

# EINSTEIN

EXPERT SYSTEM FOR AN INTELLIGENT SUPPLY OF THERMAL  
ENERGY IN INDUSTRY

Audit Methodology and Tool-Kit

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energyXperts.NET

# Einstein's approach

An integral approach to energy efficiency

# Einstein's approach

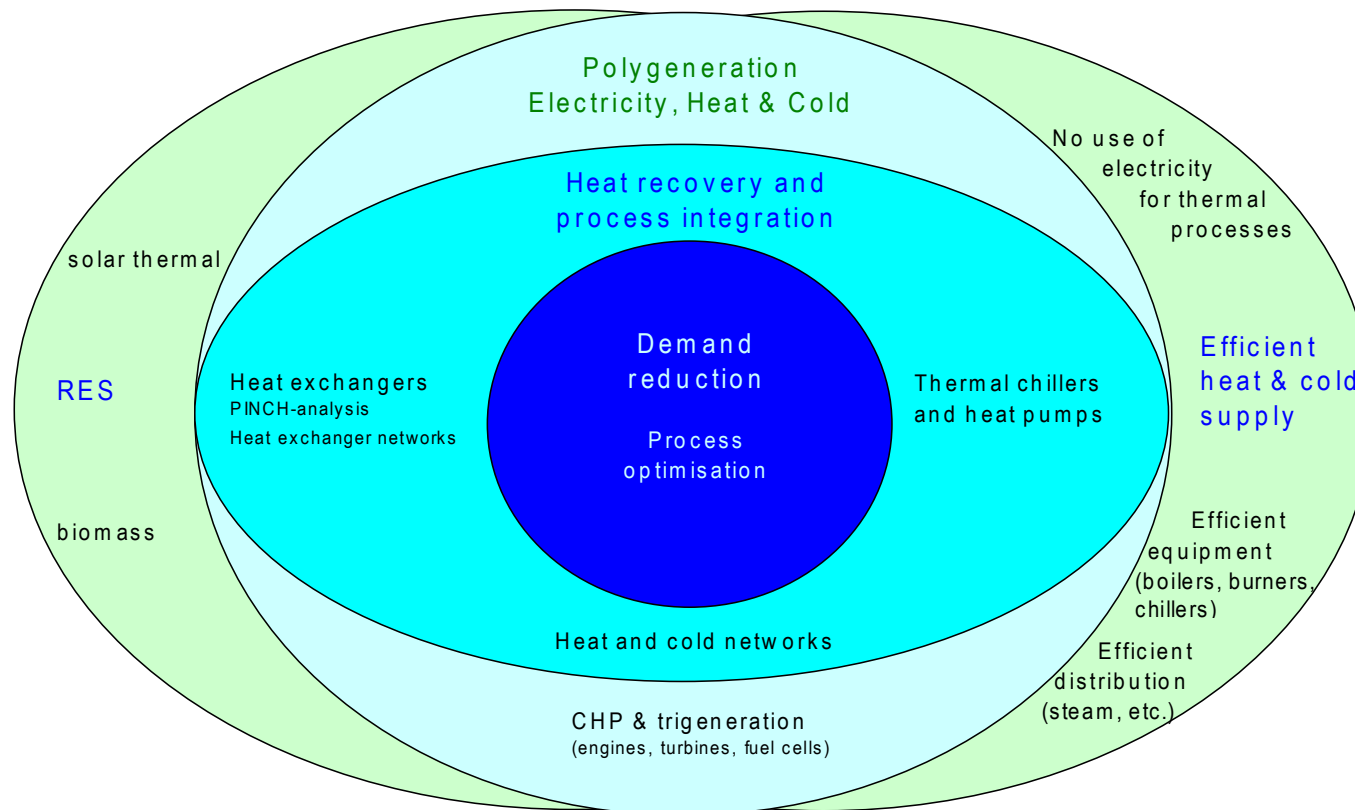
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- Holistic vision of the energy supply and demand
- 1. Demand reduction measures
- 2. Heat recovery
- 3. Intelligent combination of heat and cold supply technologies, incl. renewables

# Einstein's approach

Holistic vision...

...through the EYE of Einstein



# Einstein's approach

Focusing on the quality of the energy

Analysis of energy demand and availability in terms of:

- QUANTITY of energy
  - QUALITY of energy
- = TEMPERATURE of the required energy

Einstein enables evaluation of potential for:

- heat recovery
- application of more efficient technologies at lower temperature

# Difficulties to deal with...

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## Technical complexity of optimising thermal energy supply

- Little, and often only aggregated, data available on the present state (especially in SMEs)
- Measurements are costly and time-consuming
- Integration of processes at different temperature levels and time schedules
- Combination of a large variety of different possible supply technologies

# What do you need for a good assessment ...

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## 1. Data

- Collect
- Check, analyse, compare and draw conclusions

## 2. Knowledge

- BAT for both processes / buildings and for supply technologies
- Technical data + economical data (investment, O&M)

## 3. Calculation tools

- Dynamic system simulation of complex systems

## 4. Systematic work flow

- Processing steps
- Clear terminology / definitions
- Clear presentation of results

# EINSTEIN proposes...



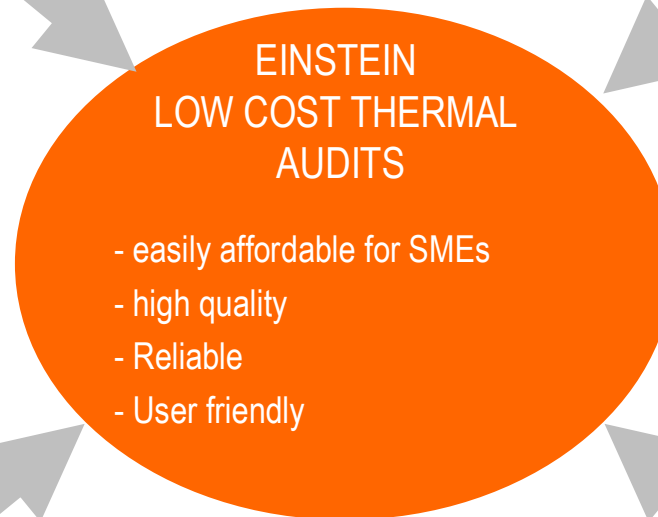
**EINSTEIN**  
thermal energy  
industry audit

## Standardisation

- Standardised procedure
- Standard process models
- Standard modules for heat supply systems
- Consideration of all available energy efficient technologies

## “Quick & dirty” fast estimation of missing data

- Tools for obtaining a complete data set based on fragmented and incomplete information



## Semi-automated

- Guided audit procedure
- Decision aids for proposal generation
- Automatic energy, economic, & environmental evaluation
- Automatic generation of reports

## Data submission by distance

- Fast audits based on data delivered via email or questionnaire
- Possibility of self assessment



# EINSTEIN'S TOOLS

## The EINSTEIN tool-kit: overview

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- EINSTEIN Audit-Guide and Methodology
- EINSTEIN software tool
- EINSTEIN Questionnaire for data acquisition
- Complementary documents  
(-> Review of thermal energy auditing practice and tools)

The free and open-source software und the different documents are available on the project web-site:

[www.einstein-energy.net/tool-kit](http://www.einstein-energy.net/tool-kit)

# EINSTEIN

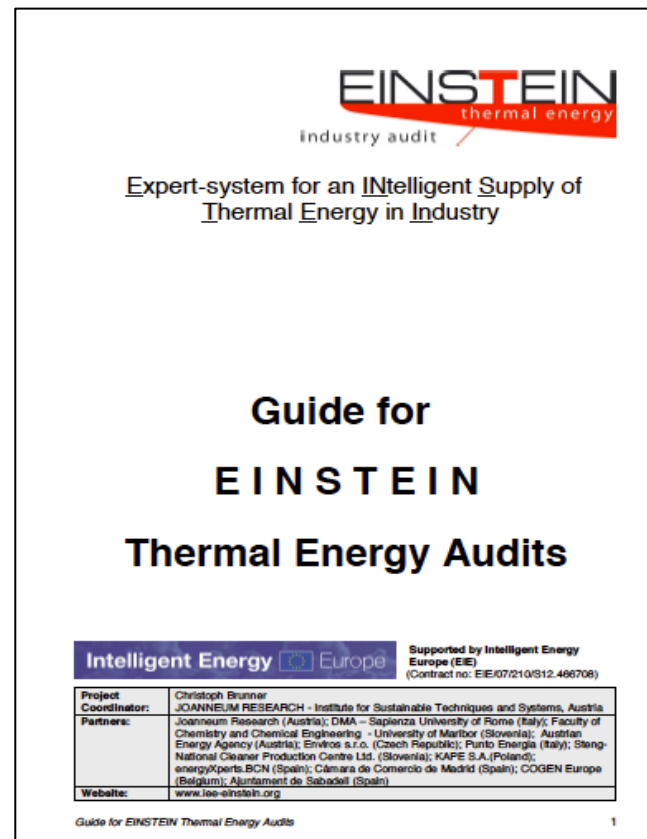
## Audit Guide and Methodology

# EINSTEIN Audit Guide

Aprox. 100 Pages. Version 2.0 (complete update to be published in June 2012)

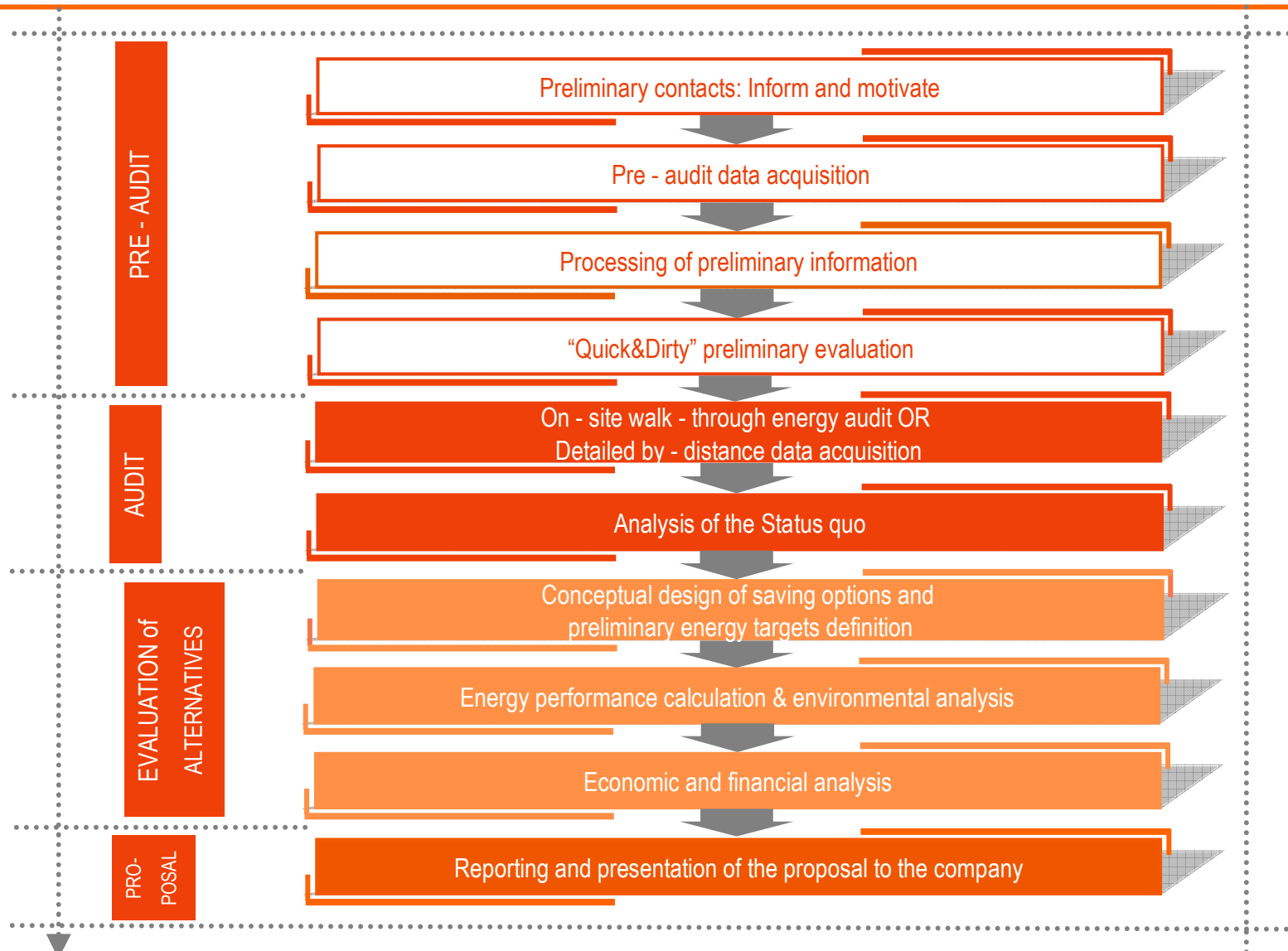
[www.einstein-energy.net](http://www.einstein-energy.net)

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# 10 EINSTEIN Audit steps

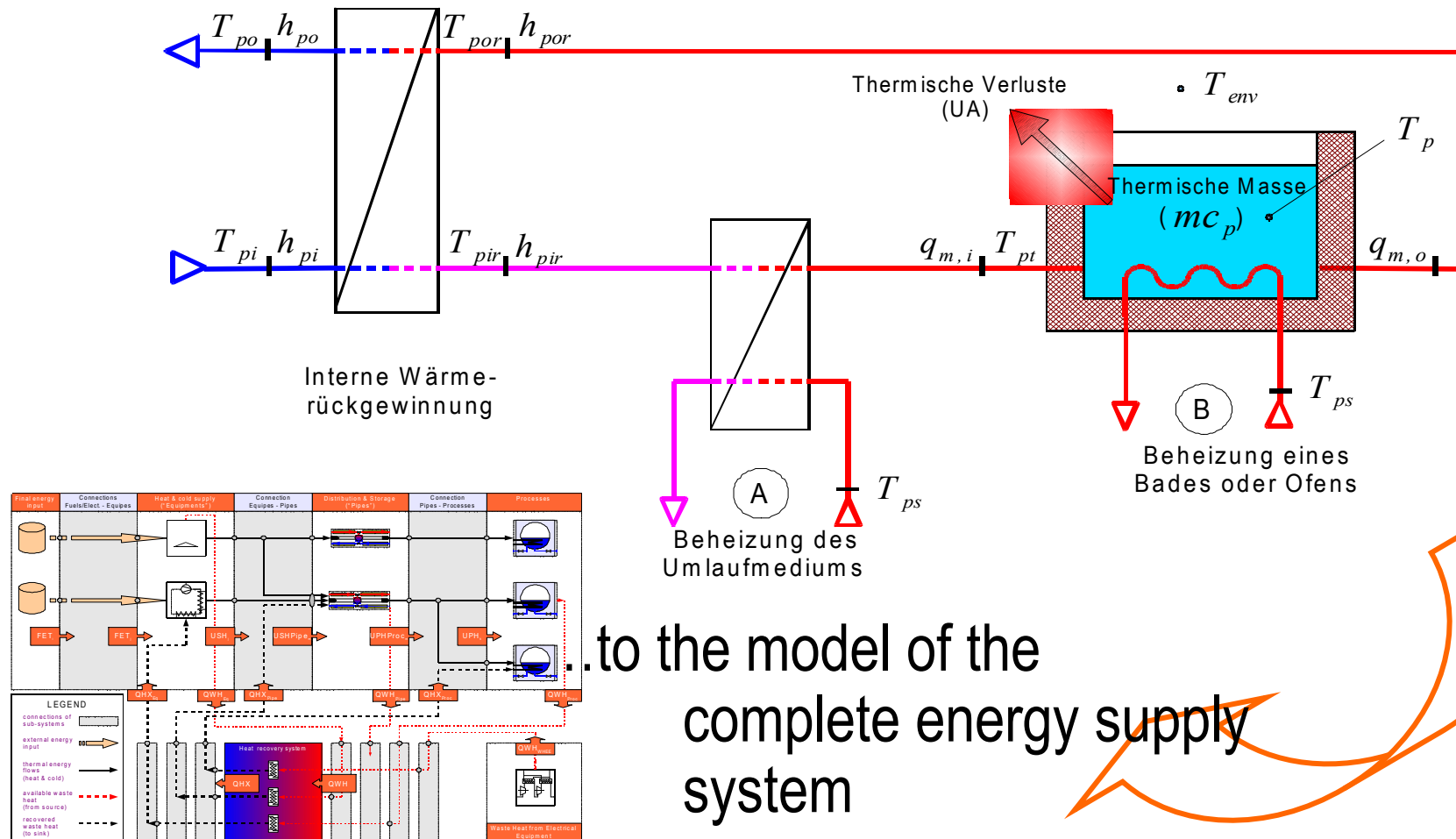
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# Temperature-dependent energy-balances

From the model of a generic process ...

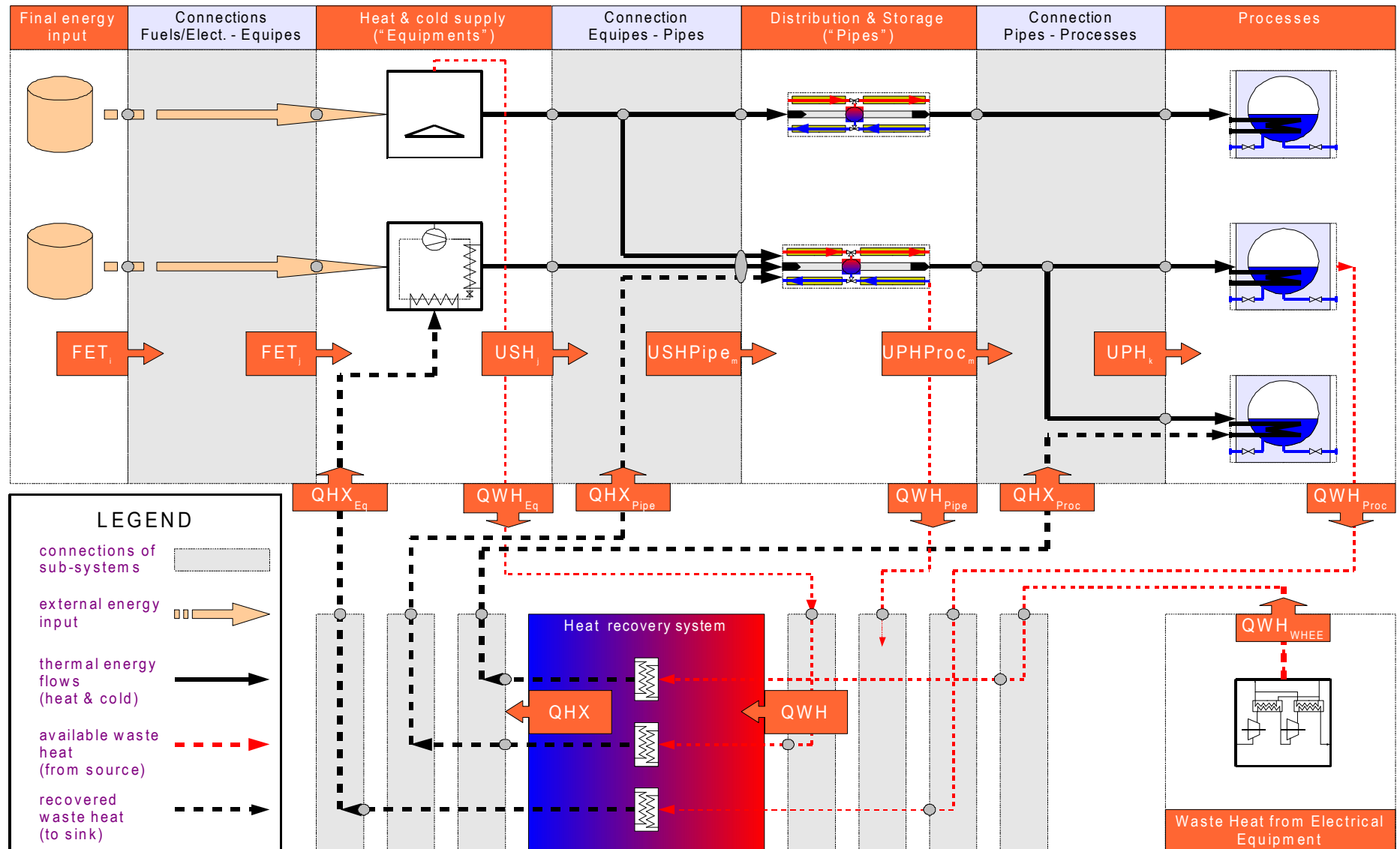
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...to the model of the  
complete energy supply  
system

# EINSTEIN – Definitions of energy flows

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# EINSTEIN – Definitions of temperature levels

## PT – process temperature

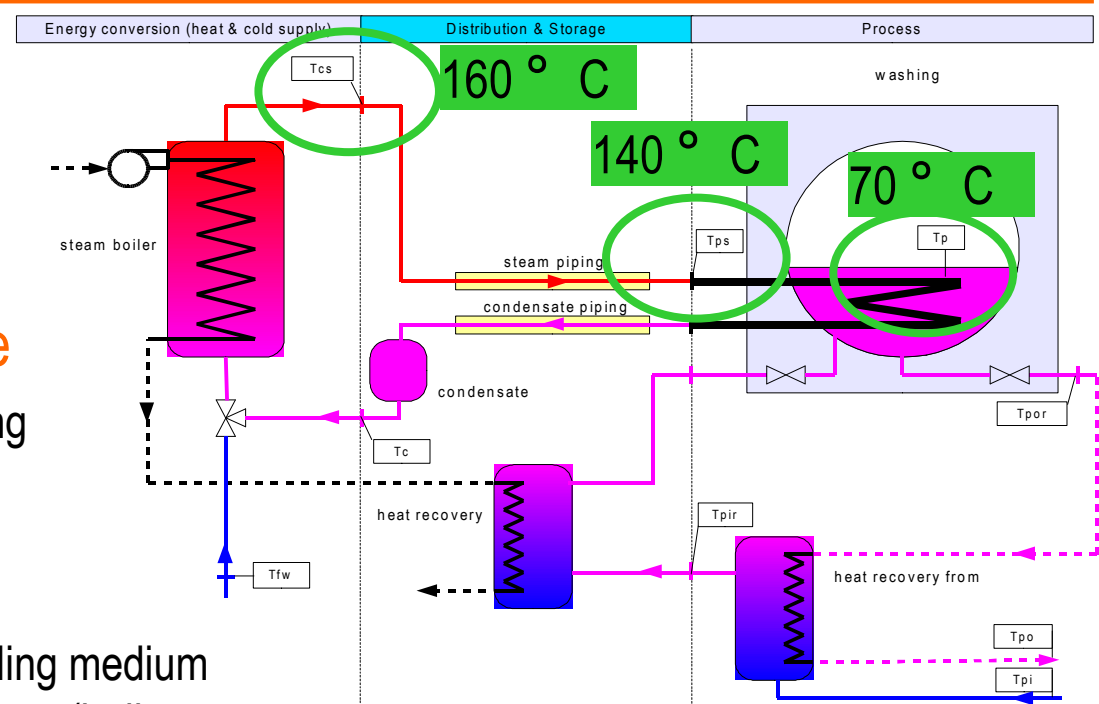
Temperature of the process medium

## PST – process supply temperature

Inlet temperature of the heating or cooling medium to the process

## CST – central supply temperature

Outlet temperature of the heating or cooling medium from the generation / conversion equipment (boilers, chillers, etc.)



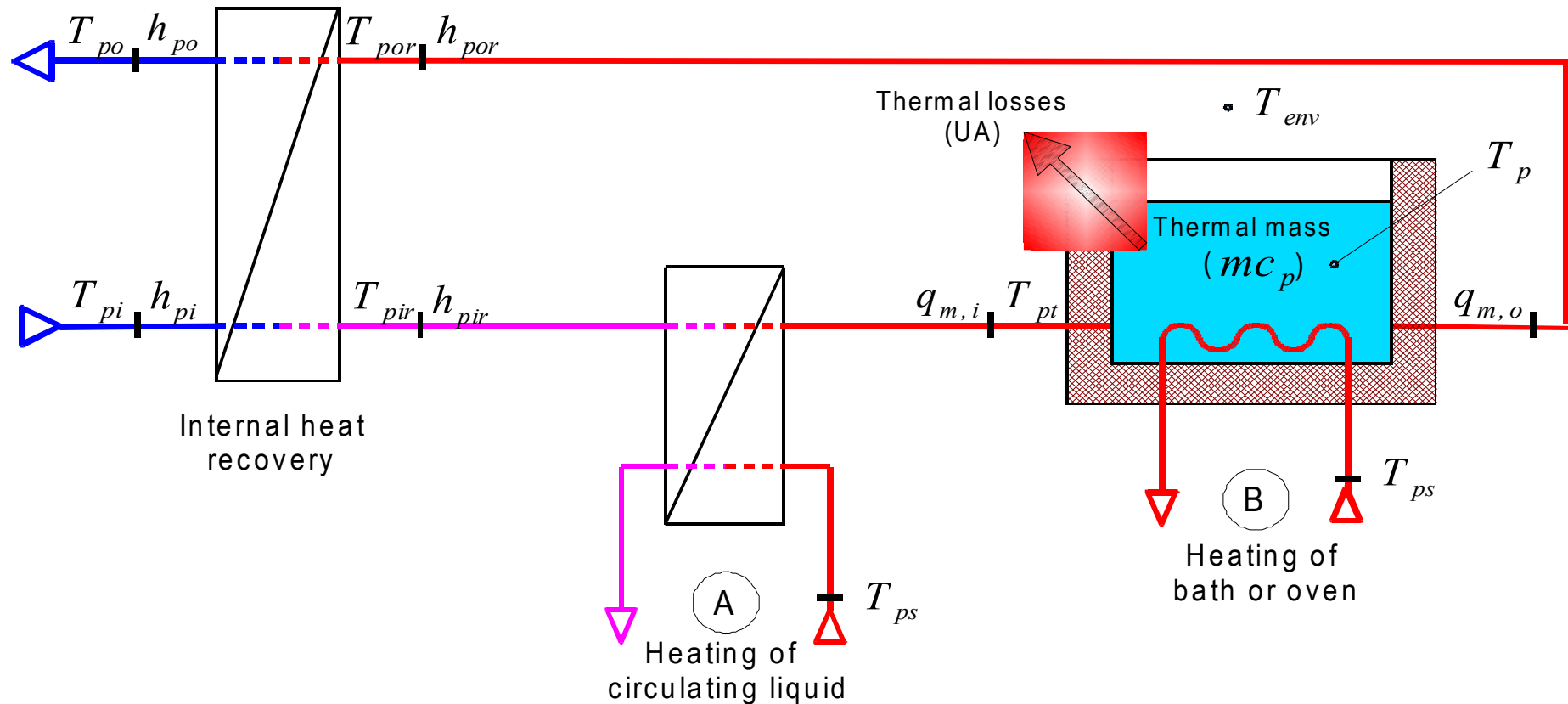
⇒ Big differences among the different temperature levels

⇒ Temperature levels can be optimised (reduced): big potential for **heat recovery** and **application of energy efficient supply technologies** at **low temperature**



# EINSTEIN – Generic process model

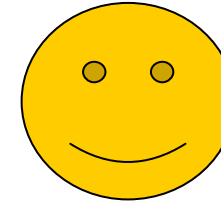
EINSTEIN thermal energy industry audit



# EINSTEIN Software Tool

# EINSTEIN's tool-kit

EINSTEIN is a GENIUS...



EINSTEIN thinks for You !!

... and ...

- Guides you through your energy audit
- Does all the annoying calculations for you
- Proposes smart solutions
- Produces an exhaustive and attractive report

## The objective ...

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thermal energy  
industry audit



## The EINSTEIN Software Tool

- EINSTEIN<sup>©</sup> is a free and open source software project distributed under GNU/GPL license (“copyleft”):  
=> [www.sourceforge.net/projects/einstein](http://www.sourceforge.net/projects/einstein)
- The EINSTEIN Software Tool builds on other free and open source tools and is platform independent (Windows, Mac-OS, Linux, etc.)



## The software tool

**Einstein**  
File View Database Settings Help

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)
1	ETCEinstein	solar thermal (evacuated tubes)	0.760	1.200	0.008	0.940

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

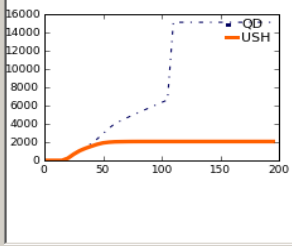
**Lay-out of solar thermal system**

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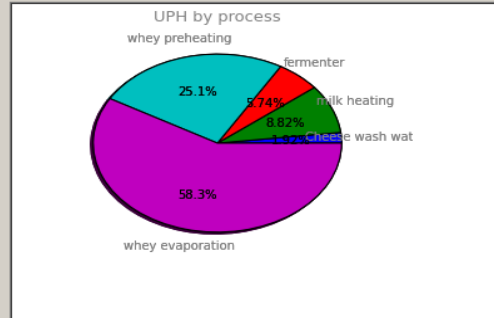
**Einstein**  
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Project: **EINSTEIN Guide 43 Base Case II** Alternative: **Present State (checked)** Design assistant: **semi-automatic**

**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**



UPH by process

- whey preheating: 25.1%
- fermenter: 5.75%
- milk heating: 8.83%
- cheese wash wat: 1.92%
- whey evaporation: 58.3%

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

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

**Einstein**

- + 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 Questionnaire

Prozessbeschreibung		1	2	3	
Kurzbezeichnung des Prozesses	0				Fügen Sie einen Ablaufplan des Produktionsprozesses ein (z.B.: der Fluss der Rohmilch in die Käseproduktion oder der Fluss von Fahrzeugchassis in der Automobilproduktion)
Prozessbeschreibung	0				Beschreiben Sie kurz den Prozess oder der Grundoperation
Prozesstyp Kontinuierlich/Batch					Geben Sie die Art der Grundoperation (laut EINSTEIN Klassifizierung) an
Art der Grundoperation	0				Geben Sie an, ob es sich um einen kontinuierlichen, oder um einen Batch Prozess handelt
Produkt oder Prozessmedium (Wasser, Öl, Luft)	0				Das Medium, das in direktem Kontakt mit dem behandelten Produkt steht, z.B. Luft zum Trocknen, Lauge oder Wasser zum Waschen, etc.
Typische (End-)Temperatur des Prozessmediums während des Betriebs	°C				Geben Sie hier die Temperatur des Prozessmediums an, nicht die Temperatur des Versorgungsmediums.
Eintrittstemperatur des Prozessmediums (vor Wärmerückgewinnung)	°C				Eintrittstemperatur des Prozessmediums vor Wärmerückgewinnung
Temperatur des Prozessmediums bei Inbetriebnahme (nach Unterbrechung)	°C				Temperatur der Anlage bei Inbetriebnahme vor dem Aufheizen
Täglicher Zufluss des Prozessmediums	m³				Kontin. Proz.: Durchfl.rate des Med. x Zirk.zeit. Bei Batch-Proz. mit Erneuerung des Mediums: Vol. x Anz. der Batches
Volumen des Prozessmediums innerhalb der Anlage oder des Speichers	m³				ssigkeit in einer zu waschenden Flasche
Leistungsbedarf des Prozesses im Betrieb	kW				nd des Betriebs (them. Verluste, Verdampfung, en; ohne Aufheizung des Zirkulationsmediums.

Wärmerückgewinnung für diesen Prozess		
Steht Wärme aus Wärmerückgewinnung für diesen Prozess zur Verfügung?	(Ja/Nein)	
Abwärmequelle	0	
Eintrittstemperatur des Prozessmediums (nach Wärmerückgewinnung)	°C	

(für Wärmerückgewinnung verfügbare) Abwärme		
Abwärmemedium	0	
Temperatur der austretenden (Ab)Wärmeflüsse	°C	
Spezifische Enthalpie der austretenden (Ab-)Wärmeflüsse	0	
Endtemperatur der austretenden (Ab)Wärmeflüsse	°C	
Tägliche Ausflussmengen des Prozessmediums	m³	
Kann aus dem ausfließenden Medium Wärme rückgewonnen werden?	(Ja/Nein)	

Available as:

- ☐ Paper / PDF / Spreadsheet Version
- ☐ Direct Data entry into software
- ☐ Short check-list

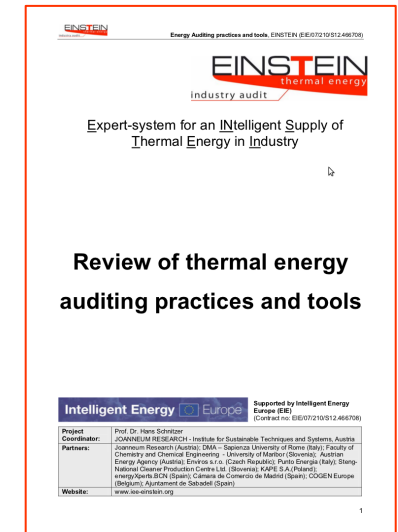


# EINSTEIN – Complementary Material

# EINSTEIN – Complementary Material

Available at [www.einstein-energy.net](http://www.einstein-energy.net)

- Review of thermal energy auditing practice and tools:  
Vannoni et al. (2008)
- Collection of 72 EINSTEIN Audit Reports in industry and non-industrial applications (hospitals, spas, office buildings etc.)
- Training material of EINSTEIN – training courses



[www.einstein-energy.net](http://www.einstein-energy.net)

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

Thanks for your attention !