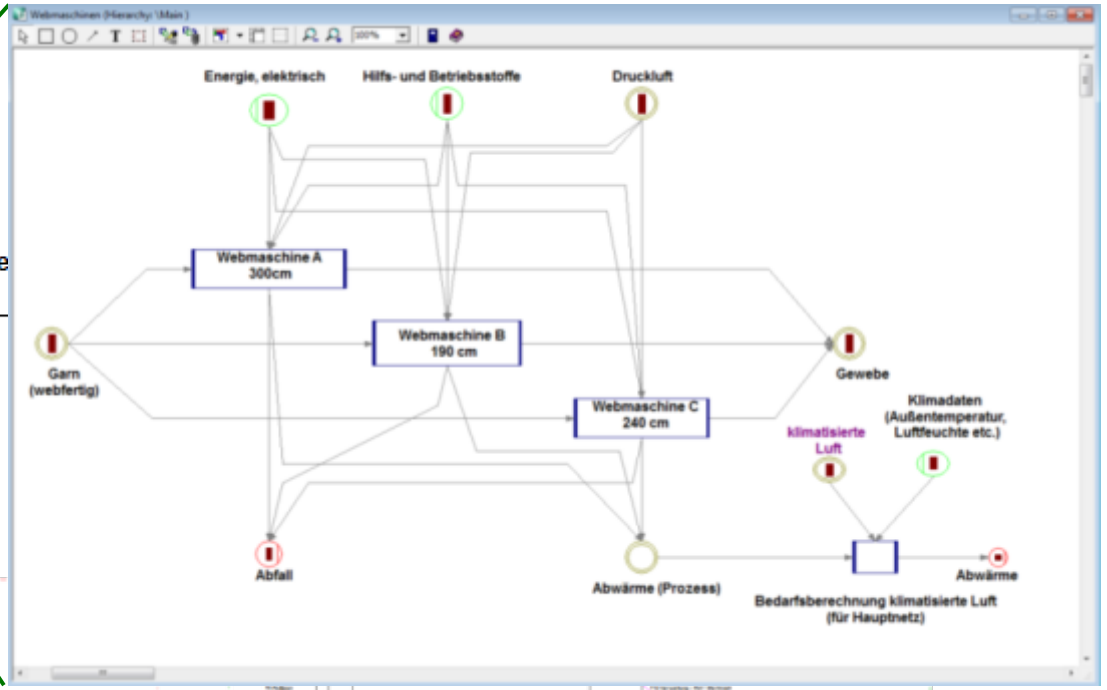
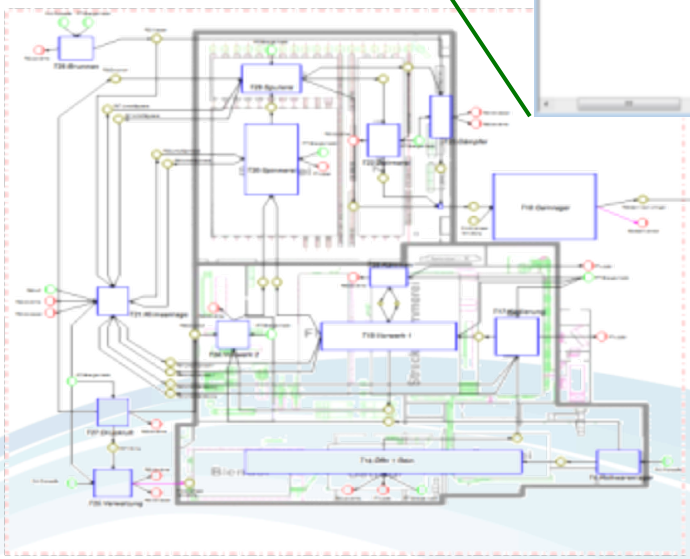
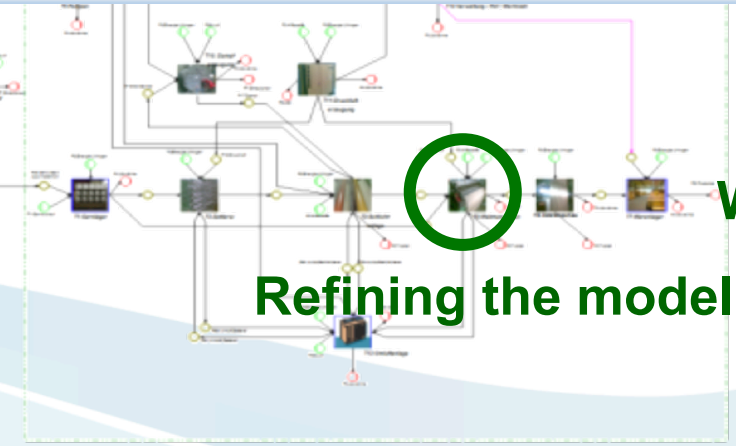
Modeling a hierarchical model









Weaving hall:

Refining the model step by step

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Advanced Modeling of Processes

Transition Specifications T2 - User Defined Functions

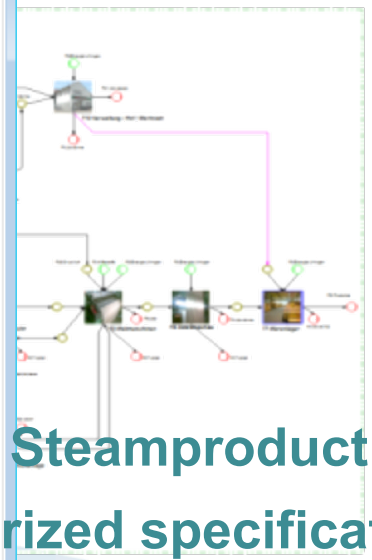
Input / Output | Parameters | Allocation Rules | Cost Center Costs | Cost Drivers | Referenced Stocks | Constraints

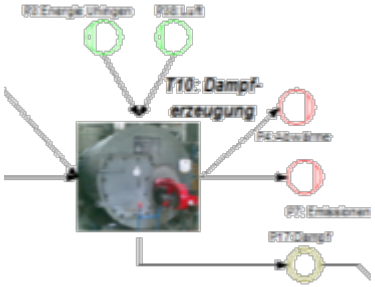
Var	Place	Material	B. Unit	DQ
X00	P4	Kondensat, Masse	kg	
X01	P6	Frischwasser, Masse	kg	
X02	P7	Brennstoff, Masse	kg	
X03	P7	Brennstoff, Energie	kJ	
X04	P6	Frischwasser, Energie	kJ	

Var	Material	Place	B. Unit	DQ
Y00	Dampf, Masse	P1	kg	
Y01	Abwärme, Energie	P5	kJ	
Y02	Dampf, Energie	P1	kJ	

Transition Specification Functions T2 - Default

```
1   ;MASSENSTRÖME
2   ;Frischwasser
3   X01=Y00-X00
4
5   ;ENERGIEBEDARF FÜR DAMPFERZEUGUNG
6   ;Energiegehalt im Dampf
7   Y02=Y00*ED
8   ;Energiegehalt im Kondensat
9   X05=X00*EK
10  ;Energiegehalt im Frischwasser
11  X04=X01*EF
12
13  ;benötigte th. Energie für Dampferzeugung
14  QH=Y02-X05-X04
15  ;Heizölenergiebedarf - Berücksichtigung der Verluste bei der Dampferzeugung
16  X03=QH/(1-ETA/100)
17
18  ;Heizöl Massenstrom
19  X02=X03/(HW *1000)
20
21  ;ELEKTROENERGIEBEDARF
22  X06=EEB*3600
23
24  ;Abwärme
25  Y01=X03*(ETA/100)+X06
```





Example: Steamproduction-parameterized specification with engineering exactness

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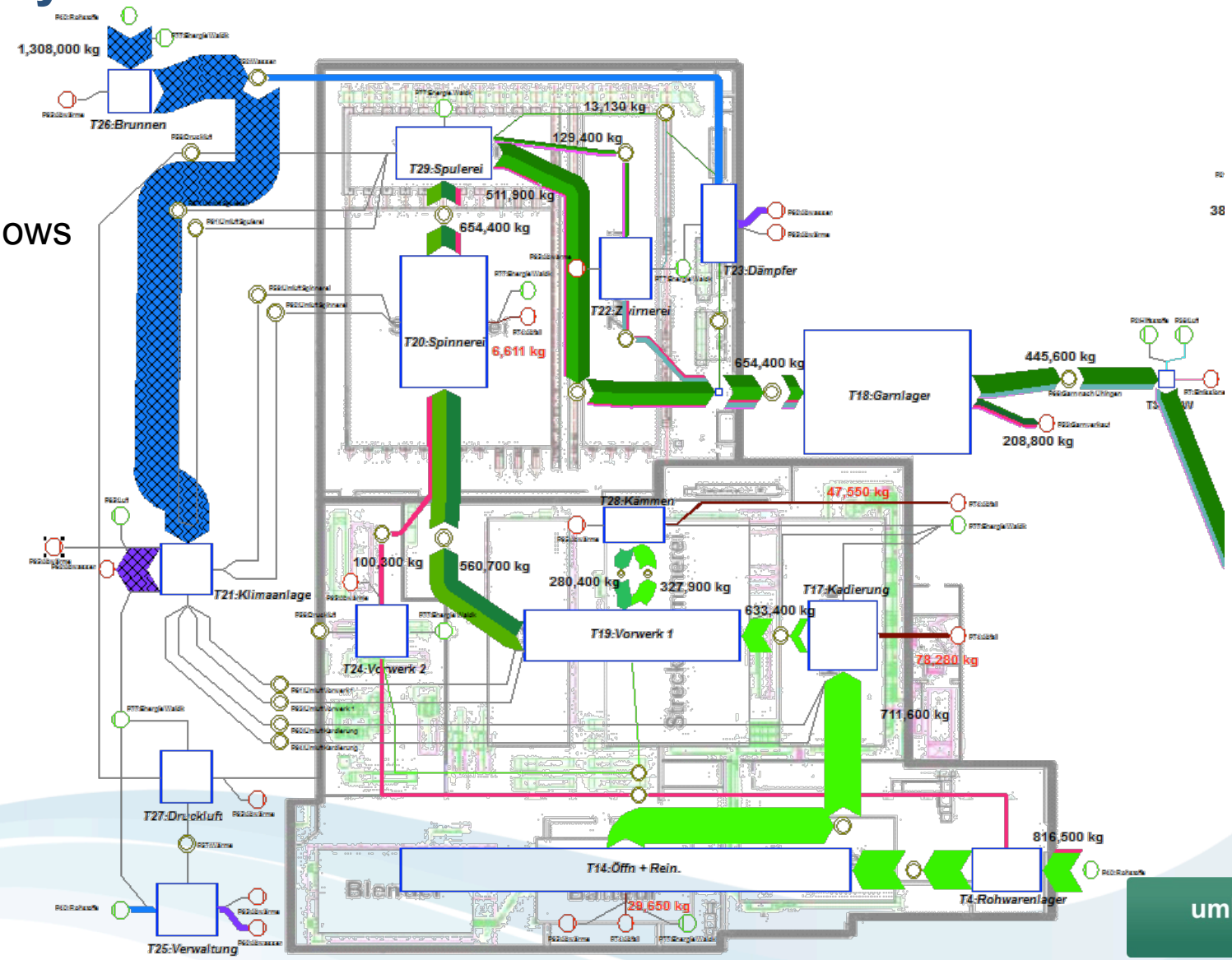
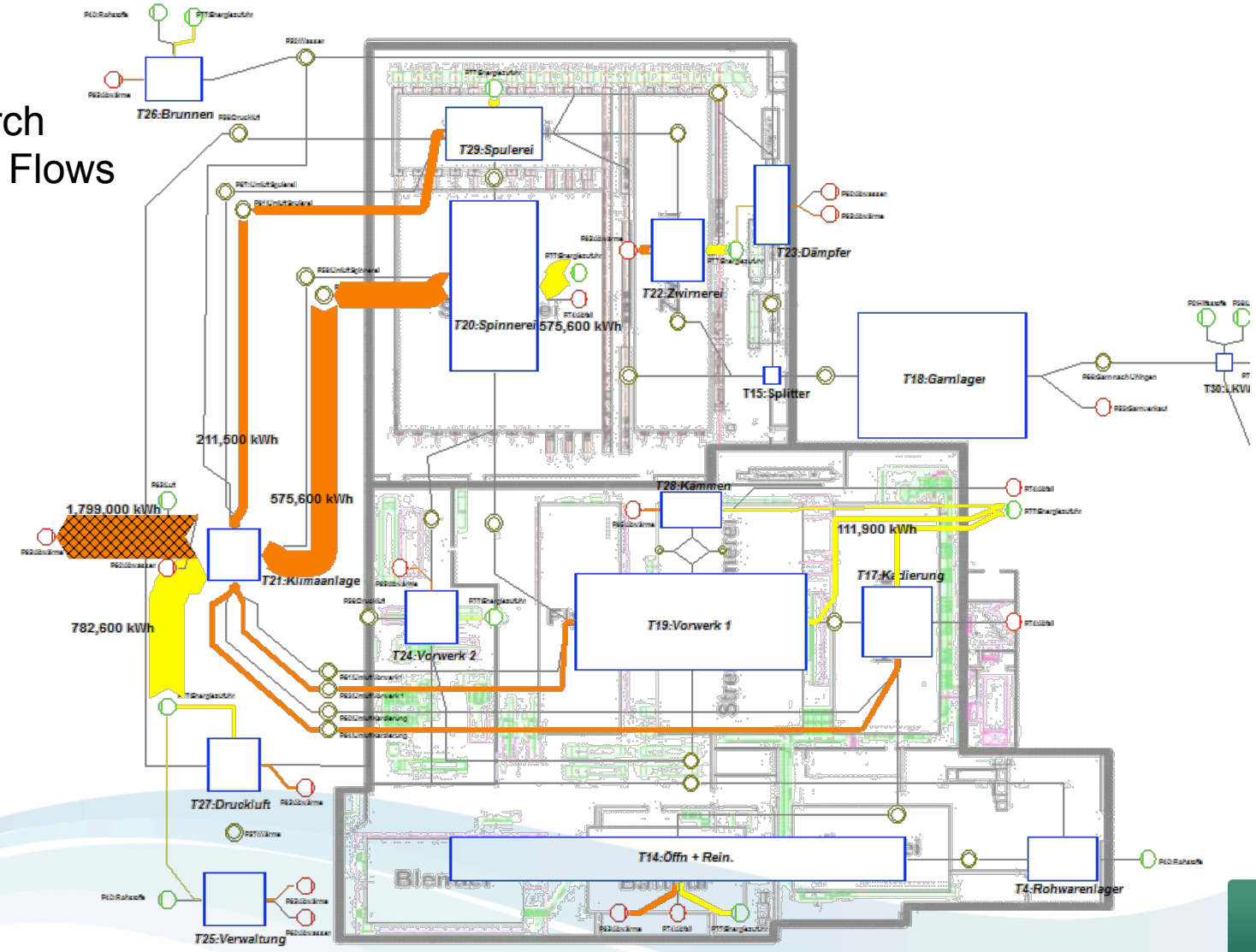
Sankey Visualization

site
Waldkirch
Material Flows



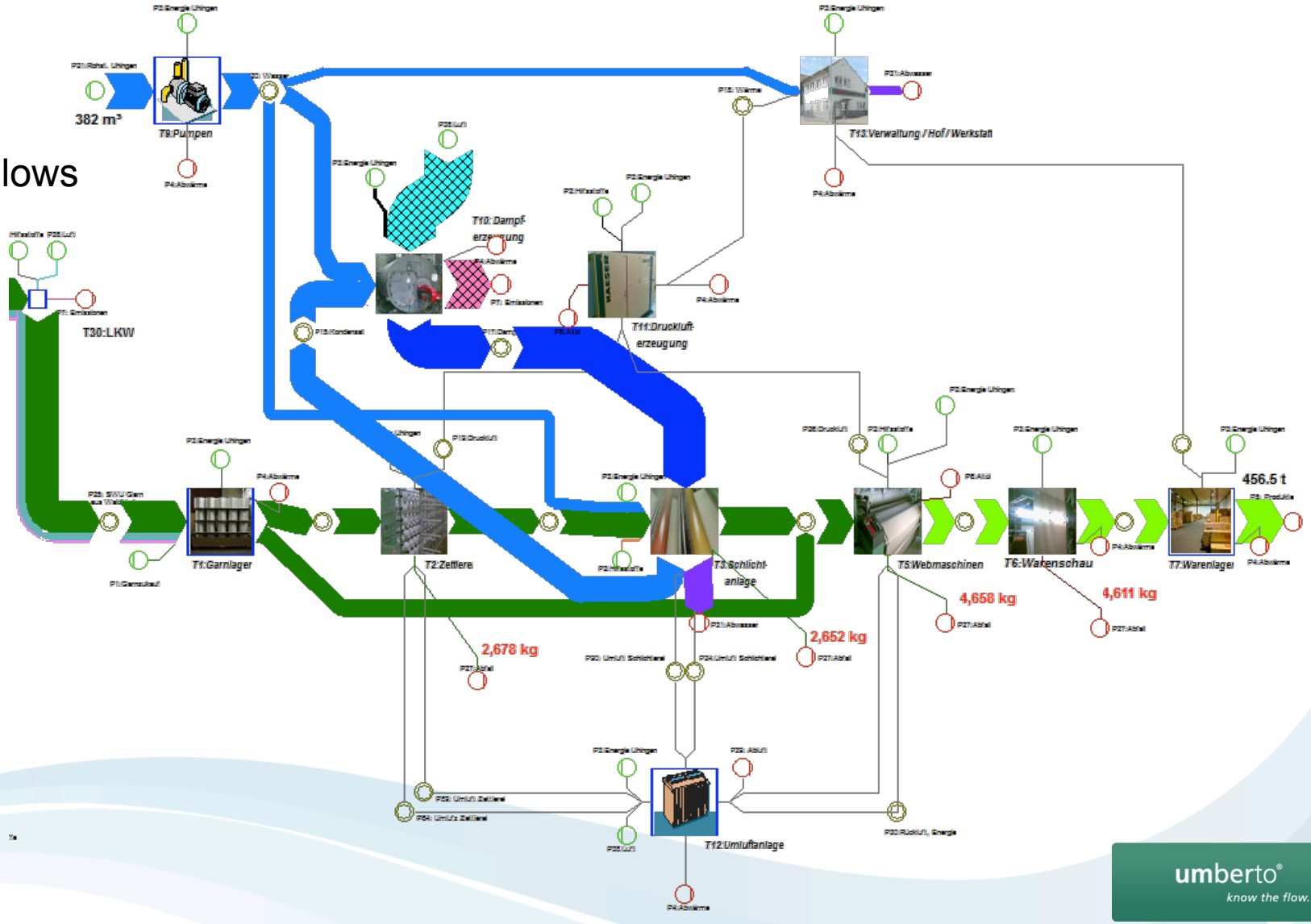
Sankey Visualization

Site
Waldkirch
Energy Flows



Sankey Visualization

Site
Uhingen
Material Flows



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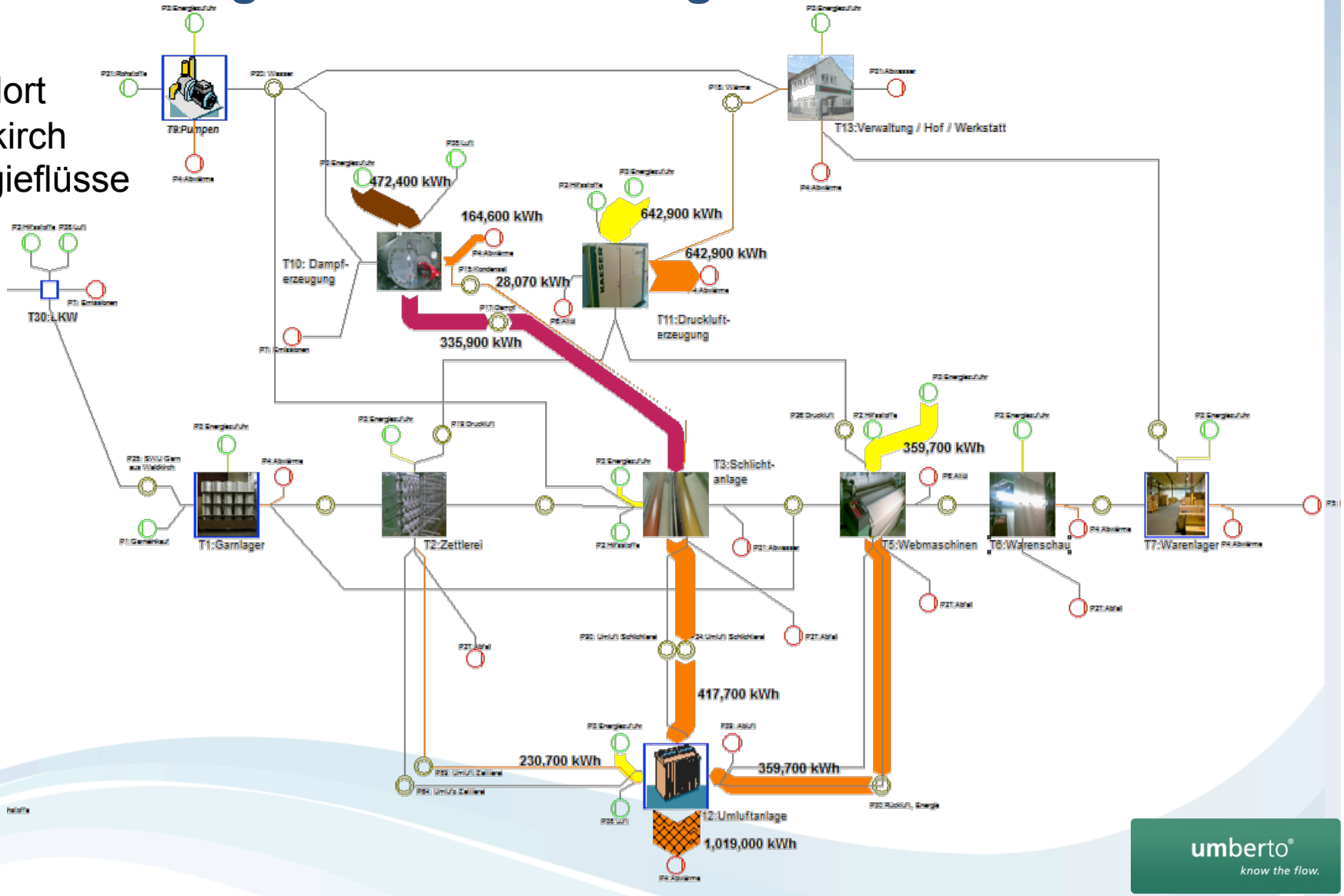
Modellierung und Visualisierung

Standort
Waldkirch
Energieflüsse



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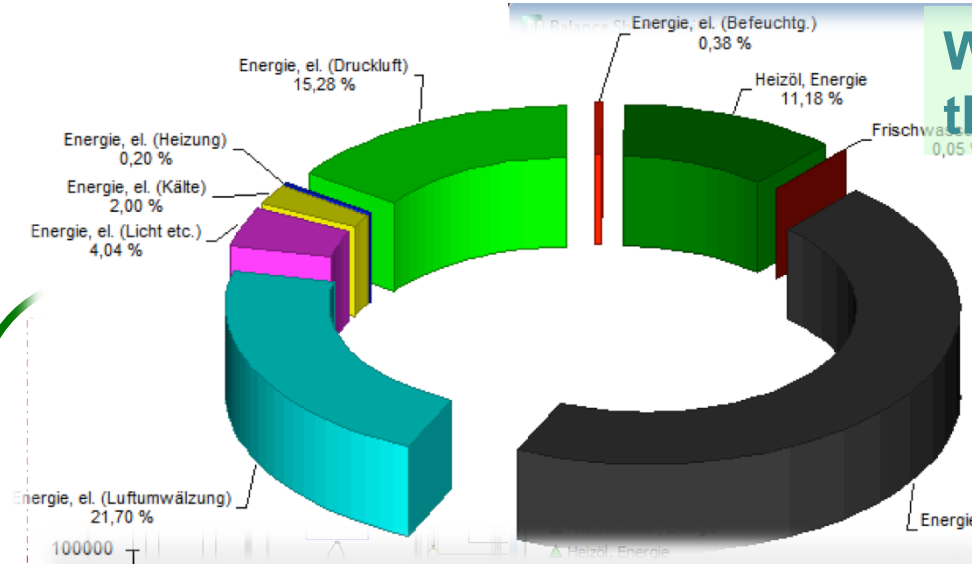
Results and Balances on a corporate level

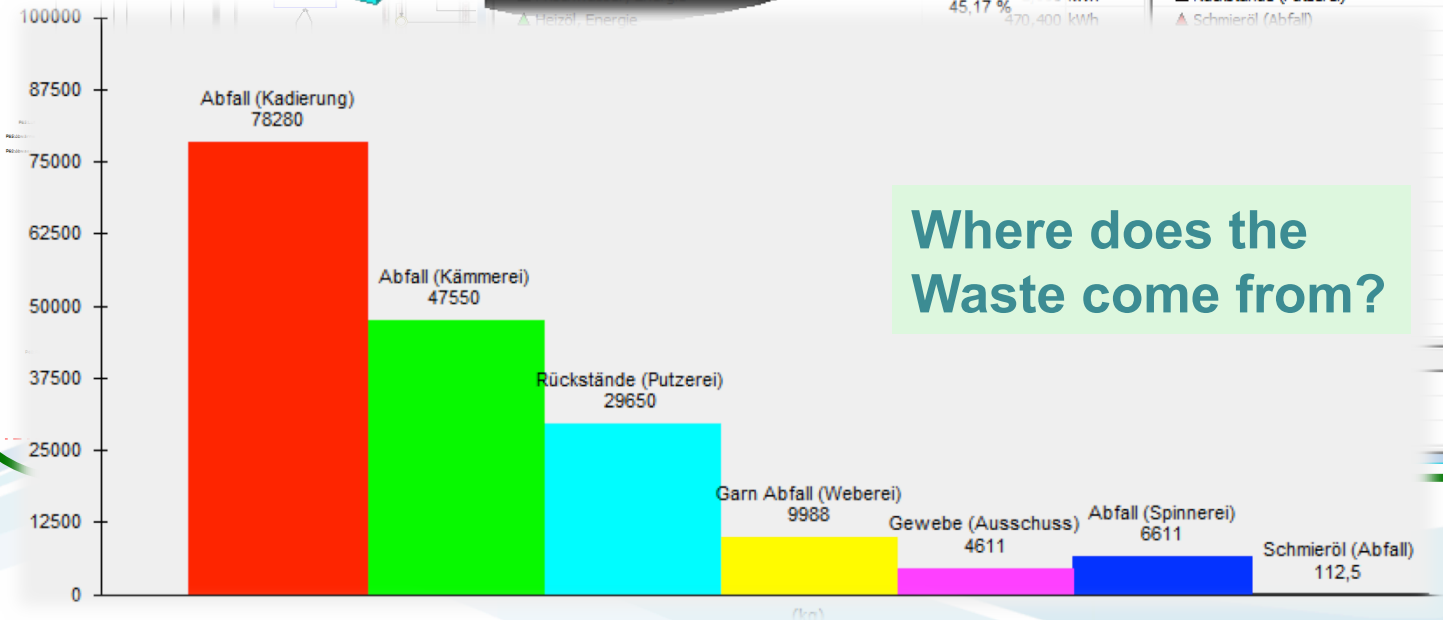


Where is the Energy used?

Item	Quantity	Unit
01 Vor- Zwischen- und Endprodukte		
Garn (Baumwolle, effekt)	103,400	kg
Garn (Baumwolle, einfach)	30,680	kg
Garn (synt. + msch., effekt)	9,468	kg
Garn (synt.+ msch., einfach)	20,650	kg
Gewebe	456,500	kg
Zwirn (Baumwolle)	24,960	kg
Zwirn (synt. + msch.)	19,590	kg
06 Abfälle		
Abfall (Kadierung)	78,280	kg
Abfall (Kämmerei)	47,550	kg
Abfall (Spinnerei)	6,611	kg
Garn Abfall (Weberei)	9,988	kg
Gewebe (Ausschuss)	4,611	kg
Rückstände (Putzerei)	29,650	kg
	112.5	kg
	4,208,000	kWh
	1.244E9	m3
	0.02526	kg
	9.747E-6	kg
	0.1001	kg
	0.001263	kg
	2.12	kg
	0.4269	kg
	130,000	kg

Quantity	Unit
1.515E10	kJ
3,420,000	kg
1.244E9	m3

Where does the Waste come from?



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Product analysis including costs

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- Product-specific analysis using Umberto LCI&Costs calculation
- Example: combed&twisted yarn vs. simple yarn

Input/Output | Stocks | LCIs | Variable Costs | Fixed Costs | Selected Elements | Parameters | Information

Zwirn (gek.) (Output, A130)

Input:

Item	Quantity	Unit
03 Energie	5,023	kWh
04 Rohmaterialien		
Baumwolle	1,376	kg
Frischluft	1,319,000	m3
Grundwasser	2.152	m³
Stadtwasser	0.1709	m³
Synthetik	2.874	kg

Output:

Item
01 Vor- Zwischen- und Endprodukte
Zwirn (gek.)
06 Abfälle
07 Emissionen
Energie
Luft (L)
Wasser

Input/Output | Stocks | LCIs | Variable Costs | Fixed Costs | Selected Elements | Parameters | Information

Garn (einfach, card.) (Output, A130)

Input:

Item	Quantity	Unit
03 Energie	3,112	kWh
04 Rohmaterialien		
Baumwolle	1,181	kg
Frischluft	1,185,000	m3
Grundwasser	1.955	m³
Stadtwasser	0.1709	m³
Synthetik	2.874	kg

Output:

Item
01 Vor- Zwischen- und Endprodukte
Garn (einfach, card.)
06 Abfälle
07 Emissionen
Energie
Luft (L)
Wasser

Sum	Quantity	Unit
kJ	11,200,000	kJ
kg	3,310	kg

Sum
kJ
kg

Input/Output | Stocks | LCIs | Variable Costs | Fixe

Zwirn (gek.) (Output, A130) 1 t

Variable Costs:

Item	Proportional Costs	Unit
03 Energie	499.6	€
04 Rohmaterialien	1,635	€
06 Abfälle	-154.1	€
07 Emissionen	11.61	€

Sum	Proportional Costs	Unit
Revenues	0	€
Variable Costs	-1,992	€

Input/Output | Stocks | LCIs | Variable Costs | Fixe

Garn (einfach, card.) (Outpu 1 t

Variable Costs:

Item	Proportional Costs	Unit
03 Energie	308.7	€
04 Rohmaterialien	1,404	€
06 Abfälle	-17.64	€
07 Emissionen	10.63	€

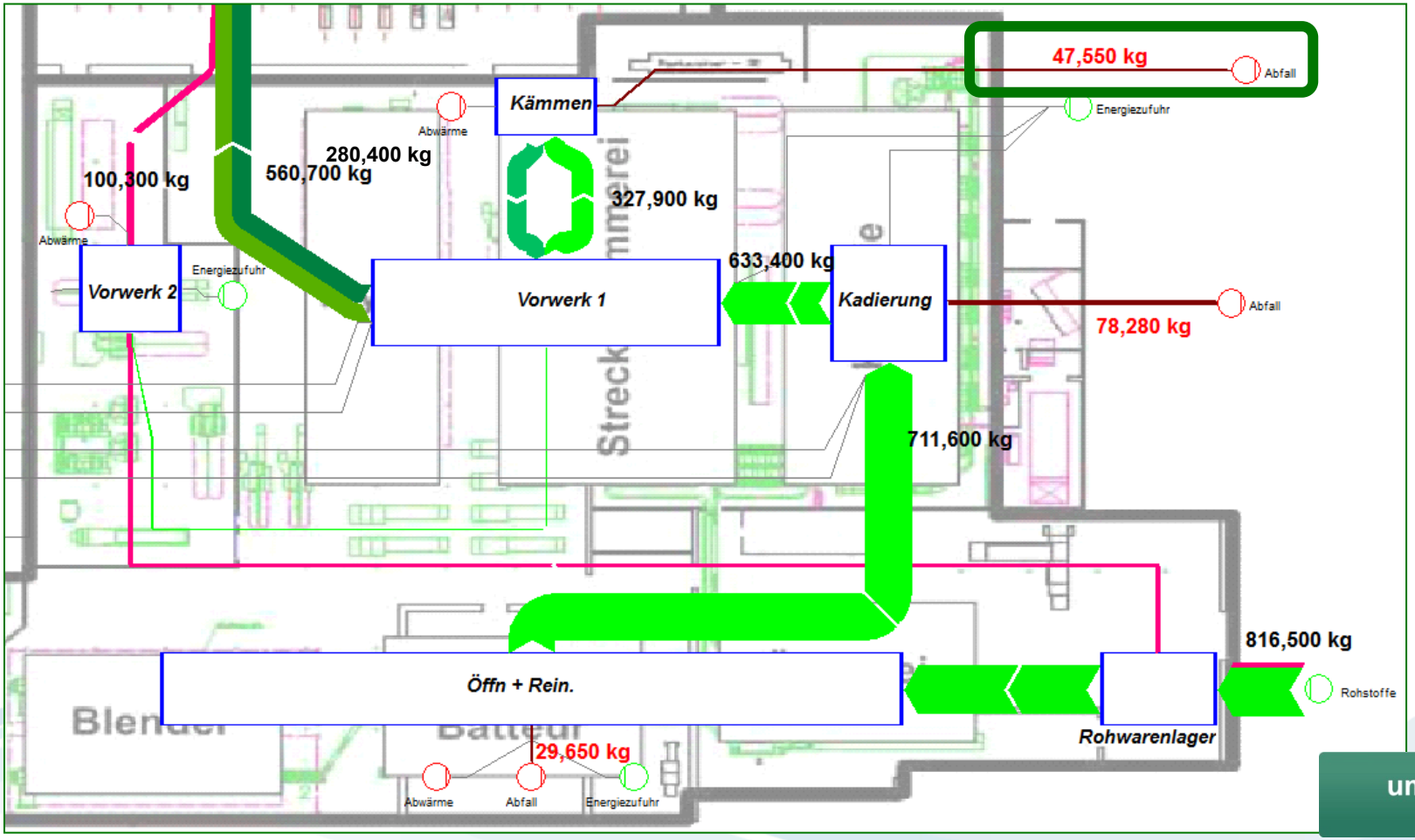
Sum	Proportional Costs	Unit
Revenues	0	€
Variable Costs	-1,705	€
Marginal Income	-1,705	€

Create transparency first!

Let‘s go to the improvements...

Analysis – MFCA

- Material Flow Cost Accounting (MFCA) according to ISO 14051
- Goal: Identification of all waste-related cost → inefficiency costs
- Example: Combing process (combed yarn waste can be sold)



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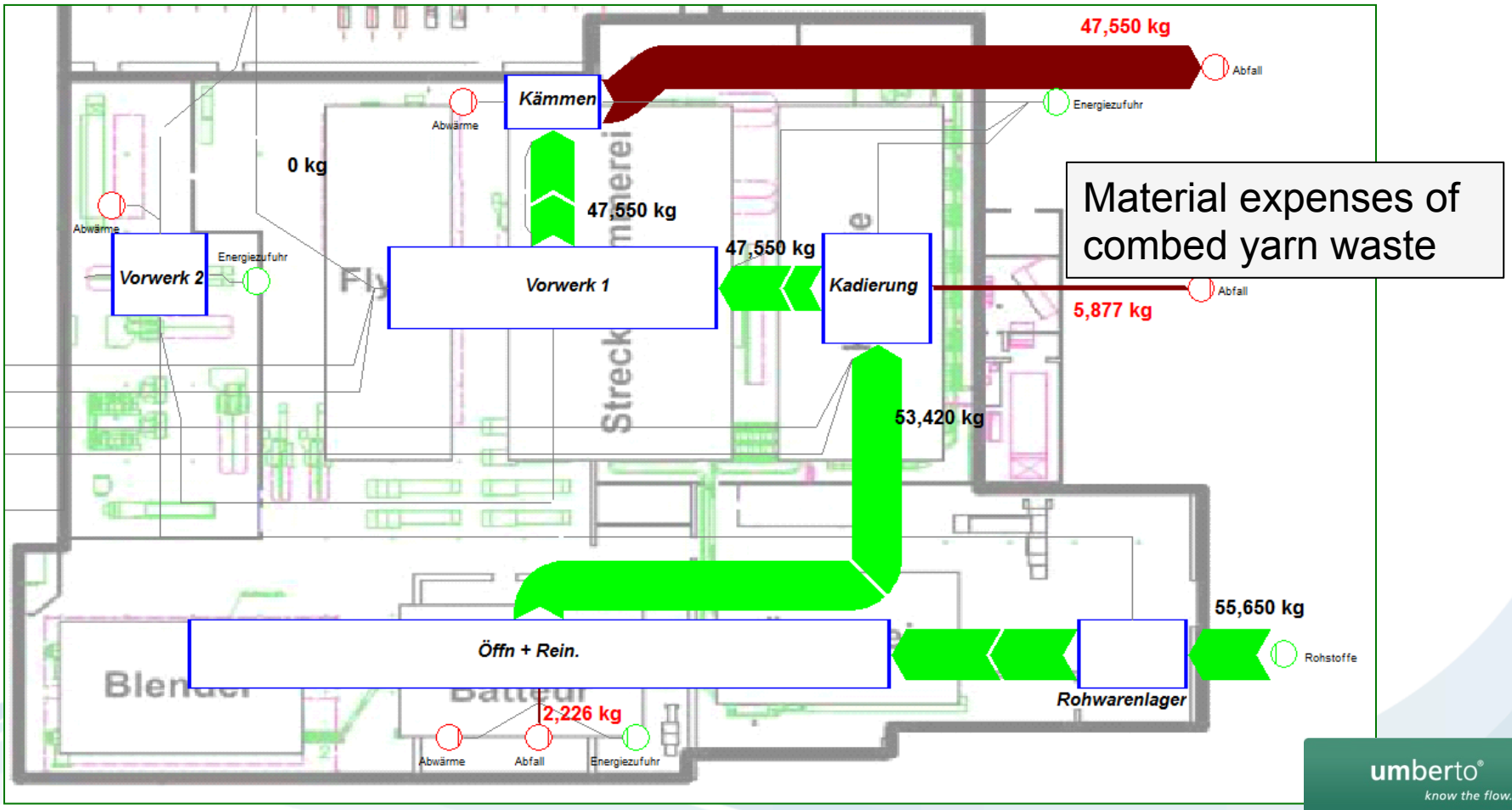

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Analysis – MFCA

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- Material Flow Cost Accounting (MFCA) according to ISO 14051
- Identification of all waste-related cost → inefficiency costs
- Example: Combing process (combed yarn waste can be sold)

Abfall (Kämmerei) (Output, A140)	1 t

Variable Costs:

Item	Proportional Costs	Unit
03 Energie		
Energie, el. (Heizung)	0.1	€
Energie, el. (Kälte)	2.0	€
Energie, el. (Licht etc.)	5.0	€
Energie, el. (Luftumwälzung)	21.2	€
Energie, el. (Maschinen)	56.8	€
04 Rohmaterialien		
Baumwolle	1,385.3	€
06 Abfälle		
Abfall (Kadierung)	-12.4	€
Rückstände (Putzerei)	-4.7	€
07 Emissionen		
Wasser		
Abwasser	1.8	€

Sum	Proportional Costs	Unit
Revenues	800.0	€
Variable Costs	-1,455.1	€
Marginal Income	-655.1	€

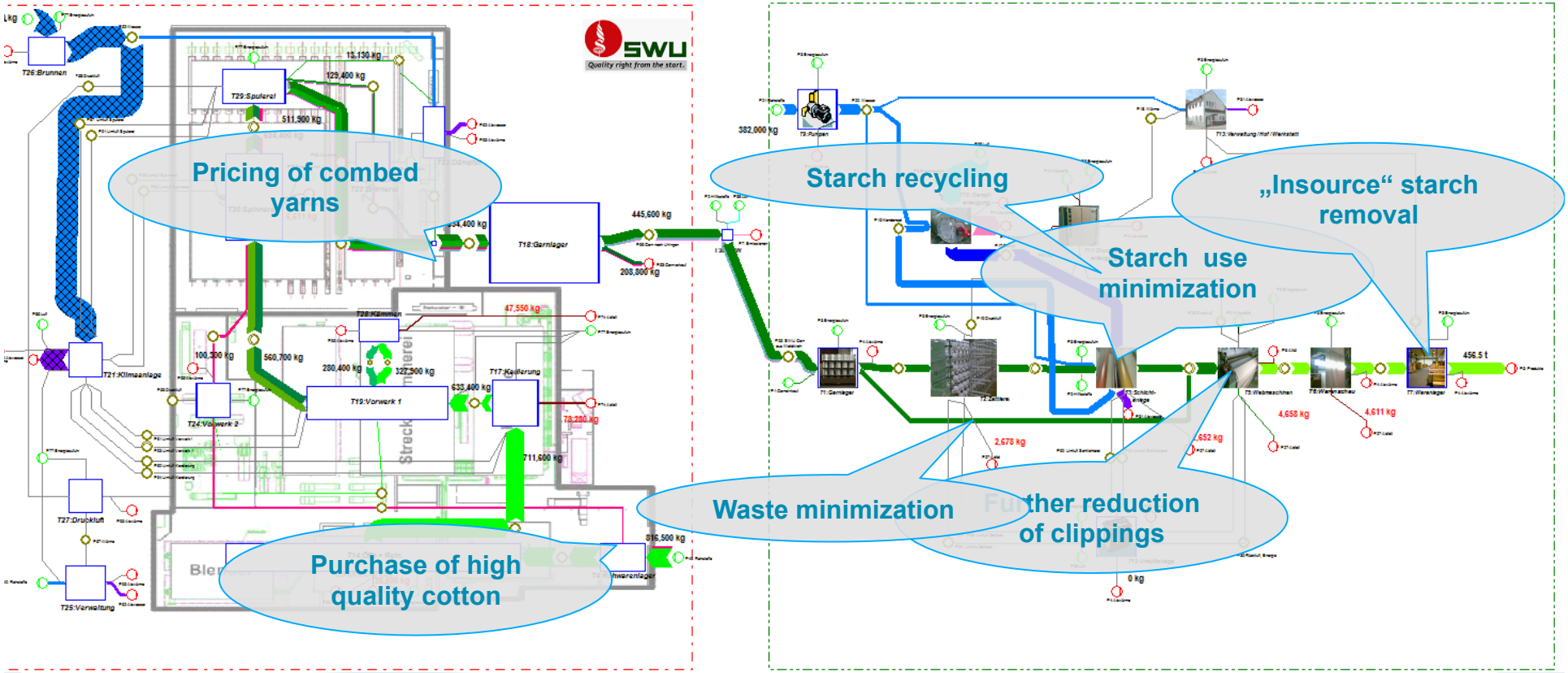
Abfall (Kämmerei) (Output, A140)	47.5 t

Variable Costs:

Item	Proportional Costs	Unit
03 Energie		
Energie, el. (Heizung)	6.0	€
Energie, el. (Kälte)	97.0	€
Energie, el. (Licht etc.)	235.4	€
Energie, el. (Luftumwälzung)	1,007.6	€
Energie, el. (Maschinen)	2,700.1	€
04 Rohmaterialien		
Baumwolle	65,865.8	€
06 Abfälle		
Abfall (Kadierung)	-587.7	€
Rückstände (Putzerei)	-222.6	€
07 Emissionen		
Wasser		
Abwasser	83.7	€

Sum	Proportional Costs	Unit
Revenues	38,038.0	€
Variable Costs	-69,185.4	€
Marginal Income	-31,147.4	€

Search for improvements



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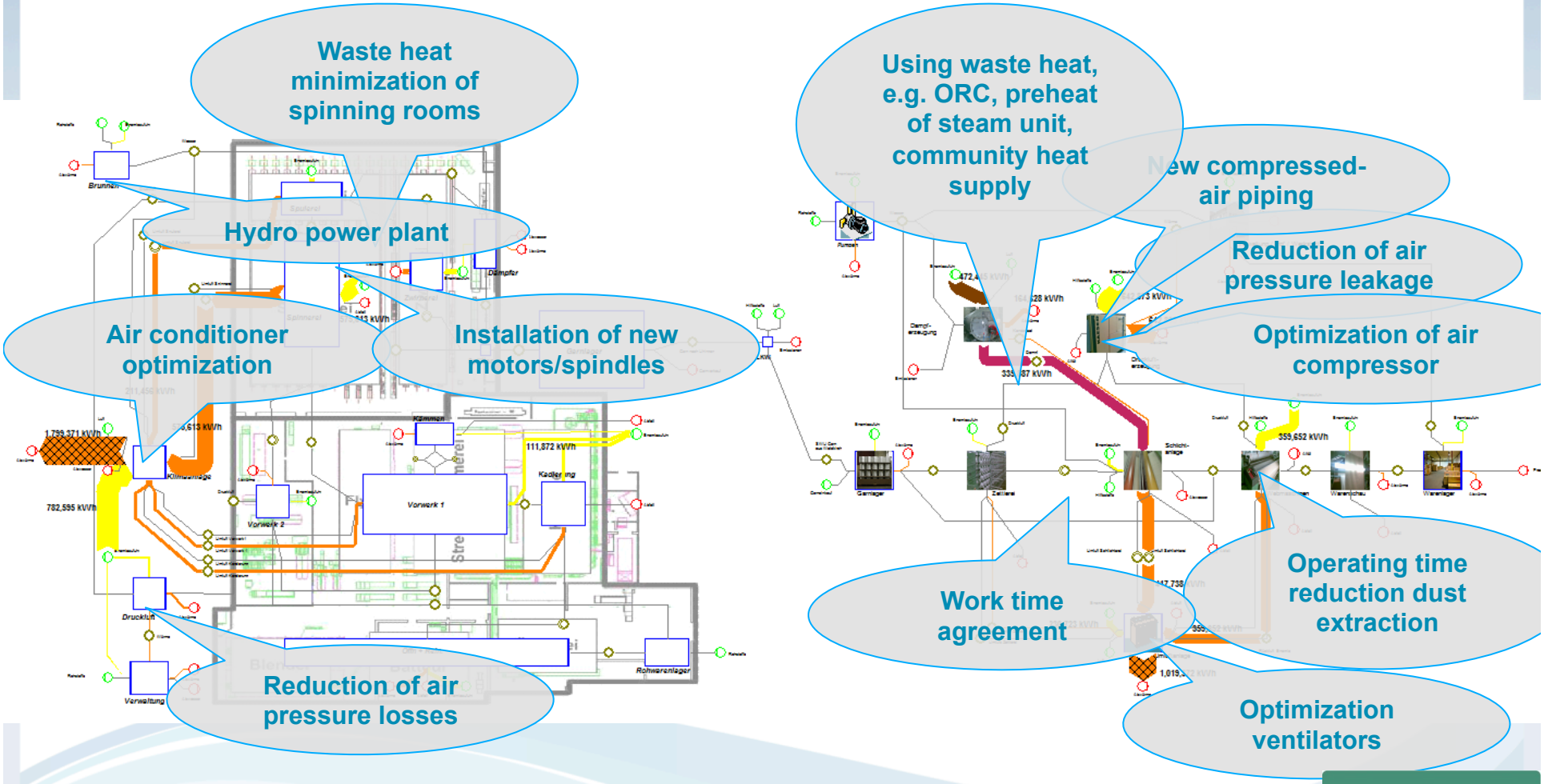
Search for improvements



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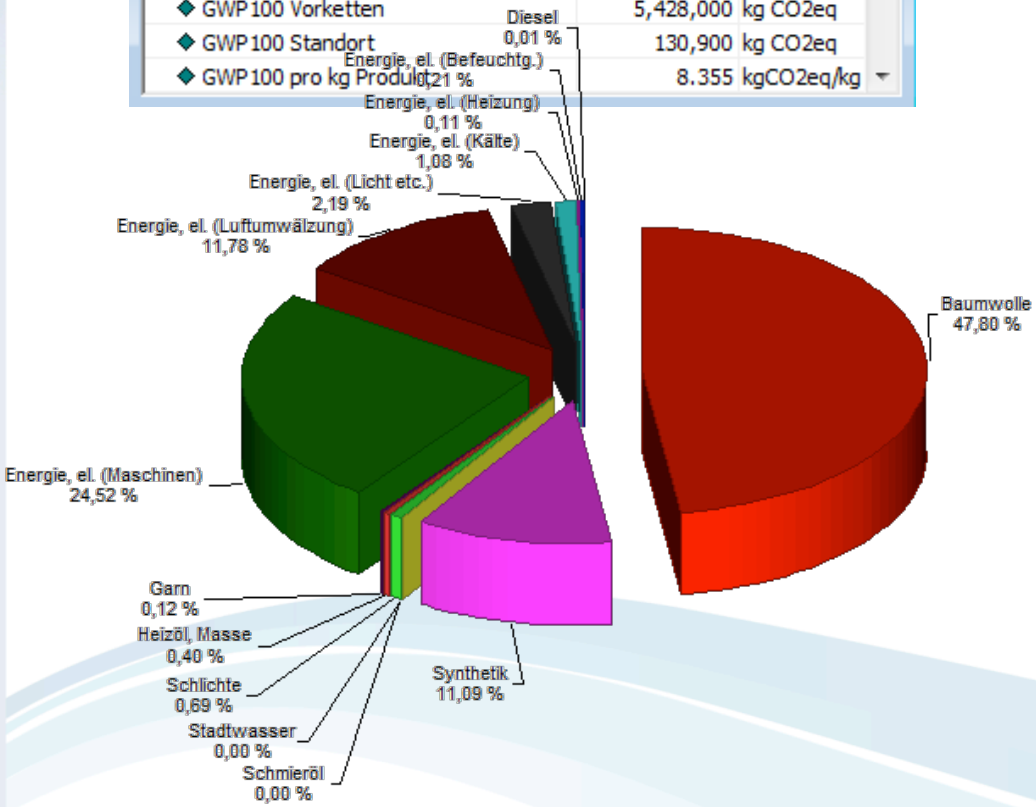
Ecological assessment

Corporate Carbon Footprint

Valuation System Results (Preview, Input/Outp...

Valuations

Item	Quantity	Unit
Überblick GWP		
GWP100 Vorketten	5,428,000	kg CO2eq
GWP100 Standort	130,900	kg CO2eq
GWP100 pro kg Produkt	8.355	kgCO2eq/kg

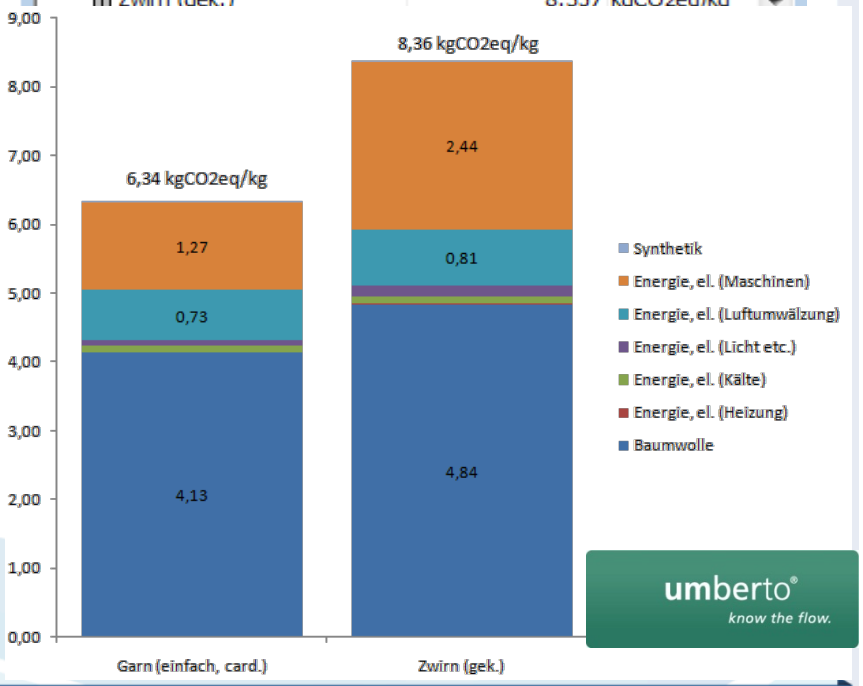


Product Carbon Footprint

Valuation System Results (Multi, LCI, Global W...

Valuations

Item	Quantity	Unit
Überblick GWP		
GWP100 Vorketten		
Garn (einfach, card.)	634,800	kg CO2eq
Zwirn (gek.)	340,600	kg CO2eq
GWP100 Standort		
Garn (einfach, card.)	0	kg CO2eq
Zwirn (gek.)	0	kg CO2eq
GWP100 pro kg Produkt		
Garn (einfach, card.)	6.335	kgCO2eq/kg
Zwirn (gek.)	8.357	kgCO2eq/kg



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Economic assessment

- Investment appraisal for resource efficiency measures
- considering all relevant material and energy flow related costs
- and interaction with other parts of the production system

Waldkirch

- Installation of efficient spindles and motors in spinning machines
- Past assessment → Don't invest (long amortization time)
- New assessment → Invest (acceptable amortization time when considering interaction, i.e. reduced energy demand of air conditioning)

SWU
Quality right from the start.

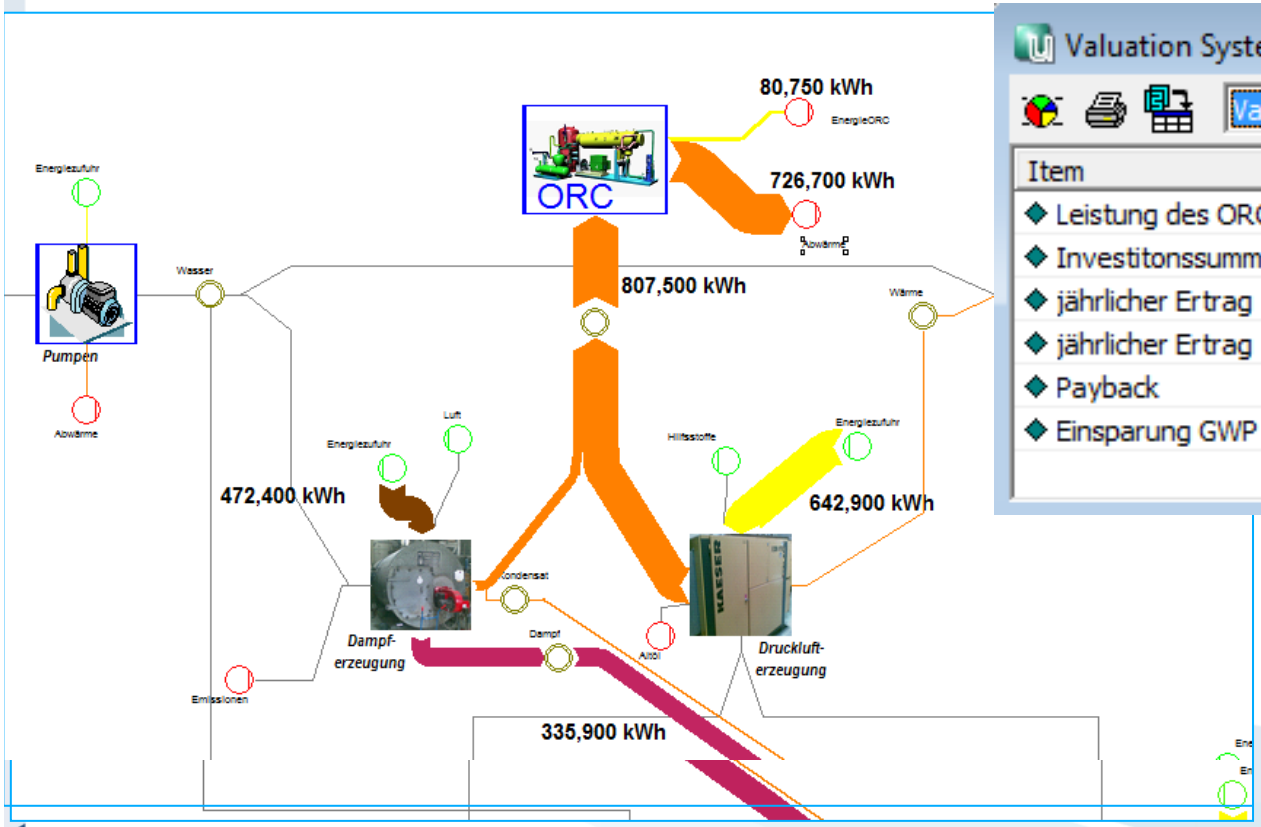
Economic Assessment

- Investment appraisal for resource efficiency measures
- considering all relevant material and energy flow related costs
- and interaction with other parts of the production system

SWU
Quality right from the start.

Uhingen

- Electricity generation from waste heat (Organic Rankine Cycle)



Valuation System Results (Preview, Inp...

Valuations

Item	Quantity	Unit
Leistung des ORC	43.17	kWel
Investitonssumme	86,340	€
jährlicher Ertrag	323,000	kWh
jährlicher Ertrag	32,300	€
Payback	2.673	Jahre
Einsparung GWP	56,520	kg CO2-eq.

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Ressource efficiency - implementation

Waldkirch

- installation of several continuous energy metering devices
- pilot study: installation of more efficient motors and spindles (successful)
- ongoing: detailed waste analysis
- ongoing: small hydro power plant (authorization process)
- ongoing: optimization of air conditioning/ventilation system

SWU
Quality right from the start.

Ressource efficiency - implementation

Uhingen

- ✓ Switch off one ventilation unit
- ✓ Operation time reduction for dust extracticon fans
- ✓ Peak control unit (peak load -10%)
- ✓ More efficient lighting
- ✓ Starch recycling
- ✓ Improved compressed-ai
- ✓ Modified working time ag

60’000-70’000 €/a savings

Spinnweberei Uhingen GmbH
73066 Uhingen
Ulmer Straße 27

24.03.2011
Seite: 1

zwischen

der Spinnweberei Uhingen GmbH

und

dem Betriebsrat der Spinnweberei Uhingen GmbH - Werk Uhingen

über den Lage der ersten Schicht einer Arbeitswoche

vom 24.03.2011

Lessons learned: Challenges

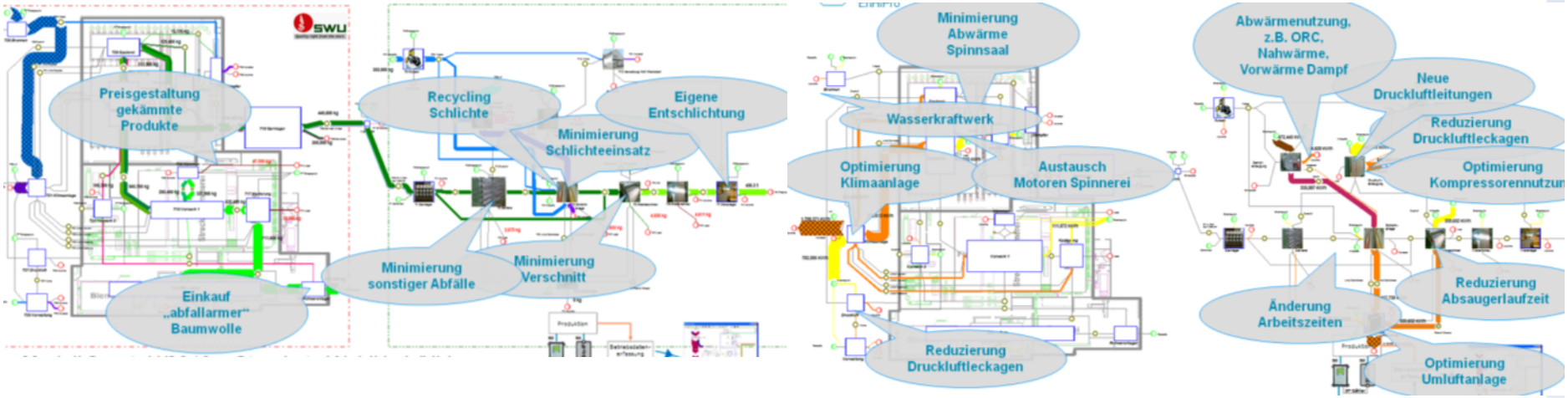
- Modeling lags behind project progress → reasons: many project partner activities, ifu (not SWU) in charge of modeling, simple efficiency improvements are quickly assessed on paper, not in Umberto
- Difficult data exchange with production planning software
- Additional ecological information is nice to have, but not yet really demanded by customers
- “Waste in – waste out” (data quality)
- Umberto modeling is an expert task…

Lessons learned: Benefits

- …understanding Umberto results is NOT an expert task
- Sankey visualization leads to new ideas and new questions
- Sankey visualization and input/output balances helped to simplify and speed up TÜV and authority audits
- Umberto results countercheck SWU's performance indicators
- Holistic view of resource efficiency issues allows priority setting
- Integration: Ecological, technical, and economic dimension
- Integration: Product, single process and whole production system
- Integration: Life cycle and company borders

Conclusions

A systematic and integrative measurement, visualization, and analysis of material and energy flows and costs …

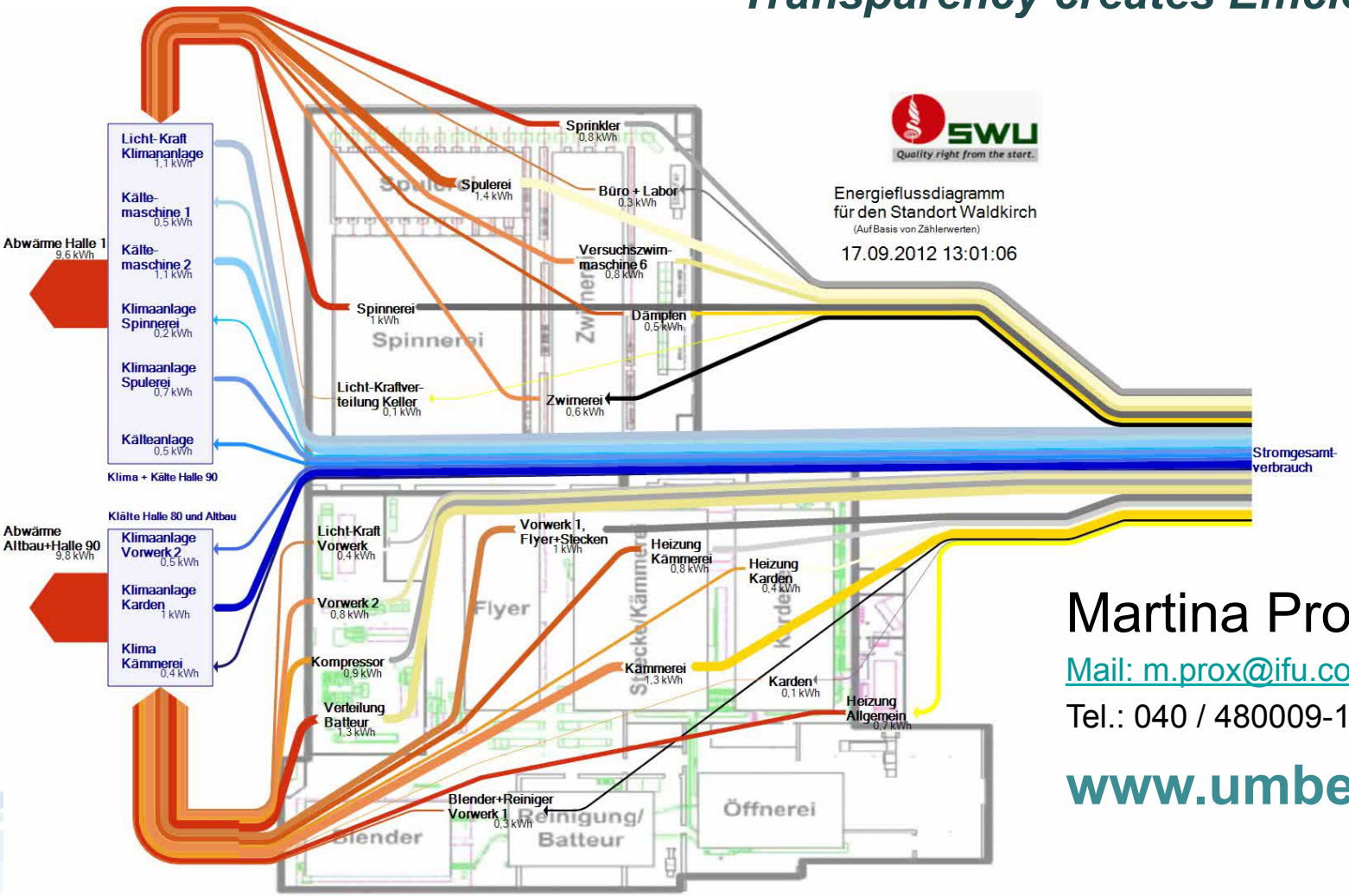


…leads to improvements and new ideas even in (smaller) companies which have been facing resource competition for many years.

This way, resource efficiency becomes a clear competitive advantage.

Creating a culture of Efficiency with Visualization…

Transparency creates Efficiency!



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