

**EXPERT SYSTEM FOR AN INTELLIGENT  
SUPPLY OF THERMAL ENERGY IN INDUSTRY**

# EINSTEIN

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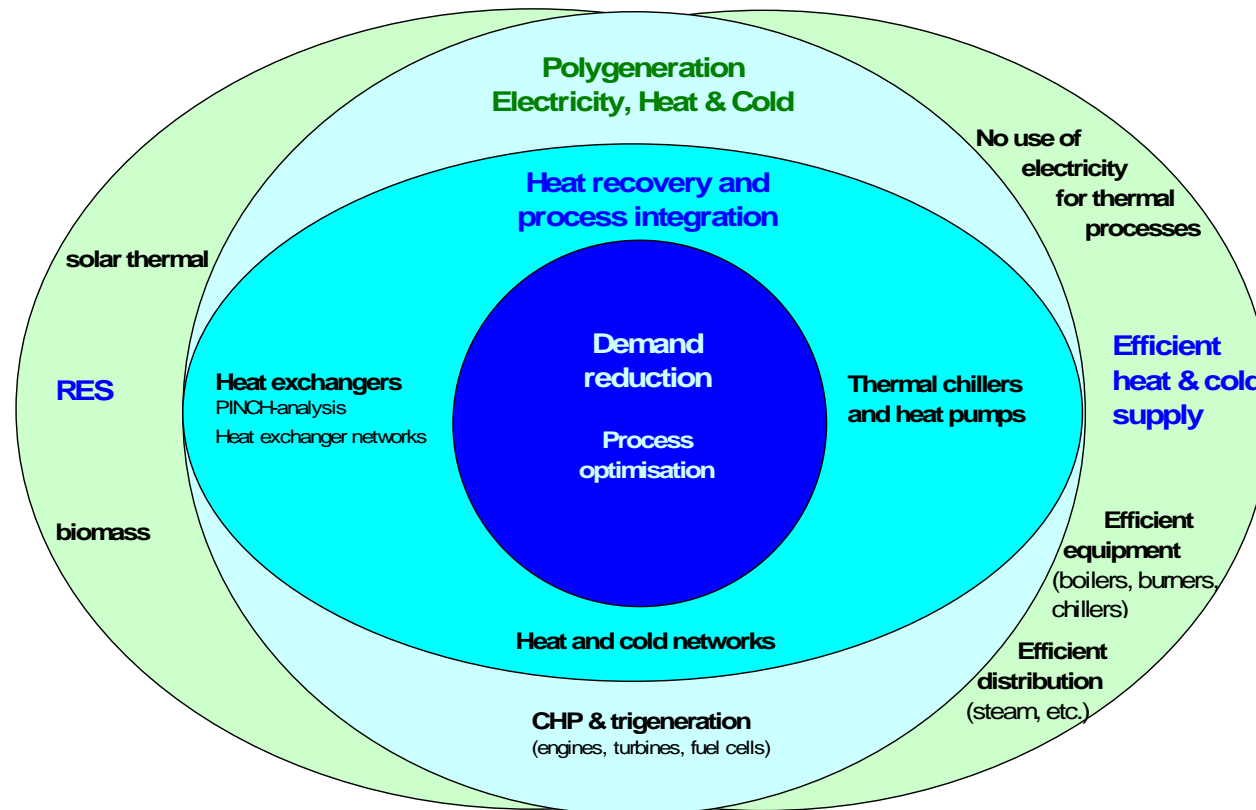
Christoph Brunner, Bettina Slawitsch, Joanneum Research (Graz, Austria)

# Einstein's approach

An integral approach to energy efficiency

✓ **Holistic view...**

...through the EYE of Einstein



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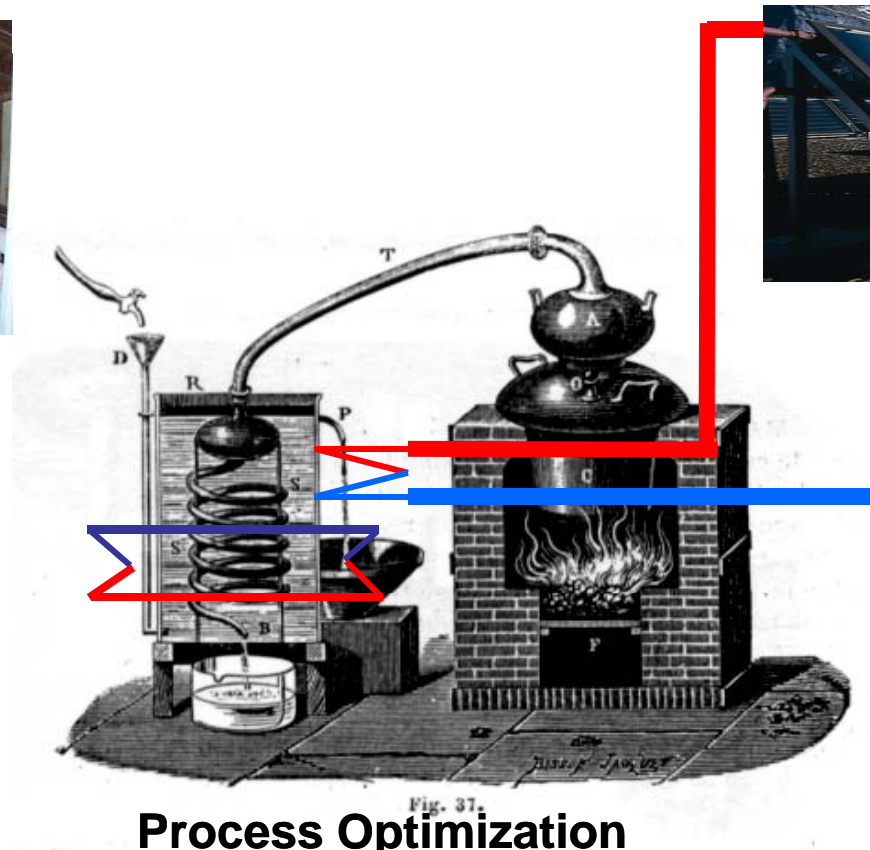
# As an example: a well-known industrial process

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Cooling



Process Optimization

Heat recovery and heat integration

Supply system optimization



Renewable energy



Heating



## Complexity of analysis of heat demand

- ✓ Distribution of demand among different processes with:
  - Different temperature levels
  - Different time schedules
- ✓ Lack of data

## Quantity and **QUALITY** have to be known

- ✓ Analysis by temperature levels of demand is crucial for optimization
  - Supply vs. process temperature
  - Different components of process heat demand

# EINSTEIN proposes...



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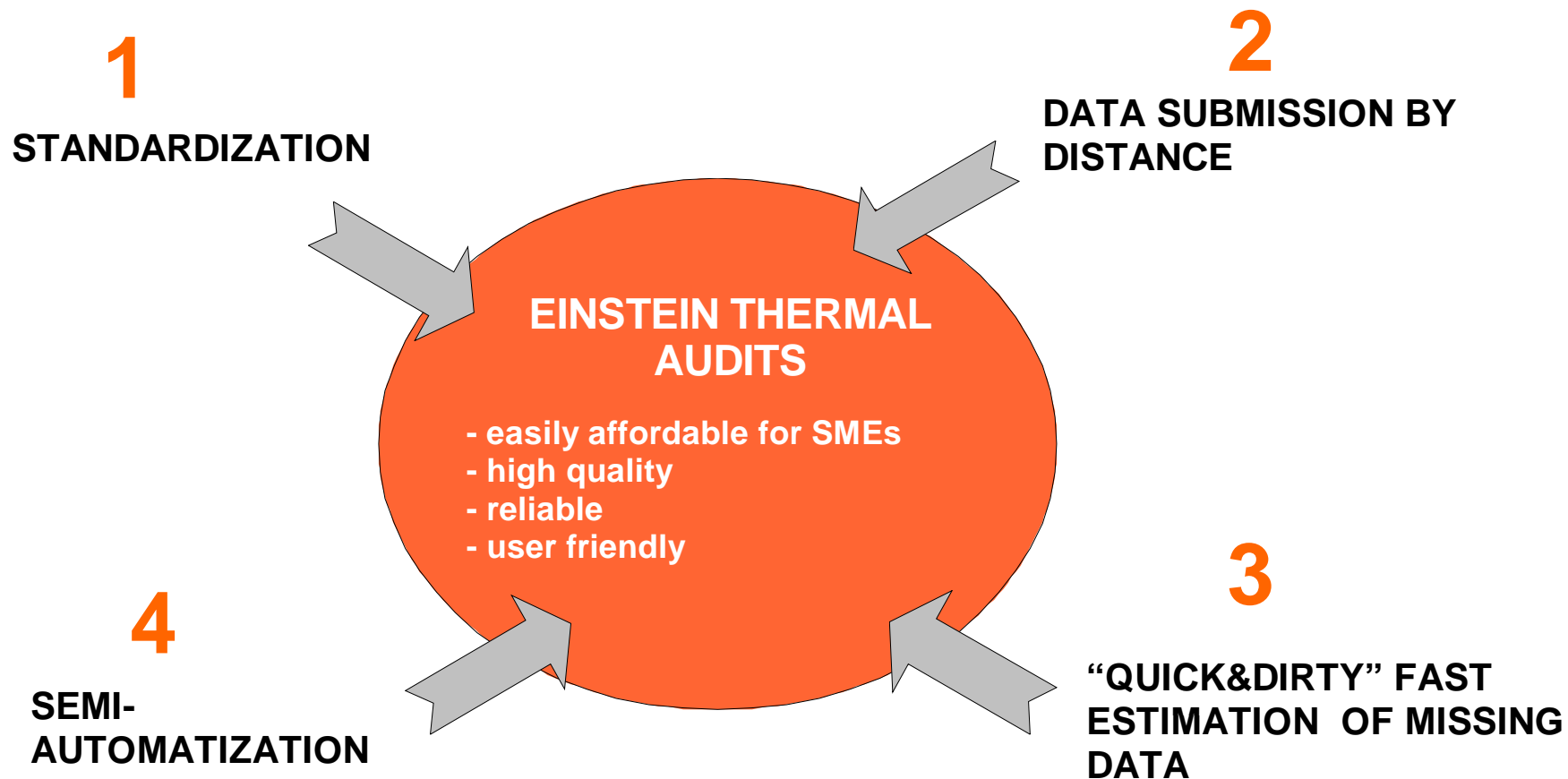
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## EINSTEIN COMPREHENSIVE LOW COST THERMAL AUDITS

- easily affordable for SMEs
- high quality
- reliable
- user friendly

# How to reach the GOAL?

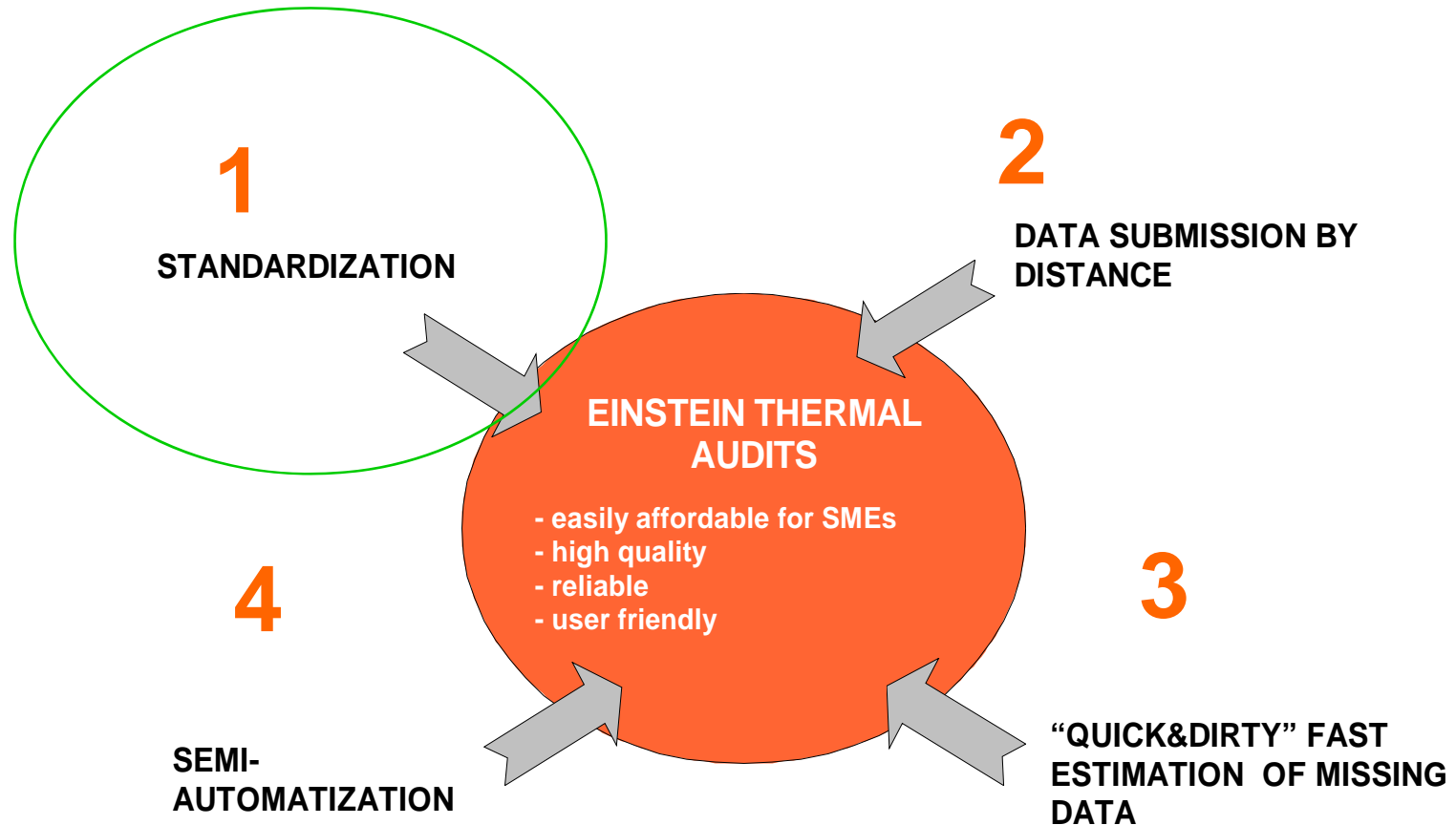
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# 1. Standardization

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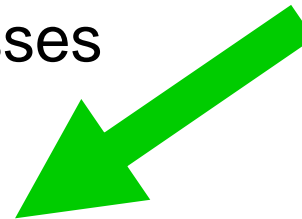
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# 1. Standardization

→ **Standardization** shortens the auditing time and improves the reliability of the results

- ✓ Standard thermal energy **audit methodology**
- ✓ Standard **accountancy** system
  - Modelling the overall energy system
  - Modelling the processes
- ✓ **Software** tool



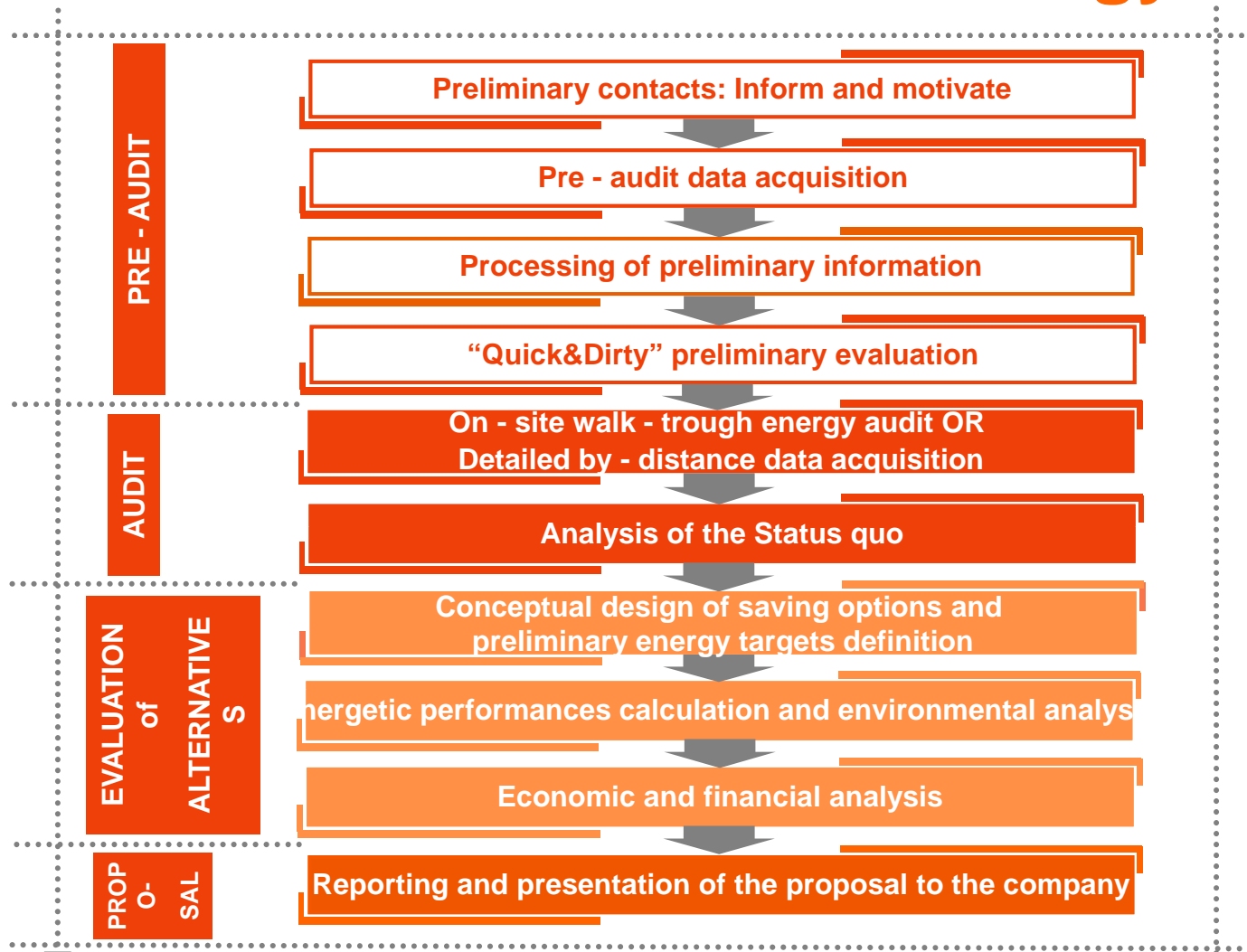


# 1.1 Standardization

## EINSTEIN's audit methodology

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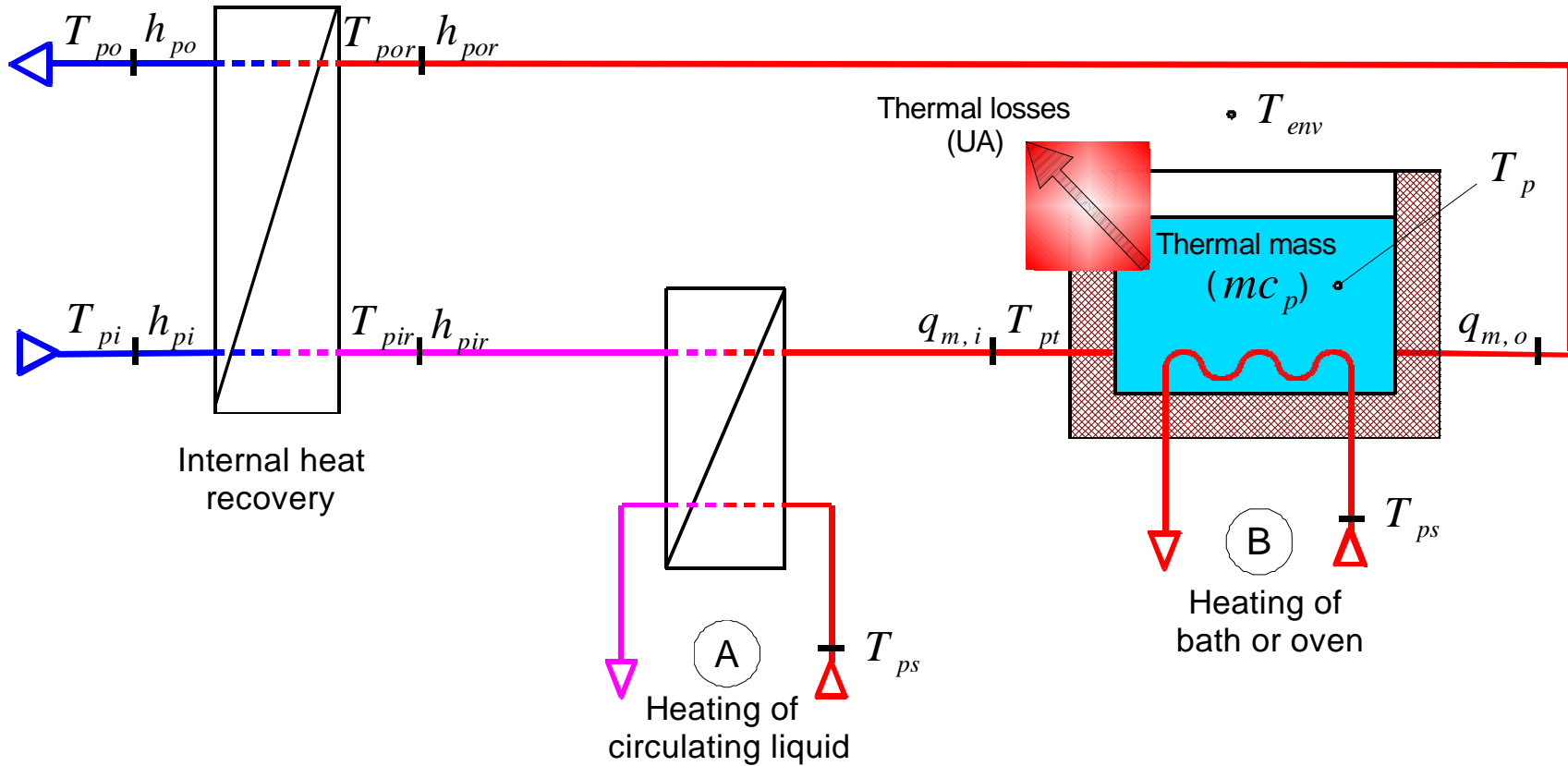
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# Process model

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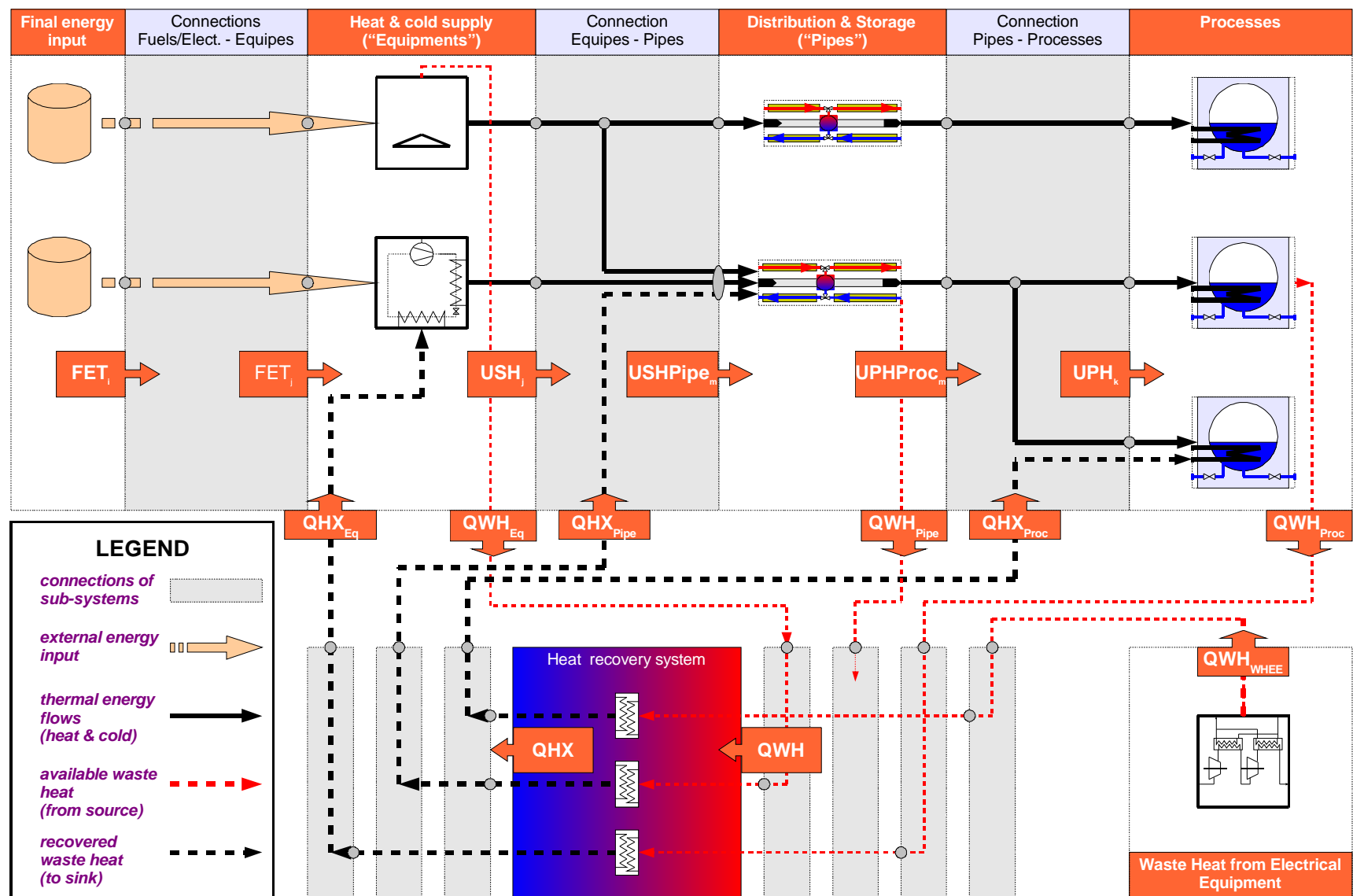
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# EINSTEIN accountancy scheme

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# 1.2 Standardization

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## Software tool

<http://sourceforge.net/projects/einstein>

The screenshot displays two windows of the EINSTEIN software. The top window, titled 'EINSTEIN - 2008-9-2 17:52.2 Processes (createAggregatedProcess)', shows a table of process heat demand and a pie chart titled 'LPH by process'. The bottom window, titled 'EINSTEIN - 2008-4-4 16:36:24 EINSTEIN now updating annual energy balance', shows a table of environmental impact metrics and a bar chart titled 'Relative comparison'.

Process	100% Heat (kWh)	Share (%)	Condition (kWh)	Makeup (kWh)	Start-Up (kWh)	Process (kWh)	Process Supply (kWh)
1 Production	4300.00	69.02	4300.00	0.00	0.00	71.94	140.00
2 Cogeneration (w/air)	630.00	10.11	379.00	252.00	0.00	39.96	140.00
3 Recovery spinning	1300.00	20.87	1300.00	0.00	0.00	69.95	140.00
4 Total	6230.00	100%					

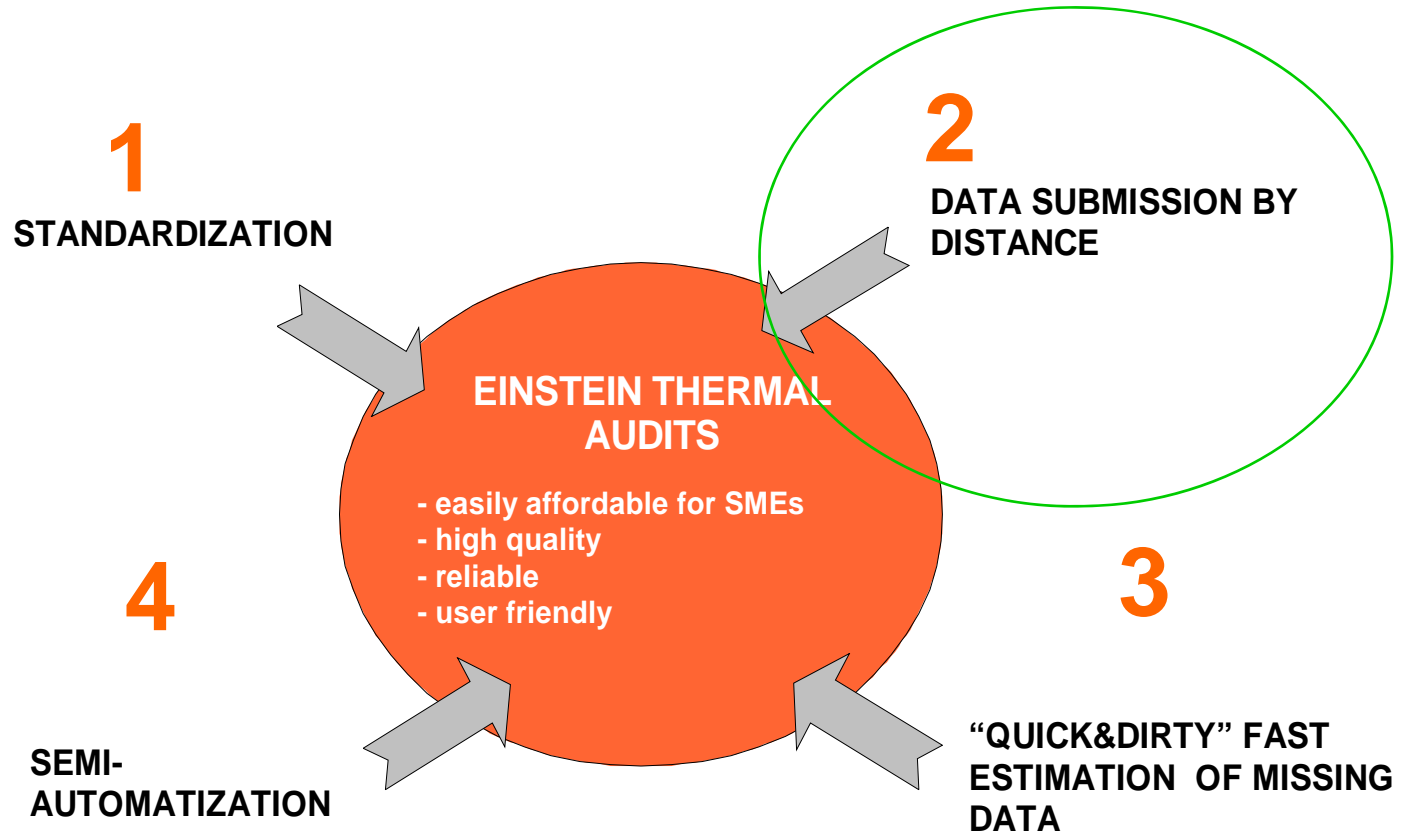
Alternative	Production of CO <sub>2</sub> (t)	Highly Reductive Nuclear Waste (kg)	Water Consumption (m <sup>3</sup> )
1 Heat recovery (HR)	2599.51	2.50	0.00
2 Heat recovery (SR)	2228.36	2.82	0.00
3 Heat pump	2401.26	5.50	0.00
4 Solar cascade	2539.31	2.50	0.00
5 EINSTEIN Super Mix	2353.48	5.41	0.00



# 2. Data acquisition

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# 2. Data acquisition

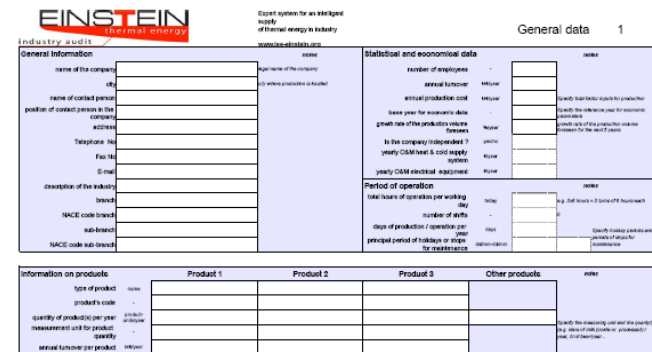
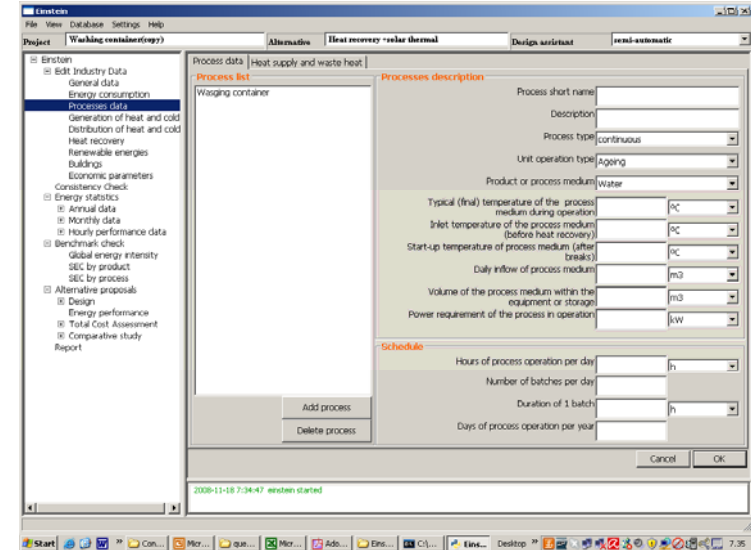
## Questionnaire for data acquisition

Available as:

- ✓ Electronic version as part of the tool
- ✓ Spreadsheet version
  - To be automatically imported/exported from the tool

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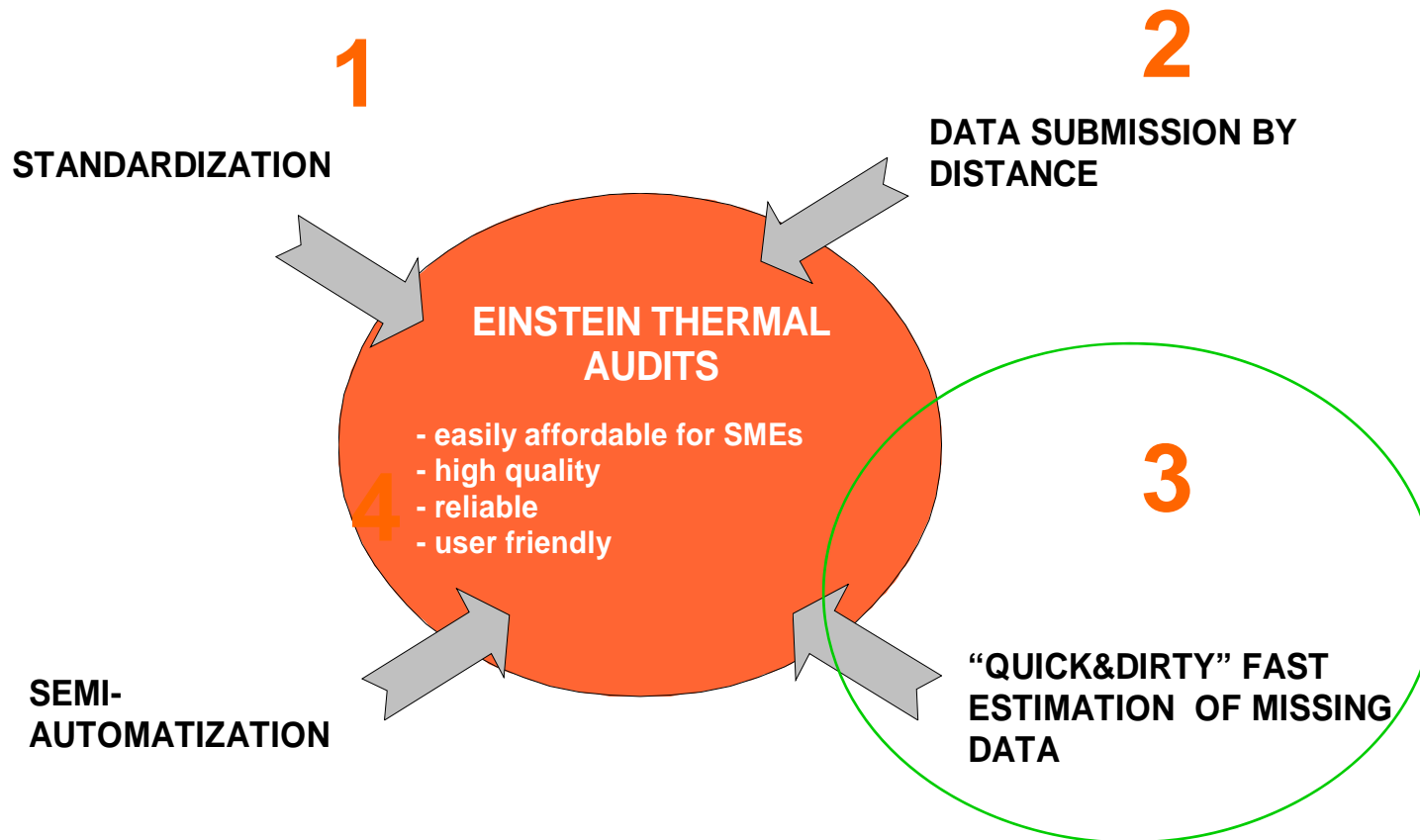
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# 3. Consistency check and estimation

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## 3. Consistency check and estimation

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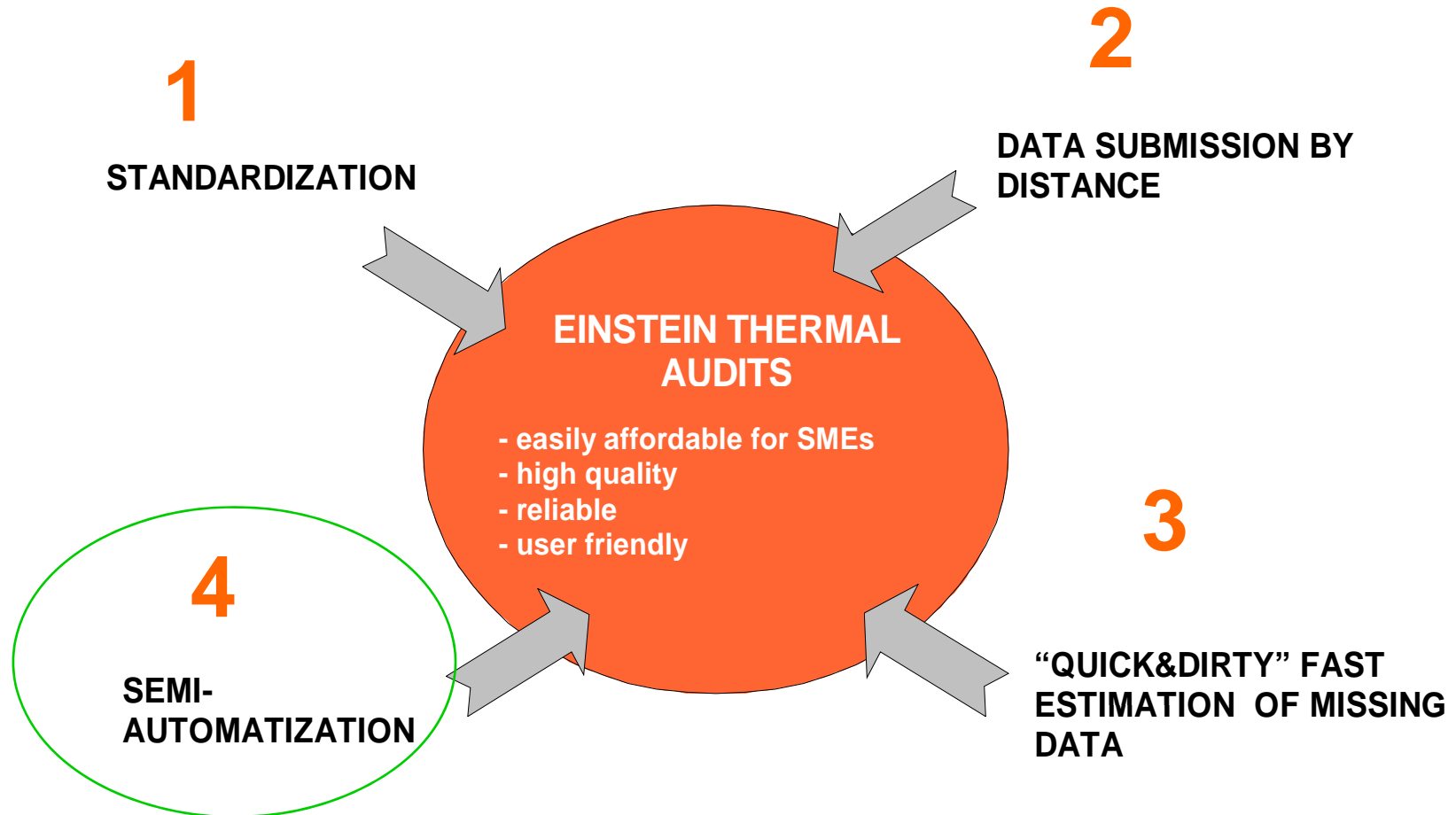
- ✓ EINSTEIN calculates the missing data on the base of mass and energy balances
- ✓ Einstein estimates figures on the base of typical values from engineering knowledge
- ✓ Einstein detects conflicts in case of data redundancy



# 4. Semi - automatization

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## 4. Semi - automatization

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### Einstein...

- ✓ Detects the potential for process optimisation and heat recovery (**Process Optimisation and Heat Recovery module**)
- ✓ Designs new alternatives (**Design Assistant in Heat and Cold Supply module**), ...
- ✓ ...combines and compares the alternatives (**Evaluation module**)
- ✓ Carries-out complex energy, environmental and economic calculations
- ✓ Writes a nice report ready to present (**Reporting module**)

# Design for alternative proposals

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- ✓ Process optimization module
- ✓ Heat exchanger network and Pinch Analysis module
- ✓ Heat and cold supply module
  - CHP
  - Heat pumps
  - Solar thermal
  - Boilers and burners



# Evaluation of proposals

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EINSTEIN calculates:

- ✓ Energy Performance (Dynamic system simulation of complex heat supply systems)
- ✓ Environmental analysis
- ✓ Economic performance and financial analysis
- ✓ Comparative study of different alternatives

# Automatic Report

## Breakdown of energy consumption by processes

Here the global energy consumption is reported, both in the present state and for the proposed alternative systems. The present state is compared with benchmarks in similar industries.

### 1 Description of the alternatives and global results

#### Process heat consumption

Process	Description	Process heat consumption		Process temperature
		MWh	% of Total	°C
Pasteurisation	Milk pasteurisation	8,63	54,00	72,00
Fermenter	Fermentation process	2,88	18,00	38,00
Mozzarella	Spinning of Mozzarella	4,48	28,00	75,00
<b>Total</b>		<b>15,99</b>	<b>100,0</b>	

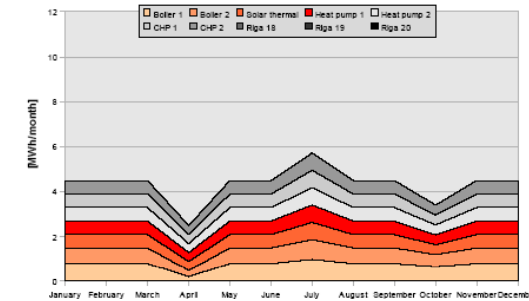
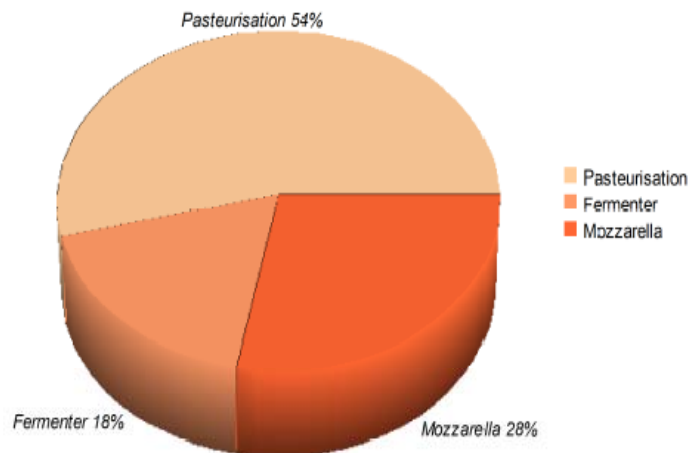


Figure 2.2.3 Distribution of the heat supply by months



Distribution of the process heat demand by processes

#### Washing Analisi Dettagliata TCA TEST

#### 2.2.2 Supply heat by temperature levels and annual operating hours

In the following the instantaneous demand for useful supply heat (USH) by temperature levels and annual operating hours is analysed. In Table 2.2.2 data of maximum power and yearly heat demand are given for base load (> 4000 h/a), medium load (> 2000 h/a) and peak load (< 2000 h).

Table 2.2.2 Supply heat by temperature levels and annual operating hours

Temperature levels	Base load		Medium load		Peak load	
	power (kW)	energy (MWh)	power (kW)	energy (MWh)	power (kW)	energy (MWh)
Total	0	0	840	2.191	840	0
< 80 C	0	0	720	1.878	720	0
< 120 C	0	0	840	2.191	840	0
< 250 C	0	0	840	2.191	840	0
< 400 C	0	0	840	2.191	840	0

# Structure and features of the software tool

# TOOL MODULES

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Project: EINSTEIN Guide 43 Base Case II | Alternative: New Proposal 1 | Design assistant: semi-automatic

**Solar collector**

Collector model	Collector type	c0	c1	c2	K(50°) (longitudinal)	K(50°) (transversal)
ETCEinstein	solar thermal (evacuated tubes)	0.760	1.200	0.008	0.940	1.100

Buttons: choose solar collector, run design assistant

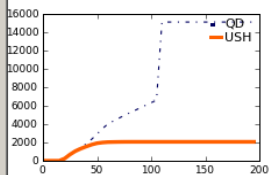
**Configuration of design assistant**

Target solar fraction [%]: 50.00  
Solar collector type: --any--  
Minimum annual energy yield [kWh/kW.a]: 300.00

**Lay-out of solar thermal system**

Installed capacity [kW]: 2075.50  
Efficiency of heat storage and distribution [-]: 0.90  
Solar buffer storage volume [m3]: 148.25

**Heat demand and solar contribution**



**System performance**

Gross surface area suitable for installation [m2]: 10000.00  
Maximum possible solar thermal capacity [kW]: 2283.40

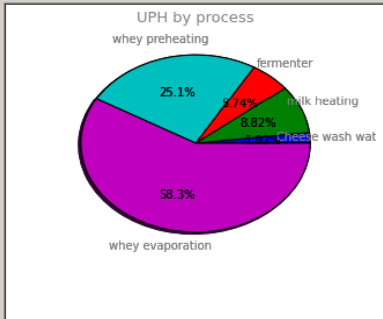
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Project: EINSTEIN Guide 43 Base Case II | Alternative: Present State (checked) | Design assistant: semi-automatic

**Useful heat demand by process (UPH)**

Process	UPH Total [MWh]	Share [%]	Circulation [MWh]	Maintenance [MWh]	Start-Up [MWh]	Process Temp. [°C]	Process Supply Temp. [°C]
1 Cheese wash water	299.58	1.92	299.58	0.00	0.00	65.00	120.00
2 milk heating	1376.53	8.83	1376.56	0.00	0.00	32.00	120.00
3 fermenter	896.23	5.75	688.26	208.00	0.00	45.00	120.00
4 whey preheating	3921.65	25.16	3921.74	0.00	0.00	80.00	120.00
5 whey evaporation	9095.70	58.34	1089.37	8007.19	0.00	100.00	120.00
6 Total	15589.70	100.00					

**Distribution of process heat demand (UPH Total) by processes**



2009-2-17 7:38:22: EINSTEIN now updating annual energy balances

**Einstein**  
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Project: EINSTEIN Dairy Industry (Steam) Alter

- Edit Industry Data
- Consistency Check
- Energy statistics
- Benchmark check
- Alternative proposals
  - Design
    - Process optimisation
    - Pinch analysis
    - HX network
  - H&C Supply
    - H&C Storage
    - CHP
    - Solar Thermal
    - Heat Pumps
    - Biomass
    - Chillers
    - Boilers & burners
    - H&C Distribution
- Energy performance
  - Economic analysis
  - Comparative study
- Report

# EINSTEIN Tool-kit

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- ✓ Copy-left: EINSTEIN<sup>©</sup> is a *free and open source software* project under [GPL license](#):
  - [www.sourceforge.net/projects/einstein](http://www.sourceforge.net/projects/einstein)
- ✓ EINSTEIN uses open source components
  - *Python*: main programming language
  - *MySQL*: data base server
- ✓ EINSTEIN is platform independent
  - It can run on Linux, Unix, Windows, etc.
  
- ✓ The software and the EINSTEIN audit guide are available from the project web:

[www.iee-einstein.org](http://www.iee-einstein.org)



# Thanks a lot to everybody ...

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## EINSTEIN

[www.iee-einstein.org](http://www.iee-einstein.org)

[www.sourceforge.net/projects/einstein](http://www.sourceforge.net/projects/einstein)

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