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PROJECT PARTICIPANTS

1	SME-AG 1	FBT (Coordinator)	Belgium
2	SME-AG 2	URBH	France
3	SME-AG 3	SPP	Poland
4	SME-AG 4	CCS-MT	Slovenia
5	SME-AG 5	CCE-ITD	Croatia
6	RTD 1	HOGENT	Belgium
7	RTD 2	SCHICON	Belgium
8	RTD 3	CTTN-IREN	France
9	RTD 4	WFK	Germany
10	RTD 5	UM	Slovenia
11	RTD 6	TTF-UZ	Croatia
13	RTD 7	PROMIKRON	The Netherlands
14	SME 1	ZEEKANT	The Netherlands
15	SME 2	KREUSSLER	Germany
16	RTD 8	ACT	The Netherlands

PROJECT MANAGEMENT TEAM

Ing. W.A.J.L. den Otter (ACT)
Mr. M. Van Severen (FBT)

DOCUMENT AUTHORS

Prof. Dr. H. Hloch	WFK	Germany
Dipl. Oec.-troph. M.Tokos	WFK	Germany
Dr. D. Spettmann	WFK	Germany
Ing. W.A.J.L. den Otter	ACT	The Netherlands
Mr. M. Groosman	ACT	The Netherlands
Ing. M. Vanderhoeven	HOGENT	Belgium
Prof. Dr. T. Pušić	TTF-UZ	Croatia
Prof. Dr. S. Šostar	UM	Slovenia
Ass. Prof. Dr. S. Fijan	UM	Slovenia
Dr. M. Seiter	KREUSSLER	Germany

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1. EXECUTIVE SUMMARY

The current project has designed the Smart Laundry-2015 through research, further development and adaptation of 16 selected sustainable key technologies (KTs), combined for green sites or individual for existing plant augmentation. These KTs include water reduction, energy savings, green fuel substitutions for CO_2 reductions, new energy systems and improved sequencing of the processes, greater textile hygiene. Full implementation of the Smart Laundry-2015 will reduce the annual water consumptions by at least 10,4 million m^3 (30%), the energy consumptions by 27,5 PJ (45%) and the overall CO_2 emissions by 2,3 million tons CO_2 per year (60% reduction) at 100% market penetration in the year 2015.
The selected 16 KTs has been investigated at pilot scale level and subsequently integrated in a unified design. A parallel benchmarking and innovation monitoring has validated both the actual energy demand and the potential of energy savings of the future innovations. An integrated concept of the industrial EU Smart Laundry-2015 has been produced. The used 'Onion' model is presented as a web based simulation tool in which individual industrial launderers can calculate the cost savings of different combinations of the 16 selected KTs in their own specific local situation. The impact of each module on the other modules has been mapped systematically.
A selection of industrial applicable and most interesting KTs with high potential savings on basis of the SMILES research results has been made. In order to reach savings of 30 % water consumption, 45 % energy consumption and 60 % CO_2 emissions reduction, it is likely to use at least a combinaton of the following main KTs:

- **Direct gas heated laundry**: *max. 40 % energy savings****
- **New textile drying (IR-drying)**: *max. 25 % energy savings****
- **Water reduction**: *max. 71 % water savings and 20 % energy savings****
  and/or Water reuse/membranes: *max. 80 % water savings and 20% energy savings****

These main KTs can be combined with
CO_2 emissions reduction: *max. 45 % energy savings****
and/or possibly with
Combined Heat Power: *max. 25 % energy savings****
and/or possibly with
Chemicals reduction: *max. 25 % energy savings****
and/or possibly with
Low temperature washing: *max. 15 % energy savings****
and/or possibly with
Reduction of microorganisms in reused-water: *max. 13 % energy savings****
and/or possibly with
Energy buffers: *max. 12 % energy savings****

* ***= if used as a single technology; % savings are less in combination with more technologies as the total of savings can not be higher than 100%***

To fulfill requirements like sustainability, careful use of raw materials, energy- and water reduction it is important to reach this goal as soon as possible. The industrial laundry itself would have an immediate benefit in reducing cost, an increase in profitability and the environment would also benefit.

The majority of existing industrial laundries has no other choice than implementing the SMILES sustainable KTs step by step. The action that has to be taken must fit into the technical equipment and the work place conditions in the plant.
Changing an industrial laundry to the design of the Smart Laundry-2015 means for the majority of the owners high investments, personal means training, life long learning and a positive attitude to change.
Leaving former traditions, leaving the comfort zone and changing a plant to a modern customer orientated smart laundry is a necessary, but also challenging step. How to start and which things can or should be done first depends on the industrial laundry itself. The level of success can vary within a single KT, energy and water reduction influence each other, so there are correlations between the KTs that have to be optimised to the conditions of every single industrial laundry.

A **Computer Expert Model system** (CEM) for the Smart Laundry-2015 has been developed and designed in the project lifetime in order to calculate the estimated possible water and energy savings for using the new KTs in an individual EU Smart Laundry. CEM is a projection of the realised consumption figures of a specific industrial laundry in practise on a virtual industrial laundry in the system. These figures can be varied in the system, where the effect of application of one or more of the new adapted technologies can be calculated.
A parallel bench marking and innovation monitoring system can validate both the actual energy demand and the potential of energy savings of the future innovations.
CEM converts the type of laundry (hospital, towels, mops, mats etc.) to the type of material they are made from (CO, PES/CO and PES) to have a better estimation of the possible savings.
Furthermore, the possibility to connect the machinery of an individual industrial laundry to an interface for the periodic transportation of data to a database has been prepared within CEM for the Smart Laundry-2015.

2. SUSTAINABLE NEW KEY TECHNOLOGIES

The following 16 sustainable key technologies (KTs) were selected for research, further development and adaptation in the industrial laundry sector:

- Water reduction
- Water reuse / membranes
- Water disinfection
- Supercritical gasification
- Low Temperature Washing (with adequate hygiene)
- Direct gas heated laundries (steamless industrial laundry)
- New textile drying techniques (AD-ID-UD-MD)
- Combined Heat Power
- Reduction CO_2 emissions
- Energy buffers
- Laundry chemicals reduction

- Cleavable detergents (and additives)
- Electrochemical bleaching
- Ultrasonic cleaning
- Reliable textile hygiene
- Synthesis for SMART LAUNDRY-2015

3. SIGNIFICANCE OF SUSTAINABLE NEW KEY TECHNOLOGIES FOR THE INDUSTRIAL LAUNDRY SECTOR

The EU-27 industrial laundry sector, with 11.000 establishments (from which more than 90% SMEs), is washing 2,7 billion kg of soiled textiles per year (dry weight) employing approximately 168.000 workers and utilises in the order of 42 million m³ of fresh water and 60 PJ of energy per year. The sector generates similar quantities of wastewater to be treated, and substantial CO_2 emissions (yearly some 3,8 million tons CO_2). Conventional laundry processes are characterized by large enthalpy destructions and resource inefficiencies. EU industrial laundries are using either Wash Extractors (WEs) or Continuous Batch Washers (CBWs). The total water use of the average Continuous Batch Washer (CBW) is 10-16 L / kg laundry and of a Wash Extractor (WE) 16-35 L / kg laundry. The use of fresh make-up water is about half.
Most industrial laundries have instituted best practices and adopted water savings measures (such as lean water washing and press water utilisation). Recycling of the rinse water (pre- and post main wash) gives a net fresh water reduction without reducing the amount of water applied per kg of textile. Water recycling increases detergent and soil accumulation on the textiles as well as lint transfer. This causes increased textile greying and incrustation (reduced textile softness, water absorption). Further water reduction can be achieved by introduction of forced flow effects in both WEs and CBWs during the rinse phase. High water reuse is not possible for all types of laundry as a high cleaning performance and hygiene can not be guaranteed at all times.
The focused and coordinated research in project SMILES has been established and new innovative technologies were developed in order to greatly enhance the performance of the industrial laundry sector. It was the purpose of project SMILES to develop and design the future SMART LAUNDRY-2015 through research, further development and adaptation of 16 sustainable KTs with its practical utilisations (*combined for green sites or individual for existing plant augmentation*). These include water reduction, energy savings, and green fuel substitutions for CO_2 reductions, new energy systems and improved sequencing of the processes as well as greater textile hygiene.

The target of full implementation of the Smart Laundry-2015 was the reduction of the annual water consumptions of the industrial laundry sector by at least 10,4 million m^3 (30 %), the annual energy consumptions by 27,5 PJ (45 %) and the overall annual CO_2 emissions by 2,3 million tons CO_2 per year (60 % reduction) at 100 % market penetration in the year 2015. The project successfully investigated 16 KTs at pilot scale level that subsequently have been integrated in a unified design. Parallel benchmarking and innovation monitoring at full scale level has been carried out for the validation of both the actual energy demand and the potential of energy savings of the future innovations. One of the main GOALS of project SMILES was the development and design of the Smart Laundry-2015 through RTD of the16 selected

KTs resulting in lower water and energy usage and CO_2 emissions.
The Smart Laundry-2015 has been defined as follows:

The Smart Laundry-2015 is a GUIDELINE for an Industrial Laundry to make use of a selection out of 16 key technologies investigated and developed in EU project SMILES in order to save water and energy consumptions by 30 % resp. 45 %, to reduce CO_2 emissions by 60 %, to reduce chemicals by 20 %, keeping an equal or even better quality level; maintaining current detergency and stain removal performance, maintaining current hygienic requirements, and maintain the original fabric properties of the processed articles.

The project has selected a **choice of many new, sustainable technologies** instead of having only a selected few, as many different situations in EU industrial laundries do exist.
Substantial savings have to be obtained with different production facilities, washing systems and grades / types of soils. It is like playing the piano: You cannot play a melody with 1 or 2 notes as a number of notes are needed! The selected KTs enhance largely each others effect regarding water and energy savings as well as lower reductions of CO_2 emissions, and have impact on each other (Table 1).

Table 1: Interaction of SMILES key technologies

	Effector technology															
Impacted technology	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.Water reduction	0	+	-	+	+	-	-	-	+	+	+	+	+	+	+	+
2.Water reuse	+	0	-	+	+	-	-	-	+	+	+	+	+	+	+	+
3.Water disinfection	-	+	0	-	-	-	-	-	-	+	+	+	+	+	+	+
4.SCWG	+	+	-	0	-	-	-	-	+	-	-	-	-	-	-	+
5.LT washing	+	+	+	-	0	+	-	-	+	+	+	+	+	+	+	+
6.Gas Heated Laundry	-	-	-	-	+	0	-	-	+	-	-	-	-	-	-	+
7.New textile drying	-	-	-	-	-	-	0	-	+	-	-	-	-	-	-	+
8.CHP	-	-	-	-	-	-	-	0	+	-	-	-	-	-	-	+
9.CO_2 reduction	-	+	-	+	+	+	+	+	0	+	-	-	-	-	-	+
10.Energy buffers	+	+	+	-	+	-	-	-	+	0	-	-	-	-	-	+
11.Chemicals reduction	+	+	+	-	+	-	-	-	-	-	0	+	+	+	+	+
12.Cleavables	+	+	+	-	+	-	-	-	-	-	+	0	+	+	+	+
13.Electrobleaching	+	+	+	+	+	+	-	-	-	-	+	+	0	+	+	+
14.Ultrasonics	+	+	+	-	+	-	-	-	-	-	+	+	+	0	+	+
15.Textile hygiene	+	+	+	-	-	-	-	-	-	-	+	+	+	+	0	+
16. Design	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0

+ = Impact from effector technology at effector technology
- = No impact from effector technology at effector technology
0 = No interaction as impacted technology = effector technology

The EU-27 is committed to reduce the greenhouse gases resulting in a decrease of the global warming by 8 % in the period 2008-2012. CO_2 emissions account for the major part of the global warming and are mostly derived from fossil fuels. There is a common EU strategy for reducing the energy consumption and CO_2 emission reduction. The Smart Laundry-2015 will make a considerable contribution in reducing CO_2 emissions in the EU-27 industrial laundry sector (Table 2).

Table 2: Annual energy savings and CO_2 emissions reduction of EU industrial laundries at 100% market penetration in the year 2015

TECHNOLOGY	ENERGY SAVINGS		CO_2 REDUCTION, **Oil (central)** (*0,073 MT CO_2/PJ*)	CO_2 REDUCTION, **Gas (central)** (*0,055 MT CO_2/PJ*)
	Single technology	Combined technologies		
2.1 Low Temperature Washing	5 PJ	4 PJ	0,29 MT CO_2	0,22 MT CO_2
2.2 Gas Heated Laundry	10 PJ	5 PJ	0,36 MT CO_2	0,27 MT CO_2
2.3 New Textile Drying	14 PJ	6 PJ	0,44 MT CO_2	0,33 MT CO_2
2.4 Combined Heat Power	5 PJ	5 PJ	0,36 MT CO_2	0,27 MT CO_2
2.5 CO_2 emissions reduction			0,50 MT CO_2	0,50 MT CO_2
2.6 Energy Buffers	10 PJ	7,5 PJ	0,55 MT CO_2	0,41MT CO_2
Total		27,5 PJ	2,50 MT CO_2	1,92 MT CO_2
Total combined*		**45%**	**2,3 MT CO_2/year**	

* Assuming 60 % oil and 40 % gas in future

These reductions will be achieved by reducing energy consumption, converting oil usage to natural gas firing where possible and by the application of sustainable energy sources. It is projected that the Smart Laundry-2015 with its 16 sustainable KTs after 100% market penetration in all EU countries will result in annual energy savings of 27,5 PJ (45 %), corresponding to 2,3 million tons CO_2 per year (60 % reduction).

4. OBJECTIVES AND TARGETS OF THE PROJECT

One of the main GOALS in project SMILES has been the development and design of the Smart Laundry-2015 through RTD of 16 selected KTs resulting in lower water and energy usage and CO_2 emissions. Table 3 presents the specific project OBJECTIVES for the development and design of the Smart Laundry-2015.

Table 3: Quantified objectives

Objectives	Indicators	Quantification	WP
1. Water reduction	L /kg laundry	**30%**	1
2a. Energy 2b. CO_2 emissions reduction	kJ/kg laundry g CO_2/kg laundry	**45%** **60%**	2
3. Chemical reduction	g/kg laundry	**20%**	3
4. Quality improvement	Quality index	**20%**	4
5. Smart Laundry-2015	Design	**completed**	5

The calculation figure of 60 PJ for the annual energy usage in the EU-27 industrial laundry sector is BASED ON OIL OR GAS AS FUEL AND WITHOUT ELECTRICITY. Electrical heated plants were excluded as these are not regarded as industrial plants. Moreover, the electrical energy usage in an industrial plant is less than 10%; so the electricity usage was excluded. Furthermore, only IN-HOUSE ENERGY COSTS and NOT ENERGY COSTS for TRANSPORT were taken into account.

The SMILES target for **WATER SAVINGS** was to achieve a reduction of 30 % water usage, which means a future average total water usage in the EU-27 of **14 L water / kg laundry**. In 2008 the average fresh water consumption of EU industrial laundries was approx. 21 L water / kg laundry. The calculation of 20 to 21 L water / kg laundry as an average for water consumption in EU industrial laundries is realistic. Also the estimated textile distribution in EU industrial laundries is correct. The main reason for the high water consumption figure is that only the big and better financed industrial laundries run continous batch washers (CBWs) and they also have the volume to run tunnels with similar loads during the day. Industrial laundries with a volume of less than 5 tons per day use predominately washing extractors (WEs) with sometimes having no bar code system. As a result they have to wash underloaded machines as such loads are dedicated to single customers.
Another aspect is that water in many countries might have been only a little or no cost factor at all in the past. Sometimes industrial laundries even had no water meter. Times have changed now. Nowadays not only modern machines are needed to run a high efficiency plant, but also the planning starts much earlier with a complete infrastructure plan of the industrial laundry before it is build.
The lowest measured level for the best performing EU industrial laundry with new equipment on the market was down to **3 L water / kg laundry** (only for lightly soiled textiles e.g. bed linen) in 2011.

The SMILES target for **ENERGY SAVINGS** was to achieve a reduction of 45 % on energy usage, which means a future total energy reduction of **2,9 kWh / kg laundry**. In 2008 was the average energy usage in the EU-27 industrial laundry sector **6,5 kWh / kg laundry**, based on different studies and experiences from practise.
The values in kWh/kg textile include washing and drying complete. The higher values of the past are mainly caused by high water consumption, lack of water recovery systems, old not very efficient steam boilers and the market dominated by smaller industrial laundries with mainly washing extractors (WEs).
The lowest measured level for the the best performing EU industrial laundry with new equipment on the market was down to **0,9 kWh / kg laundry** in 2011.

5. OVERVIEW OF POTENTIAL SAVINGS BY THE 16 NEW KEY TECHNOLOGIES

The Design of the Smart Laundry-2015 is based on the savings potentials for water and energy consumption. Table 4 presents the % savings of the different single KTs for water consumption, energy consumption and CO_2 emissions reduction. Savings of each KT have to be noticed separately, as much more that 100 % savings cannot be achieved by adding values in one column!
A main topic is the water content of the processed articles after washing and before drying. Better dewatering nowadays is the result of increased temperatures in the rinse, the higher influence for washing extractors is higher g-force during spin and higher pressure being increased from about 35 bar nowadays to maybe 51 or 52 bar.

As a consequence 100 % cotton will only have a rest humidity of about 45 % and cotton/PES blends 40 % after extraction or pressing. This means that about 400 to 500 mL of water per kg of textiles is evaporated in drying or mangeling processes.

Table 4: Overview potential savings key technologies
(***if used as single technology, not combined with more technologies***)

Key Techno-logy	**Title**	**Expected savings WATER Consumption** (*single technology*)	**Expected savings ENERGY Consumption** (*single technology*)
1	Water Reduction	71 %	20 %
2	Water Reuse / Membranes	20-40 % 70-80 %	5-10 % 20 %
3	Reduction of microorganisms in reused-water	n.a.	13 %
4	Supercritical Water Gasification	Expected 90 %	10 %
5	Low Temperature Washing	n.a.	15 %
6	Gas Heated Laundry	n.a.	40 %
7	Textile Drying	n.a.	25 %
8	Combined Heat Power	n.a.	25 %
9	CO_2 Emissions reductions	n.a.	45 %
10	Energy Buffers	n.a.	5 – 12 %
11	Chemicals Reduction	10 %	20 – 25 %
12	Cleavable detergents	10 %	-
13	Electrochemical bleaching	5 %	Higher consumption level
14	Ultrasonic Cleaning	Higher consumption level	Higher consumption level
15	Reliable Textile Hygiene		
16	Synthesis Smart Laundry-2015	>30 %	>45 %
	TARGET SMILES	**30 %**	**45 %**

n.a. = not applicable

NOTES:
1. The percentages in Table 4 are maximal percentages for single technologies.
2. The Smart Laundry-2015 is applicable for ALL categories of industrial laundries; the savings per category are different, but the technology works in all cases.
3. Approx. **70 %** of total supplied energy in an industrial laundry is used for **drying and finishing** and **29 %** for **washing**.
4. All water release systems have to be very high efficient and able to textiles of elevated temperatures, as far most energy in laundry is consumed by evaporation of water.
5. High water consumption levels, without water- and heat recovery systems, result in high energy consumption levels.

6. SELECTION OF MOST APPLICABLE / INTERESTING KEY TECHNOLOGIES

Technology 16 'Synthesis' has produced an integrated concept of the industrial EU Smart Laundry-2015. The model used in the project is the 'Onion Model' with at the core the resource utilisations, followed in the intermediate layer by enabling technologies. The Onion model is presented as a web based simulation tool in which individual launderers can calculate the cost savings of different combinations of the 16 key technologies (KTs) in their own local situation. The impact of each module on the other modules has been mapped systematically. The degree of influence is also qualified and quantified. Thereafter the KTs are integrated to larger blocks within the layer followed by integration of the different layers.
A selection of industrial applicable and most interesting KTs with high potential savings on basis of the SMILES research results was made. In order to reach savings of 30 % water consumption, 45 % energy consumption and 60 % CO_2 emissions reduction, it is likely to use at least a combinaton of the following main KTs:

- **Direct gas heated laundry**: *max. 40 % energy savings****
- **New textile drying (IR-drying)**: *max. 25 % energy savings****
- **Water reduction**: *max. 71 % water savings and 20 % energy savings**
  and/or Water reuse/membranes: *max. 80 % water savings and 20% energy savings****

These main KTs can be combined with
CO_2 emissions reduction: *max. 45 % energy savings**
and/or possibly with
Combined Heat Power: *max. 25 % energy savings****
and/or possibly with
Chemicals reduction: *max. 25 % energy savings****
and/or possibly with
Low temperature washing: *max. 15 % energy savings****
and/or possibly with
Reduction of microorganisms in reused-water: *max. 13 % energy savings****
and/or possibly with
Energy buffers: *max. 12 % energy savings****

* ***= if used as a single technology; % savings are less in combination with more technologies as the total of savings can not be higher than 100%***

To fulfill requirements like sustainability, careful use of raw materials, energy- and water reduction it is important to reach this goal as soon as possible. The industrial laundry itself would have an immediate benefit in reducing cost, an increase in profitability and the environment would benefit as well.
The majority of existing industrial laundries has no other choice than implementing the SMILES KTs step by step. The action that has to be taken must fit into the technical equipment and the work place conditions in the individual plants.
Changing an industrial laundry to the design of the Smart Laundry-2015 means for the majority of the owners high investments, personal means training, life long learning and a positive attitude to change. Leaving former traditions, leaving the

comfort zone and changing a plant to a modern customer orientated smart laundry is a necessary, but also challenging step.
How to start and which things can or should be done first depends on the individual industrial laundry itself. The level of success can vary within a single KT: energy and water reduction influence each other, so there are correlations between the KTs that have to be optimised to the conditions of every single industrial laundry.

Trying to reach the goals of SMILES in the next step KT1 (water reduction) in combination with KT5 (low temperature washing) will immediately influence the profitability of the plant. The main impact on KT1 and KT 5 with existing technology is the use of efficient laundry products and sophisticated process technology. The invest for KT1 and KT5 in this step is very low and by far overcompensated by massive energy and water reduction going down from high temperature disinfection to a 60°C chemothermal disinfection process. That means for the majority of white wash (hotel linen, restaurants, work wear food industry, hospital wash) the benefit can be seen immediatly, increasing quality and prolonging the life time of the textiles. In the long term KT 7 and the use of gas heated dryers save a lot of energy compared to conventional textile drying. Keeping in mind that about 70% of the energy in an industrial laundry is used for drying and finishing, every investment or improvement will influence direct profit and losses calculation of a plant. Having done all these improvements consequently the use of heat exchangers starting with the laundry process, continuing with heat recovery from mangeling systems has a high potential. It is difficult to recommend in detail how every single modification should be done in a plant, the important thing is that the owner should have a plan. Usually the industrial laundry needs advise from suppliers, which also have interest that the industrial laundry should grow and become profitable.
Depending on the local situation and area of the industrial laundry KT2 (water reuse systems, membranes) will save cost, but needs also a certain degree of maintenance.

Brand new industrial laundries that expand in foreign markets often have a detailed planning before the plant is constructed. These plans already implement different KTs and optimise it for the specific demands of the industrial laundry. These new industrial laundries - in order to stay profitable and to have an advantage against competition - implement or will implement the SMILES-KTs to be successful in the market.
On EU level many small steps of existing industrial laundries in the direction of a Smart Laundry Design have the potential not only to reach the goals of SMILES with environmental targets, but also be the baseline for a future orientated European laundry business.

7. DESIGN OF SMART LAUNDRY-2015

7.1 General design

The Smart Laundry-2015 is applicable for ALL categories of laundries. The savings are different, but the technology works in all cases.
The selection of devices has enormous consequences: e.g. avoiding a boiler house for energy savings means the necessary usage of **GAS** instead of oil as a fuel.

The Key technology potentials for water and energy savings are presented in Fig. 1 resp. Fig. 2.

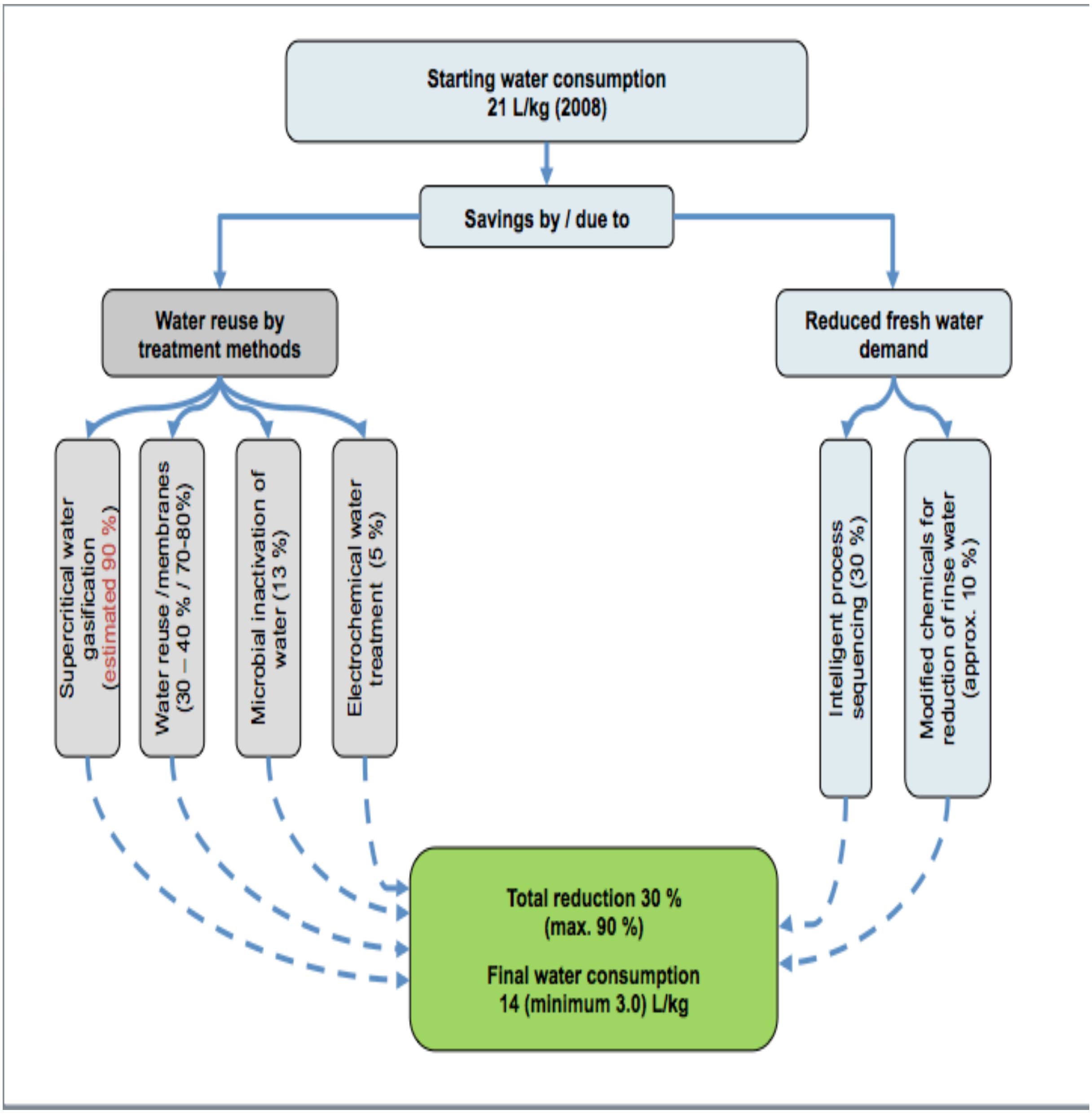

Figure 1: Key technology potentials for water savings in an industrial laundry

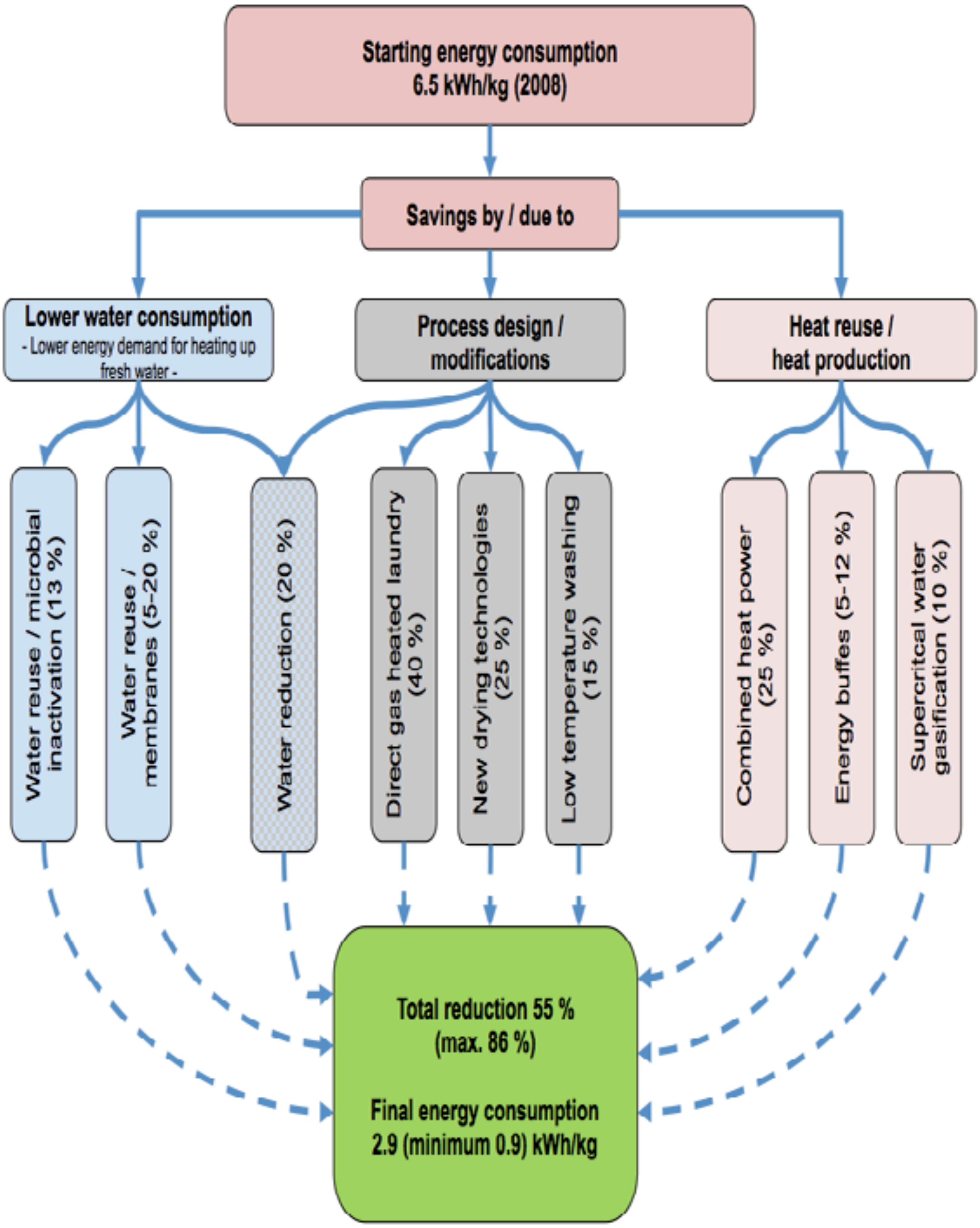

Figure 2: Key technology potentials for energy savings in an industrial laundry

7.2 Machinery Design

Table 5 presents the energy savings recommendations for the Machinery Design of the Smart Laundry-2015. The Smart Laundry-2015 is applicable for ALL categories of laundries. The savings are different, but the technology works in all cases.

Table 5: Energy savings recommendations for Machinery Design of the Smart Laundry-2015

Laundry Department	Type of Machinery	Recommendations
Washing	CBW Systems	1. Direct or indirect heating-up of washing liquors and storage tanks
		2. Incorporated heat recovery systems for effluent water
		3. Automatic overhead loading systems, correct loads, sufficient storage
		4. Automatic weighting of batch / level adaption
	Water extraction presses	1. Very high efficient extraction systems (*at least 51-56 bar)* for low RH of textiles
	Washer extractors (WEs)	1. Heat recovery for effluent water
		2. Very efficient and high spinning
		3. Built-in weighting system
	Centrifugal extractors	1. High G force: g-factor >300 g
		2. Energy recovery during speed reduction
Drying & Finishing	Dryers	1. Large drum diameter for optimum drying
		2. Direct gas heating
		3. Moisture controlsystem (infrared) for optimum drying processes to avoid overheating
		4. Heat exchangers
		5. Thermal isolation system
		6. Short cycle times
		7. Auto cleaning of lint
		8. Infrared heating technology as additional feature to accelerate drying processes
	Ironers	1. Direct gas heated
		2. Complete thermal isolation
		3. Large roller diameters
		4. Heat exchangers

8.3 Process Design

Table 6 presents the different laundering procedures and hygiene aspects for the Process Design of the Smart Laundry-2015. The Smart Laundry-2015 is applicable for ALL categories of laundries. The savings are different, but the technology works in all cases.The Smart Laundry-2015 Process Design of expert laundering includes the optimisation of the laundering procedure factors: energy, chemicals, water, laundering quality. It will implement the following important factors:

Table 6: Energy savings recommendations for Process Design of the Smart Laundry-2015

Washing	a	Laundering procedures must have a sufficient hygienic effect in order to avoid further use of inappropriately laundered textiles that can be a vehicle for the transmission of pathogenic microorganisms.
	b	Using less water and chemicals means less energy consumption.
	c	Low temperature washing is an important factor for savings of energy- and water consumption. However the appropriate disinfection effect must still be achieved through other parameters such as: innovative chemicals, duration, and mechanical action, etc. without compromising the laundering quality (primary and secondary laundering effects.
	d	Warm rinses are another important factor for making use of the Smart Laundry-2015 as it is possible to save water and energy using warm rinsing without compromising the laundering quality.
	e	Using innovative smart chemicals with higher amounts of active substances with higher efficiency than conventional chemicals will result in an overall decrease of chemicals as well as energy consumption.
	f	Reusing water for washing after effective wastewater treatment methods (*water recovery systems*) such as membrane filtration (*membrane bioreactor, reverse osmosis, etc.*) will result in reducing the amount of fresh water without reducing the amount of water per kg textiles.
	g	Automatic dosing systems for chemicals are intended to reduce over- and under- dosing, which can result in an inefficient laundering procedure.

	h	The trend is to install hygienic safe continuous batch washers (CBWs) with the possibility to conduct energy and water efficient laundering procedures instead of WEs. Hygienic, energy and water efficient procedures should be implemented in case of use of washer extractors (WEs).
	i	The trend is to install oxygen bleach systems. These are State-of-the-Art: innovative highly effective bleaching and disinfecting agents will result in cost efficient laundering procedures.
Water exaction	a	Water extraction using water press extractors must have easy to access and clean machine parts in order to maintain a sufficient hygiene level.
Ironers, dryers	a	All equipment for further textile treatment (drying, sorting, ironing, packing and expedition) after laundering should be regularly cleaned and disinfected with effective sanitation plans.
	b	Worker hand hygiene has to be implemented in regular hygiene plans and in in-house education.

8.4 Effects of different washing processes

Fig. 3 presents the water flow of a laundering process in a Washer Extractor (WE) that was used during the project. In this diagram, the process differs from a normal laundering process by reusing the rinse water. Instead of using fresh water in every washing bath, here the rinse waters of the second and the third rinse are recuperated and used for the prewash, main wash (*prewash is transferred into the main wash with the same bath*) and first rinse of the following run.
The rinse waters of the second and third rinse are passed through a sieve to eliminate larger impurities and lint.
By using this treatment, water savings of 20 to 40 % can be achieved depending on the used washing process.

In order to save some energy a heat exchanger can be used to warm up the cold rinse water by the heat from the warm wastewater of the main wash and the first rinse.

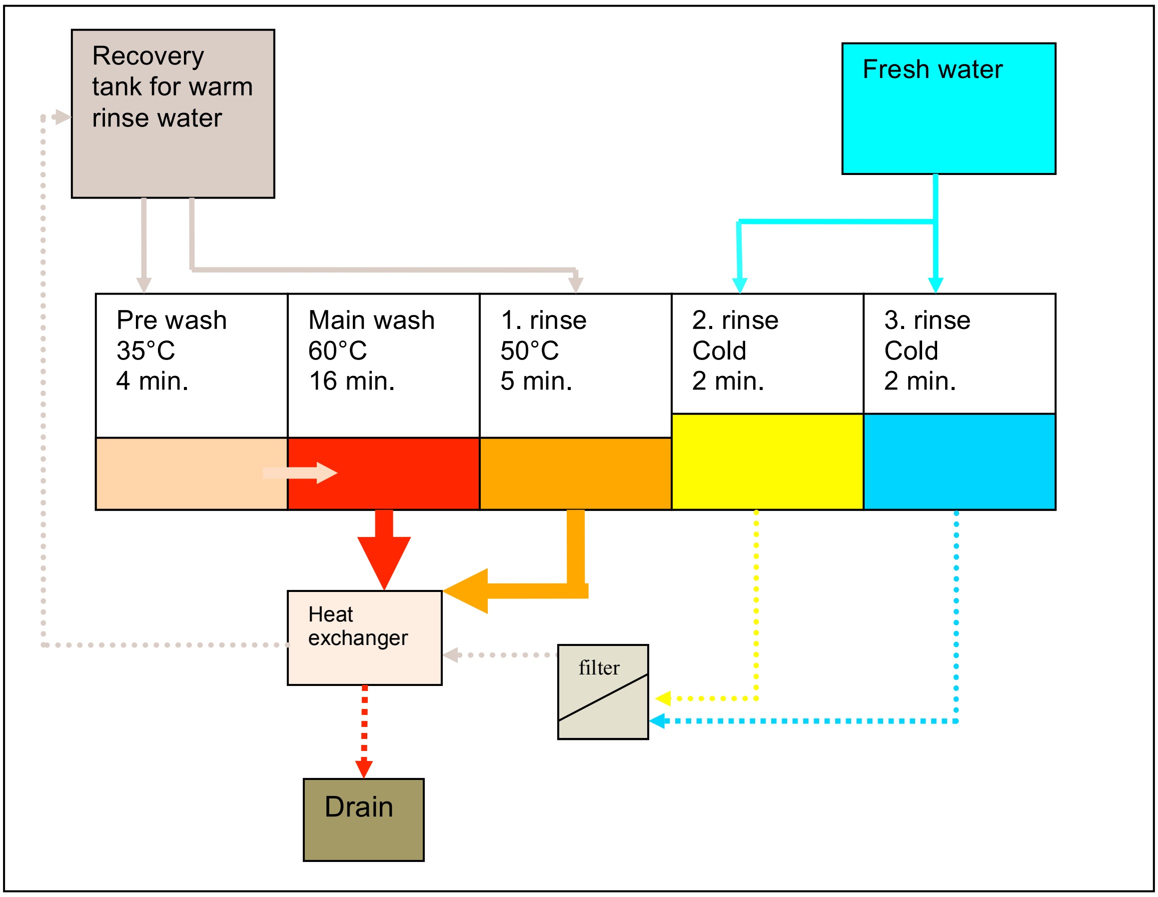

Figure 3: Washing process in a WE with reuse of rinse water (water savings: 20 – 40 %)

Fig. 4 presents the water flow of a laundering process in a Continuous Batch Washer (CBW) with heat and water recovery systems. CBWs currrently usually have a fresh water consumption of approximately 6 to 9 L/kg laundry (in some cases higher). The prewash is performed with recovered water from the press, from the rinsing phase and supplemented with fresh water if necessary. At the end of the prewash zones (40 °C), the free liquor is discharged. The water used in the main wash comes from the rinsing phase and is heated up to 60 °C.

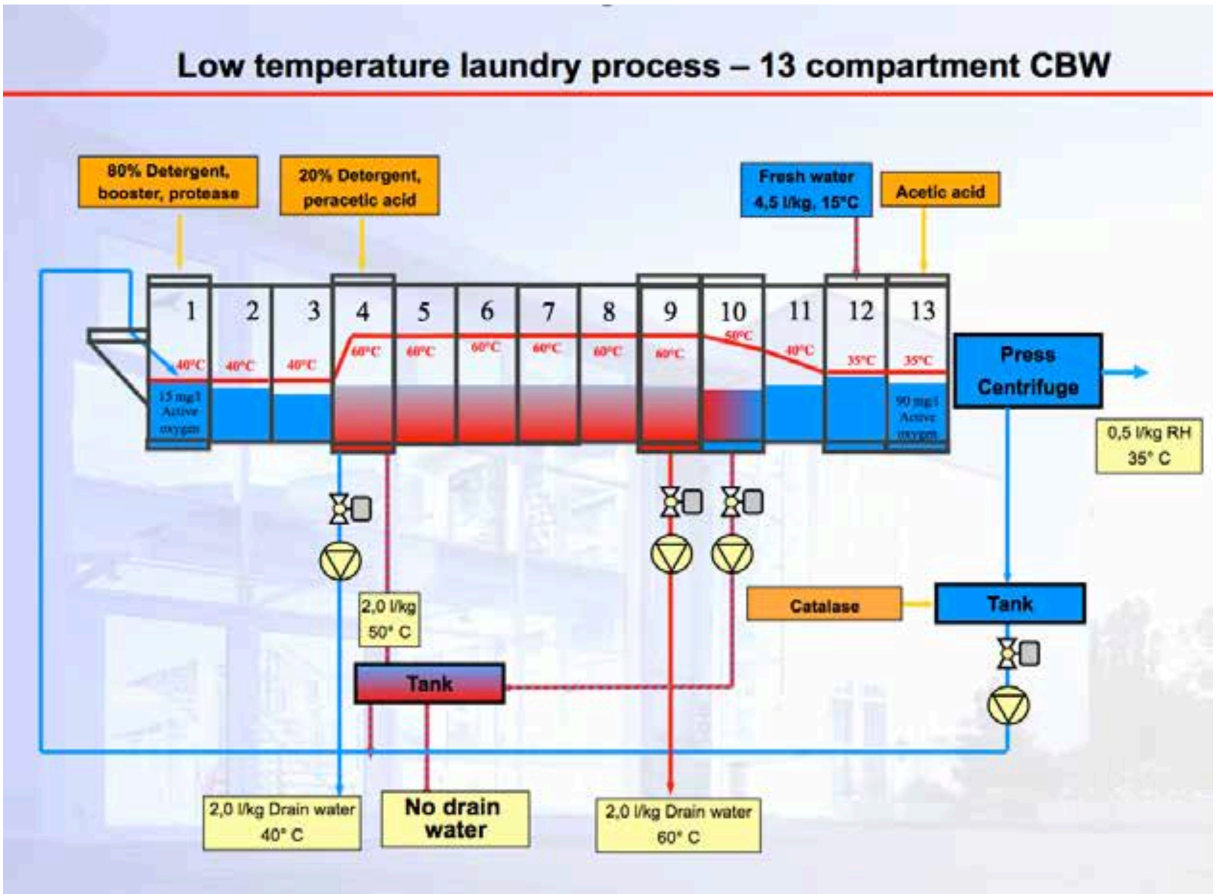

Figure 4: Low temperature laundry process on a 13 compartment CBW

9. COMPUTER EXPERT MODEL

9.1 System of Computer Expert Model

The SMILES Computer Expert Model system for the Smart Laundry-2015 is developed and designed to calculate the estimated possible water and energy savings for using the new technologies in an individual Smart Laundry. The system is a projection of the realised consumption figures of a specific industrial laundry in practise on a virtual industrial laundry in the system. These figures can be varied in the system, where the effect of application of one or more of the new adapted technologies can be calculated.
The savings by interaction between the new technologies are figures based on the SMILES research results in certain set-ups and cannot be calculated exactly for the individual industrial laundries as the Smart Laundry-2015 exists as
a) it is a guideline model with maximum savings per technology and
b) there are numerous different circumstances and parameters in which the individual industrial laundries are operating and which are influencing its water and energy consumption levels.

The outcome of the SMILES Computer Expert Model system is to provide a good insight to an EU industrial laundry for his individual potential water and energy savings possibilities if he is going to apply new technologies.
On basis of the outcome new technologies and equipment for future investments can be selected.

An EU industrial laundry has to carry out the following 3 steps for e.g. changing the figures of the energy consumption of his laundry in the SMILES Computer Expert Model system:

1. Measure the actual energy use and CO_2 production related to the kg laundry processed;
2. Look at the status of the industrial laundry regarding the application of the 16 new technologies;
3. Forecast a possible energy and CO_2 production if applying the new technologies.

The system will take the following consumption figures into account:
- Gas
- Electricity
- Fuel oil
- Petrol / Diesel
- Water

This execution is a possible practicle way to look after all laundry processes, conditions and measures for lowering the energy consumption per kg laundry processed.

Each industrial laundry can be disposed of a personalised web based dashboard to monitor and benchmark his CO_2 emission.

9.2 Bench marking and innovation monitor

A parallel bench marking and innovation monitoring system can validate both the actual energy demand and the potential of energy savings of the future innovations. The Computer Expert Model system converts the type of laundry (hospital, towels, mops, mats etc.) to the type of material they are made from (CO, PES/CO and PES) to have a better estimation of the possible savings. Indeed, an industrial laundry only washing cotton has far more water to evaporate from wet to dry compared to another industrial laundry that is specialised in polyester materials. The residual moisture content after mechanical extraction for cotton is about 50 %, for polyester/cotton about 35 %, for polyester 10 %.
All water must be heated up to 100 ^{0}C for evaporation. The less water the textile will contain after washing, pressing and spinning, the more savings can be reached.
An energy database oriented management system puts the data in readable figures and pictures to compare the figures of a specific industrial laundry with the average of other companies in the EU-wide sector.
So, the individual industrial laundry will receive an indication where it stands

compared to its competitors in the EU sector regarding its energy use and possible CO_2 emissions reduction.

In the project lifetime the production and energy data were collected from the industrial laundries within this project from the past years in order to achieve information on what savings are realised in real practise.
The SMILES Computer Expert Model system for the Smart Laundry-2015 makes it possible to compare the EU industrial laundries regarding their average energy and water consumption per kg laundry processed. The smallest period for receiving a representative average is a month, but a year is the best period for the comparison as season variations in the loads of the machineries are included.

9.3 Computer Expert Model for measuring energy consumption

Furthermore, the possibility to connect the machinery of an individual industrial laundry to an interface for the periodic transportation of data to a database has been prepared within the Computer Expert Model system for the Smart Laundry-2015.
At this stage the model system is feeded through manual input of data per EXCEL spreadsheet. Data of an industrial laundry can become available through two canals:
a) directly from machines with digital interfaces and
b) data on invoices of suppliers (water, oil, gas, electricity, and chemicals).
This new tool provides the specific knowledge to EU industrial laundries for their individual performances regarding energy consumptions and CO_2 emissions compared with other industrial laundries as well for their individual consumption levels in the past years. The tool provides excellent graphical representations of the data development (Fig. 5).

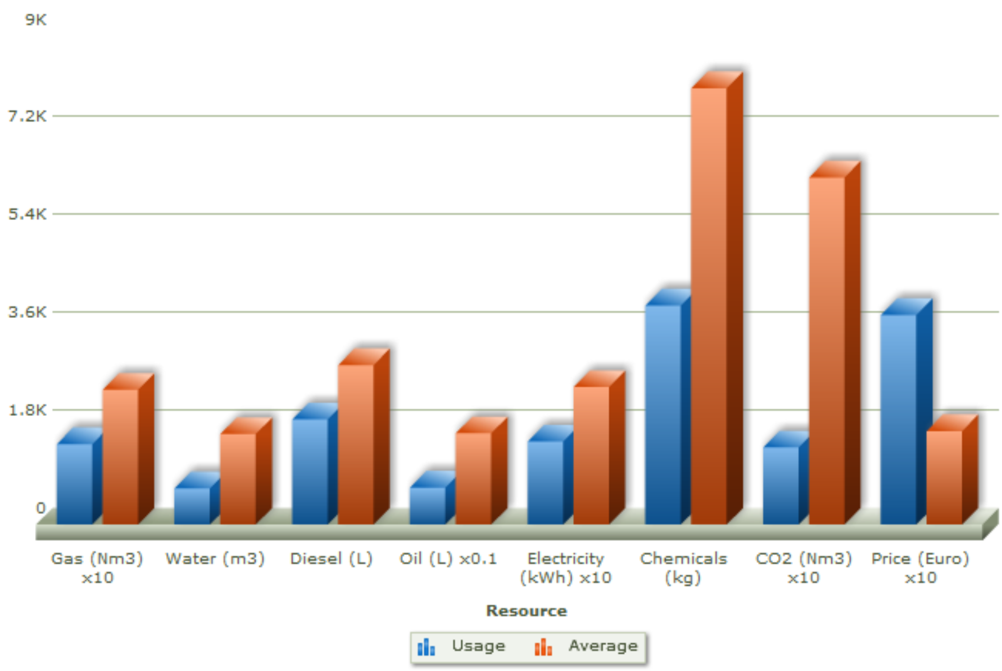

Figure 5: Example of benchmark of one industrial laundry (blue) compared to the average of all industrial laundries in the system (brown)

9.4 Use of Computer Expert Model with examples from practise

The SMILES Computer Expert Model system will collect data (location, machinery, quantitative important customers, kind and volume of material for washing, etc.) in to establish a profil of the industrial laundry at first.
Secondly, the collection of the production and energy data over a period of time is calculated to achieve the average consumption per kg laundry processed.
Thirdly, a new technology can be adapted to check which influence this technology has on the average consumption figures.

As an example the computer expert model system has calculated that a 10 tons industrial laundry per day changing from 90 °C to a 60 °C laundry process will economise about 5,4 Mio kWh, corresponding with about EUR 30.000,00 / year. This industrial laundry was a member of one of the participating Associations in the project.

Furthermore, project participant KREUSSLER (individual SME) has developed a simple calculator for water savings in only the washing department and will make this available for industrial laundries through its website (www.kreussler/com).