Greening of industry Network Conference
November 15-18 1998, Roma

Paper for the workshop
The sustainable household: technological and cultural changes
organised by Philip Vergragt

CLOTHING CARE IN THE SUSTAINABLE HOUSEHOLD

Carlo Vezzoli

CIR.IS Politecnico di Milano
Dip. DI Tec
via Bonardi 3, 20133 Milan, Italy
tel. and fax + 39 2 2399 5124
E-mail Carlo.Vezzoli@polimi.it

INDEX

ABSTRACT

This paper summarises the first results of a research on sustainable scenario clothing care activities in households. This work is part of a European research project titled Strategies towards the sustainable household. The research project aims at developing and evaluating strategies for the transition to sustainable households. Besides clothing care, two other functions are being studied in this project: the Shelter and the Nutrition.
The Clothing care function is being studied in three countries: Germany, Italy and The Netherlands.

The clothing care function covers all those activities carried out by the user of clothes and/or by the clothing care services during and at the end of the clothes' using phase. In other terms the acquisition (activities for purchasing or renting of clothes), the maintenance (cleaning, ironing, rearranging, ordinary substitution of wear parts, storing, etc.), the up-grading, the reparation, the reuse, and the collection/destinations of de-missed clothes (recycling, combusting, landfilling).
All those household activities have a high environmental impact, mainly due to the energy consumption for cleaning and drying, the water consumption for cleaning, the emissions of various consumables for caring when used, the energy consumption and the solid waste due to clothes' purchasing/substitution.
Environmentally promising technical-cultural options and various social-organisational ways to fulfil the function (individual Vs social, inside the household Vs outside, services Vs products, do it yourself Vs final products, sharing Vs individual use) are being studied. With the help of stakeholders, some scenarios of possible development towards sustainability will be formulated.
Those scenarios will then be evaluated in environmental, economical and social terms.

1 INTRODUCTION

The household clothing care function is analysed and framed here in the perspective of developing and evaluating strategies for the transitions to sustainable households. This is part of a European research project titled Sustainable Household. Strategies towards the sustainable household.
The Clothing care function is being studied in three countries: Germany, Italy and The Netherlands.

Clothing care covers all those household's activities carried out by the user of clothes and/or by the clothing care services, at the beginning, during and at the end of the clothes' using phase. In other terms the acquisition (activities for purchasing or renting of clothes), the maintenance (cleaning, drying, ironing, ordinary substitution of wear parts, storing, etc.), the up-grading, the reparation, the reuse, and the collection/destinations of de-missed clothes (forwards to recycling, combusting or landfilling).
All those household activities have a recognised high environmental impact, mainly due to the energy consumption for cleaning and drying, the water consumption for cleaning, the emissions of various consumables for caring, the energy consumption, the transportation and the solid waste due to clothes' purchasing.

Since 1970, ownership levels and the average number of times the appliances for clothing care are used have increased and the total EU energy consumption has tripled, even though energy efficiency of those appliances has improved during the last two decades.
More than 90% of the EU's 144 millions households in 1994 own a washing machine, while driers are possessed by approximately 2 millions households (driers are more common in Northern areas).
Ownership levels of appliances for clothing care have been steadily increasing over recent decades and the number of installed appliances is still expected to grow in the years to come. This is mainly due to increases in the number of household in Europe. On another level the consumption of clothing care has increased due to higher and higher rhythms of clothes turnover (in Europe, some 16 kg of textiles are consumed per person per year) mainly because of their cultural obsolescence.

Anyhow potential for improvement of the eco-efficiency of this function fulfilment do exist.
Some studies (GEA, ENR, 1995) on the potential for energy savings by proven technological improvements, show that the efficiency of the average new European washing machine can be improved by 25% for washing machines and 10 % for driers. When considering the infrastructural options and consumer beheviour saving potential in addition to that deriving from technical options it may be possible to reach (for washing machine) another 25% through improved consumer behaviour, and up to another 25% through infrastructural options. That means that when seeking for sustainable solutions they have to be the results of an integration of technical, infrastructural and consumer oriented options.

The matter is then to investigate environmentally promising technical-cultural options and various social-organisational ways to fulfil the function in order to prefigure promising scenarios and to assess them in environmental, economical and social terms.

2 THE CLOTHING CARE FUNCTION

The following points out what is meant by **clothing care** within the context of this research: the possible activities, behavioural attitudes, appliances, tools, consumables, services and systems that could enter into this definition.
Its legitimization in environmental terms will then be drawn out.

2.1 Definition of the function and system boundaries

By **clothing care** we imply all those activities carried out by the user of clothes and/or by clothing care services on his/her behalf, at the beginning, during and at the end of the clothes using phase.
That means the boundaries of the system range from the acquisition, the maintenance and the collection (the destination) of the de-missed clothes.
Listed below are the activities entering into the above definition:

- *Acquisition*. Activities for purchasing or renting of clothes
- *Maintenance*. Activities for preserving and maintaining the operative functioning conditions: cleaning, drying, ironing, ordinary substitution of wear parts, storing, etc.
- *Adaptation and up-grading*. Activities related to the change of external conditions (e.g. new household, new geographical location), but also to the change of individual conditions (physical growth and cultural change)
- *Reparation*. Activities focused on fixing damages or tears due to wear or improper use
- *Reuse*. Use of clothes or parts of them in a different market or in a secondary use (e.g. de-missed clothes used as rags for household cleaning)
- *Collection/destination of de-missed clothes*. The recycling, combusting or landfilling.

Of course, all the connected activities have to be considered (e.g. transportation to the service site).

It is worthwhile underlining that the given definition of clothing care concerns, as pointed out, even the product life extension.

2.2 Fields of analysis

Two fields of analysis concerning clothing care can be used to schematise its characteristic: these are the **technical-technological** and the **social-cultural** fields.

In **technical** and **technological** terms, a more sustainable clothing care scenario relate to the development and the innovation of all those alternative options that may influence, more or less directly, the environmental performances. In this perspective the activities to be considered overcome the mere operations of clothing care. For example, the development of fibers and fabrics that facilitate or reduce the use of materials and energy consumption for caring.
The areas of interest under this perspective are listed here below.

- The development of appliances, tools and other durable goods for clothing care (e.g. washing machines, dryers, irons, sewing machines, closets, etc.)
- The maintenance and reparation of appliances, tools and other durable goods for clothing care (users and/or services)

- The development of consumables for clothing care (e.g. soaps, detergents, materials for drying, ironing, conservatives tablets, etc.)

- The development of energy and water resources and distribution/procurement systems (e.g. the distribution of water and energy, the type of water and energy, etc.)

- The development of fibers and fabrics
- The development of clothes

In **social** and **cultural** terms, a more sustainable clothing care scenario relates, more or less directly, to all those environmental opportunities offered by the possible changes in consumer behaviour and socio-organisational patterns.
While analysing user expectations for clothing care, it is also important to analyse the social expectation for clothing. This is obvious as far as the latter influences the former. (e.g. if we do not use cloth, we do not need to take care of it).
The above means that both the alternatives for change in clothing care and clothing itself may have an important outcome on the environmental improvement of the caring activities. In other terms the analysis of environmentally interesting social and cultural innovations has to be made both for *clothing* and *clothing care.*

2.3 Needs for clothing care

This chapter aims at framing the needs for clothing care fulfilment.
The analysis on the clothing care function or better still on the needs of its fulfilment could distinguish what is a physical and what is an aesthetic-semantic issue.

Physical needs, such as the protection from cold or warm temperatures, are assumed to be the starting point (even though this could be sometimes difficult to prove).
This is not aimed at eliminating aesthetic-semantic needs, but, in fact, to start from physical needs -which are somehow more objective- to understand where and how socially satisfactory alternatives could be identified (alternative aesthetic-semantic needs).
Here below is a list of *physical needs* for clothing.

- Protection from cold temperatures
- Protection from warm temperatures
- Protection from external atmosphere (e.g. rain, wind, etc.)
- Protection from specific external conditions (e.g. dangerous working environment)
- Protection from accidents
- Hygienic protection
- …

Semantic needs are connected with communicating something to the others and/or to ourselves throughout the clothes and the way we care about them.
Here below is a list of *Aesthetic-semantic needs* for clothing.

- Pleasing others
- Enhance own personality
- Conforming to a gender
- Conforming to a group
- Conforming to an age
- Show hierarchy
- Show status
- Attract mates
- Ceremonial exhibition
- Cleanness and hygienic sensation
- …

Furthermore the functions of clothing depend, more or less, upon other factors as listed below.

- Season
- Age
- Gender
- Inside use
- Outside use
- Daily use
- Night use
- Special use
- Ceremonial use
- Leisure
- Sport activities
- …

The socio-cultural impact of fashion

In this framework and on the ground an important matter to consider is fashion. In fact rapid changes in fashion increase demand for clothes. It means new clothing is produced and the old, still usable, is discarded.
In reality even without changes in fashion, seasonal trends and the habit of consuming force people to buy new clothes. It is a common social attitude to feel that is not proper to wear the same shirt more than once a year, since it is culturally obsolescent.
Fashion strongly influences changes in the entire system. As a matter of fact, several studies have shown that in Western European countries customers buy clothes for the following reasons, in order of priority: 1. change in fashion, 2. attractive price, 3. special occasion (e.g. wedding), 4. label, 5. habit to shop regularly and 6. to replace old worn-out garments.
The fact that the physically compulsory reason is many times the least important, should scare us. In fact, it shows that there could be room for improvement. The ultimate message should be that the consumption of clothing could be cut down.
Anyhow fashion shows that rapid and massive change may occur in a short time. This could be seen as a positive attitude as far as the change could be oriented towards a more sustainable way of caring.
Even advertising may lead to a reduction in consumption. (e.g. Levi's commercials keep their jeans popular for a long time even raising up the status of old Levi's. That result in growing sales of second-hand Levi's).

Easy clothing care

Another trend worthy to be underlined at this level is that of easy clothing care. There are signs that this could be leading value criteria in the next coming year. In fact, in the last century a high improvement has been gained as soon as the electrical domestic appliances have entered the household. Meanwhile the attention to hygienic condition has increased, even over its objective need.
Today, in this frame, we (Western European countries) are living a period in which there is a growing perception that the time we personally are ready to dedicate to those activities is shorter and shorter.

3 THE ENVIRONMENTAL IMPACT OF CLOTHING CARE

3.1 The environmental impact of the clothes chain

When concerning the clothe chain, from fibre, textile and clothes production up to their disposal, some studies have shown that the environmental impact of the using and caring phase is much heavier then in the other phases.

A german study (COGNIS 1994) shows a ratio of 85% primary energy consumption for washing and ironing (without electrical ironing) and15% for production[1].

Fig.2 Energy consumption in the clothing chain (%)

Another study (Van Holsteijn en Kemma, GEA, 1994) indicates the following figures as far as the energy and material consumption are concerned in average dutch household in 1992.

Fig. 3 Energy consumption in the clothing chain (%)

Fig.4 Material consumption in the clothing chain (%)

Even though those fugures are related to the energy indicator only, they are meaningful to understand the heavy weight of the using phase in general terms.
Differencies may arise when considering different types of textile (see figure below) or, even more important, different life spans of clothes. In fact, the life span decreases the environmental impact of the production and de-mission phases increase respectively.
Nowadays in the European countries, the life span is less and less related to the wearing out of clothes and more to their cultural obsolescence. New fashion 'imposing' high rhythms of clothes substitution are socially and culturally dominant in today's Western European countries.
Anyhow the using and caring phase, wuold determine a very high enviromental impact.

Fig. 5 Comparison of fibres in terms of energy consumption (production of raw material and spinning of fibre)

All the above shows that focusing on clothing care (the activities directly related to the household) is, in enviromental terms, very appropriate even when concerning the whole of the clothes chain.
In other terms, creating new scenarios of the clothing care activities and assessing their environmental impact is meaningful even when considering the clothing in general (i.e. even the production of fibre, fabrics and clothes).

Furthermore caring includes even purchasing of clothes (see boundaries definition) and hence frequency of clothes change. In other terms, the less frequently we purchase clothes the less frequently fibres, textiles and clothes have to be produced and disposed off (i.e. extension of clothes' life). That means that the caring activities indirectly reduce the environmental impact (whatever it is) of the fibers, textiles and clothes production as well.

3.2 Clothing care main unsustainabilities

The most unsustainable activities, among those mentioned to be part of the clothing care, are generally known to be those of washing and drying, folowed by ironing. In

[1] The study has been conducted on army clothes. Assumptions made are (functional unit): amount: 1 kg; usage: 4 years; washing cycle: weekly.

those cases the unsustainability is due to energy (from carbon content sources), water and detergent (or other consumables) consumption.
It has to be noted that the use of drying machines could be very different in different countries, being much more relevent in Northen European countries.
Other Impact are caused by: water emissions in terms of quantity and quality due to washing and quality of consumables for caring (e.g. euthropisating emission of detergents); transportation in terms of energy consumption and air emissions due to purchaising or transportation of clothes to sites for caring.
Finally, as mentioned before, it is relevant the indirect impact of clothes productions and disposal (solid waste) due to clothes frequency substitution.

The figures below show the energy (direct and indirect) consumption related to a certain amount of clothes (MJ/kg) to be washed, ironed and dried (GEA, ENR, 1995). These are, as mentioned, the most critical processes in clothing care.

Fig. 6 Direct and indirect energy requirements for domestic washing, drying and ironing (MJ/kg)

More detailed analysis on washing machine's energy consumption breakdown per cycle, illustrate that the heating energy (for water, heat loss and load) constitues the 86% of the total in the 60° C cotton cycle (see figure below).

Fig. 7 Energy consumption breakdown for an average washing machine in Europe (60° C cotton cycle)

As regards to driers (air vented driers) the main cause of energy consumption is due to water out processes (see figure below).

Fig. 8 Energy consumption breakdown (%) for an average air vented tumble drier in Europe (4.5 kg cotton load)

Further consideration could be made when comparing domestic appliances, with larger scale systems. An analysis conducted in the Netherland shows that domestic washing is more energy , water and detergent consuming than neighbourhood washing and laundries. This is basically due to scale dimension and high professional profile of those latter options.

Fig. 9 Energy requirements for domestic washing drying and ironing, neighbourhood washing centres and laundries

Another interesting result comes out when assessing consumer behaviour. An analysis (Grießhammer, Bunke, Gensch, 1997) of the environmental impact of 3 washing behaviour (the "wishy-washy" average household, the "smart" model household and the very hygienic "scrubbed" household) shows a potential of energy consumption reduction to 23% when comparing average to "smart" behaviour.

Fig. 10 Washing machine energy consumption per different household type (%)

3.3 Potential environmental improvement of clothing care

Technically feasible potential
The following paragraph summarises the outcome of a research (GEA, ENR, 1995) evaluating potential improvement of technical, consumer and infrastructural options on the systems of washing and drying. The comparison is made between the average European case and several 5 to 10 years feasible options.

As far as the washing machine is concerned, combining technical design, consumer and infrastructural options the (energy could be reduced to 9%, the water to 34% and the detergent to 58%). It should be noted that in this case the infrastructural option is given only by the switch from electric to gas heating system, with a gain of 24%.

Fig. 11 Washing machine energy savings potentials: technical design, consumer and infrastructural options

Fig. 12 Washing machine water savings potentials: technical design, consumer and infrastructural options

Fig. 13 Washing machine detergent savings potentials: technical design, consumer and infrastructural options

As far as the drying machine is concerned, the energy saving potential is 3% with proven options and 49% with experimental one (see the figure below).

Fig. 14 Venting drier saving energy potential

Consideration
From what above something could be argued. Firstly all significant saving potential do exist for what are recognised to be the most unsustainabilities. Secondly, the solutions, to be sustainable, have to be the results an integration of technical, infrastructural and consumer oriented options.

4 POSSIBLE EVOLUTION AND KEY STRATEGIES: A FRAMEWORK

Here are presented possible innovation for the functional fulfilment on two levels.
- *Promising evolution of the clothing context*
- *Possible evolution of clothing cares.*

4.1 Innovation of the clothing context

As mentioned above, on a **first level**, what is discussed and proposed are some possible ways in which clothing may evolve.
It is here made a distinction between social and cultural aspects of innovation and technology is not always precise. In other terms, they may easily overlap or, better, the former may influence the latter or vice versa.

Anyhow, in order to outline the typologies of possible alternatives, we provide below some examples of possible innovations, classified as

- behavioural and cultural changes with regards to clothes as such
- technological options with regards to clothes as such.

Overview of environmental interesting behavioural and cultural changes

Based on the defined framework, listed below are some possible changes in lifestyle and behaviours with respect to clothes need. The following list aggregates changes lead by various factors: functionality (comfort, wearability, etc.), communication (variety, personalisation, need for changes, etc), cost.
The list is an open list to be improved and country specialised.

- Comfort as a leading quality (e.g. use of light and ergonomic clothes)
- Easy wearing as a leading value (e.g. easy to wear, no need for frequent changes; one dress usable for all the day and night)
- Environmental friendly clothes as a leading value (e.g. eco-label, other information on clothes, fibre and fabric production and distribution).
- Clothes sharing (several persons using the same clothes in different moments)
- Uniforms as a leading value (i.e. no need to wear certain clothes to conform to certain context)
- Clothes rising quality with time and use (e. g. leather jackets)
- Acceptability of clothes warn out and tear of time (e. g. blue jeans)
- Belongings to a wide group throughout clothes similarity (e.g. university students wearing the same uniform)
- Homogenisation/similarity of clothes being a sign of a non-classiest society (lower differentiation in cloth typologies)
- Wearing only what is essential
- Inexpensive purchasing as a leading value

Some of these options may lead to the clothes life extension (e.g. clothes rising quality with time and use). Others to minimisation of clothes (e.g. use of light and ergonomic clothes). Other to minimisation of clothes production (e.g. Inexpensive purchasing as a leading value). Other more towards reduction in clothes variety and hence to optimisation of clothes caring cycles (Uniforms as a leading value).

Overview of environmental interesting technological options

A preliminary list of possible technological innovations in clothes is listed here below (clothing care options are described after).
The list is an open list to be improved and country specialised.

- The clothes (fabrics) are naturally and biologically produced
- The clothes (fabrics) are synthetically produced for single-use-clothes to be recycled
- The clothes (fabrics) are produced for single-use-clothes being biodegradable
- The clothes are simplified into two fundamental layers: one directly over the skin (with its hygienic functions) and the second one for other external functions
- The clothes are made of smart fabrics for clothes that automatically adjust to climate changes (e.g. from winter to summer)
- The clothes are locally customised (e. g. tailored clothes constructed from prefab garment sections, body scanners)
- Do-it-yourself clothes design (e.g. very simple CAD programs to allow consumers to design their own clothes)

4.2 Technical and cultural options (innovations) for clothing care

Given the above clothing contextual opportunities for change, here are identified some alternatives to evolve towards a more sustainable way of clothing care.

The techno-cultural options below are introduced through some examples of possible innovations. With the same criteria the socio-organisational options are then discussed.

Innovative technical options

With the aim of providing necessary background knowledge for carrying out the research, a preliminary analysis of the technologies and their possible development is presented. The lists of technological options are organised and classified in a sort of matrix intersecting *clothing care* activities (see definition above) with the following *technological areas of concern*.

- Appliances, tools and other durable goods
- Energy resources and water procurement system
- Fibres, yarns and fabrics
- Finishing processes
- Clothes

The options have been filtered giving particular attention to those opportunities leading to a reduction in environmental impact (e.g. improvement in cleaning, drying, ironing processes; long lasting easy to clean fibres). For example, when analysing the characteristics of appliances and tools, attention has been given to the consumption of energy or materials, their emissions and their durability (single use, short, medium or long life products).

When analysing the characteristics of the system, it is necessary to consider issues regarding the quantity of materials, energy, emissions and solid waste, the harmfulness and toxicity of the emissions and wastes and the shortage of materials and energy.

The analysis of technologies is on a worldwide level on what is currently available or is proven to be in the next future.

Appliances, tools and other durable goods for clothing care

Keep lasting

- Clothes that are industrially washed have a short life expectancy (half of that of normal textiles), because of the tough mechanical agitation.

Keep clean

- Rooms for clothes ventilation (e.g. during the night)

Cleaning

- Local stain remover
- Washing machine down scaling (15-20%)
- Eco-button
- Tubeless drum concept
- Fuzzy logic
- Software up-gradable washing machine
- Gas system
- Washing machine heated directly by district heating (heat exchanger in the machine)
- Professional laundries (consume less detergent, water and energy per kilogram of laundry)
- Bubble washing (the laundry is moved by water jets)
- Closed water system washing machine
- Supercritical (pressurised) CO_2 especially for large scale use (pilot tests proved to be more efficient than normal dry cleaning solvents)
- UV washing machine (especially for large scale use)
- pre-soaking the laundry in the laundry -basket
- Bacteria laundry closet
- Microwave washing machine

Drying
- Room combining storing and drying sun and/or wind energy supplied
- Microwave dryer

Consumables for textile care
Cleaning
- Enzymes for soaking/prewashing
- Low temperature detergents
- Multi-component detergent dosage (automatic/improved detergent dosage system)
- Washing ball

Energetic resources and water procurement system
Cleaning
- Local rain water for washing machine instead of tap water
- Closed water system
- Water quality differentiation (drinkable and non-drinkable)
- Use of energy in the night time

Drying
- Use of freezer and refrigerator heat (or other lost heat) for drying
- Sun/wind energy for drying

Fibres, Yarn and Fabric
Keep lasting
- Synthetics and acetate are quite resistant to insects and microorganisms.
- Fibre blends (e.g. PES/CO, PA/WO) are one way of improving durability (or easy maintenance)
- The addition of synthetics sometimes prohibits washing in high temperatures, which may in turn shorten the life of the textile product, if stains can't be washed out.
- Polyamide is durable and elastic.
- PCP (Highly toxic!) can be used to prevent degradation and mildew during storage.
- *Metallic parts* are durable. (Non-electroplated metal parts are more advisable because they don’t creates toxic sludge)

Keep clean
- Fibre-coating preventing dirt from attaching.
- Flat, smooth surface structures of the fibre are soil repellence
- Four channels polyester fibres create a system structure able to carry out the clamminess from the skin to the outside of clothes and get faster its evaporation. It does not keep odours.

Cleaning
- Synthetics are good for minimising energy consumption in washing
- Coated fabrics. They have an extra layer, solid or porous (nowadays usually a polymer film or polymer foam (PVC, PA or PUR)).
- Cotton can be washed hot for fighting fungi and bacteria (e.g. army socks).

Drying
- Fibre quality and type of weave or knit affect wrinkling and drying
- Fibre-coating speeding up the times for drying

Ironing
- Synthetics are good for minimising energy consumption in drying.
- Fibre coating could make ironing superfluous.

Material life extension
- All textiles can be torn to fibres and recycled to make non-woven or yarn for weaving a knitting.

- Wool is recyclable to almost similar wool products, silk too, and cellulose-based fibres to papers.
- Synthetic polymers are by nature very durable, thus the best choice would be to recycle them.
- Recycled textile felt is used among others for oil recovery from spills, furniture upholstery, and insulation of buildings.
- Synthetic fibres from used carpet can contain as much as 40 % dirt by weight and are therefore not easy to just melt down and respin. So far they have been recycled to lower end-uses, like floor tiling.
- *Polyethylene* is fairly clean and energy-efficient to produce and ideal to incinerate, and also recyclable (main applications are decorative fabrics, floor coverings and protective clothing)
- 100% wood cellulose, can be recycled, landfilled or digested in sewage. In aerobic digestion the fibre's tensile properties are significantly reduced after four weeks

Finishing processes

Keep clean

- Metal (chromium, tin) compounds and organochlorides in finishes against microbiological attack and odour (used mainly in camping textiles and carpets, but sometimes also in socks and sportswear).

Keep lasting

- Though meant to be permanent, many finishes wear off and may leave the fabric even more vulnerable to the unwanted substance (water, soil).
- Bleaching weakens the fibre.
- Most synthetics don't need bleaching, but white pigment can be used.
- Some cottons grow quite white by nature (silk, too).
- Flax bleaches naturally in washes and sunlight.
- Man-made fibres can also be coloured already in the fibre production stage. The result is even and permanent. The trouble has been that producers prefer to make relatively big amounts of each colour.
- Without mordants, natural dyes' resistance to washing and light are mostly poor. Environmentally conscious dyers prefer iron sulphate or alum (contains aluminium, which is not entirely free from suspicions), but also heavy metal (copper, tin, chrome) mordants are used.
- Prints can make textiles more fun, but trendy prints can become old-fashioned very fast.
- Fashionable or aesthetic finishes such as moon, sand, and stone washes often weaken the fabric
- Easy-care finish (in manufacturing, this finish can consume quite a big proportion of all energy) saves the energy for ironing.

Clothes

The consumer must be given the information for correct use and care. Instructions for care (washing, etc.) should accompany textile products (preferably sewn on to it).

Keep clean

- Dark textiles usually need less washing (e.g. especially furniture or interior textiles that are difficult to clean should not be made from sensitive materials).

Keep lasting

- Leather, wood or mother-of-pearl (natural) materials don't stand heavy washing
- Coconut shell and other natural materials are very durable.
- Metallic parts are durable and washable (non-electroplated metal parts avoid toxic sludge).

Cleaning

- Detachable garment (e.g. collars, bands and cuffs) to be washed separately can reduce the amount of laundry:
- The lining (in clothing) shrinks more (because it is not pre-shrunk) than the main material, or shoulder pads/interlinings don't stand water.
- Underarm patches with delicate (silk) dresses or garments that are worn very seldom reduce the need of dry cleaning.
- Protective clothing for dirty jobs (e.g. in a very oily jobs, a protective overall made from a cheap non-woven material to be use until it is oily enough and then put it to waste).
- Everyday furniture benefits from having detachable, washable covers.

Adaptation
- Modular textile product (e.g. carpet).
- Multi-functional clothing

Reparation
- Carpet with mechanical bonding of a loop fabric that covers the entire underside of the carpet to a pressure-sensitive hook tape that is applied to the floor. It allows easy removal, repair, access and changes to the floor design.
- Repair kit for special clothes (e.g. Gore-Tex sell repairs kit for their jackets).

Re-manufacture use of textile products
- Clothes *Re-manufacture* for second use (e.g. esprit experiments with a virgin collection (undyed new clothes), that is for second use transformed individually into cheaper, colourful garments).

Reuse of textile products part
- Textile products accessories can often be reused (e.g. buttons, etc.)
- Cascade approach (e.g. cut the textile into patches or carpet rags and use those as material for new textiles).

Recycling
- Design the product for easy of disassembly, if required for recyclability (e.g. Gore-Tex is recycling the Teflon and polyester polymers)
- Unbreakable combinations of metals and fabrics should be avoided (like metal-zips or rings, because in the environment metals can be toxic, and in waste incineration metals act as catalysts in the forming of toxic compounds.

Disposal
- Disposable underwear

Innovative cultural expectation options

Listed below are some examples of possible cultural options meaning innovations in user expectation.
The following lists are indicative and have to be improved and country specified.
- Environmental friendly clothes as a leading value (e.g. eco-label, other information on clothes caring and disposal, maintenance, reusing, recycling, etc.)
- Objectivity in perception of hygienic condition of clothes (abandonment of whiter than white ideology)
- Easy care as a leading value (long lasting - no need for frequent shopping, easy washing, drying, ironing, repairing, etc.)
- Inexpensive care as a leading value

The options have been filtered giving particular attention to those opportunities leading to a reduction in environmental impact (e.g. minimisation of resources consumption for caring).

4.3 Key strategies

Here below are outlined some key strategies to reduce the environmental impact.

Some strategies are in any condition (independently) favourable (e.g. the use of energy during the nighttime). Most of them, otherwise, present a trade-off dependence upon various possible conditions (household life style, geographical location, etc.). That means that they have to be judged in relation to every specific scenario that is going to be built.

Enhance of clothing care Vs easy clothing care
Keep caring about things usually is understood to be environmental promising in the sense that it leads to a product life extension.
On the other side, easy care does not mean always better environmental performance; easy care could be interesting in environmental terms, whenever it conducts towards lower material and energy consumption.

Scale dimension of specific caring process
In technical terms there is an environmental optimum, given a certain process for clothing care. Furthermore, it could be identified a consumers group dimension optimising the operative conditions (scale dimension).

Reducing varieties of clothes Vs differentiating/specialising clothes
Reducing varieties of clothes may lead to the environmental optimisation of the taking care systems because of scale economies connected advantages.
Specialised clothes may lead to the most efficient ways and processes of taking care (e. g. washing) in relation to every functioning and environmental condition.
For example, washing very oily clothes consumes more detergents and energy than normal laundering, and usually oil is difficult to decompose in waters. In this case a good idea cloud be a protective clothing overall, made from a cheap non-woven material, to be used until it is oily enough to be put to waste.

Mono-component clothes Vs multifunctional demountable ones
Mono-component may lead to an easiest way of treating and handling clothes and hence to an environmental optimisation of the system.
Multifunctional parts may lead to an overall reduction of clothes production.
Detachable parts may lead to an overall reduction of caring operation (e.g. washing only easy to dirt part; use underarm patches with delicate (silk) dresses or garments that are worn very seldom to reduce the need of dry cleaning).

Multi-purpose Vs single-purpose
Multi-purpose garments helps to reduce the total amount of clothing.
Single-purpose garments may optimise the activities for taking care.

Consumer know-how Vs fuzzy logic systems
Instructions for use and care is helpful, especially when the product is new (like polypropylene underwear for sports in cold climates).
Fuzzy logic system works as a black box for user automatically optimising the functioning condition; hence reducing the resources consumption, reducing the emissions and prolonging the life of the clothes.

Uniformation Vs differentiation of taking care processes and treatments
It could be interesting to improve scale economy and reduce resource consumption through the use of the same process for today's differently treated types of clothes.
Differentiation of clothes or clothes parts (small, large, costly, difficult, personal and not-personal) could be environmentally interesting as well (e.g. small personal laundry at home and the remaining handled by an outside professional washing service).

Focused actions Vs large scale interventions
Remove stains at once when they appear, may reduce the frequency of washing. Large scale caring may minimise the consumption of energy and material as well as emissions.

Renting clothes services Vs individually owned products
One of the well-functioning, sustainable ideas, i.e. textile rental has become increasingly popular. It has always been used for special festive wear like masquerade costumes and wedding gowns. New markets have been opened by companies specialising for example in carpet rental and cleaning, rental and laundering of working clothes and babies' nappy services.

Natural materials Vs synthetics
Energy consumption is different for each major fibre type. Natural fibres need little in production, but usually demand more energy and chemicals in further processing and maintenance.

Recycle Vs biodegradation
Almost all textile waste can be recycled. Most textiles recycling are down-cycling. Fibres lose quality when recycled. Still, recycling saves in the total outlook of materials and energy.
Synthetic polymers are by nature very durable, thus the best choice would be to recycle them. But there is a demand for biodegradable synthetics, partly because recycling does not work well enough or is too expensive, and partly because some synthetic polymers or products can not easily be recycled.

4.4 Preliminary socio-organisational forms for clothing care

Below there are some main general socio-organisational forms of household that may combine the above mentioned technical and cultural options in different ways.

Shared facilities in housing combine social user behaviour with an inside technical organisation of the clothing care.

Clothing care in combination with other activities combines social user behaviour with an outside fulfilment (organisation) of the clothing care.

Small optimised appliances may combine the requirements of individual user behaviour with an inside fulfilment (organisation) of clothing care.

Clothing care service at home combines the requirements of individual user behaviour with an outside fulfilment (organisation) of clothing care.

The presented options are mapped in the following figure. The axis are the *household (technical) organisation* (more or less inside or outside the household) and the *user (social) behaviour* (more or less individual or social attitude).

Fig 15 Socio-organisational map

Consideration

A promising leading concept to be studied is the easy care, or better eco-efficient easy clothing care. As already said this is one of the strongest trend among those readable in the next coming changes of the way we behave towards clothing care.

In this framework we may identify two main strategies when the easy care is due to the fact that a service is caring about it and on the other side when technical system for caring is made in such a way that is less time intensive even thought internally carried out by the household members.

When considering easy clothing care in the sense that an external body is providing the service, several strategies could be viewed under the general concepts of: non-owning and vertical integration in the clothing chain (production of fibre, textiles, clothes, renting caring and disposing of clothes). It is remarkable that the offer of a more integrated mix of product and service has interesting economic opportunities in this direction.

When considering easy care as internally carried by the household several strategies could be seen under the following concepts: owning and specialised localised (specialised clothes, use of local resources, specialised appliances, lower sense of hygenicity, less buying/longer lasting clothes).

5 BIBLIOGRAPHY

AA.VV., *La moda nel secondo dopoguerra*, Clueb, Bologna, 1992

AA.VV, "Speciale Casa - Le nuove abitudini dell'abitare", *Io Donna*, Corriere della Sera,13, Milano,1998

AA.VV., *Moda*, Rapporti, Sole 24Ore, 1998

AA.VV*, Tra Sogno e Bisogno*, foto e saggi sull'evoluzione dei consumi in Italia, Coop - Longanesi, Milano, 1986

G. Bassanini, *Tracce silenziose dell'abitare*, Franco Angeli, Milano 1995

Centro Tessile Cotoniero e Abbigliamento, brochure *Oeko-Tex Standard 100*, Busto Arsizio, 1998

Citer, "Le fibre intelligenti", *Citer News*, 2, 1998

COGNIS - Gesellschaft für Bio- und Umwelttechnologie mbH: Untersuchung des Bekleidungsverbrauchs einer bundesdeutschen Behörde. In: Umweltverträgliches Stoffstrommanagement - Konzepte, Instrumente, Bewertung. Studien im Auftrag der Enquete-Kommission des Deutschen Bundestages "Schutz der Menschen und der Umwelt" (Hg.), Bd. 4, Bonn, 1994

Di Nallo E., (a cura di), *Il significato sociale del consumo*, Laterza, Bari, 1997

Q.Delanaunay, *Histoire de la machine ‡ laver*, Presse Universitaires de Rennes, Rennes 1994

ENEL, La domanda di energia elettrica degli utenti domestici dell'Enel, 1993

Euromonitor (1998): European marketing data and statistics, London, Vol. 33.

Federtessile, *fashion 1000*, Milano 1990

FutureConceptLab , "Home Scenarios ", website, 1998

A.Gigli Marchetti, *Dalla crinolina alla minigonna: La donna, l'abito e la società dal 18° al 20° secolo*, Clueb, Bologna, 1995

Group for Efficient Appliances (GEA), *Washing machines, driers and dishwashers*; Volume I (Basic assumptions and impact analysis), Denmark, 1995.

Group for Efficient Appliances (GEA), *Washing machines, driers and dishwashers*; Volume III (Background Reports no 7, 8, 9), Denmark, 1995

ISMERI EUROPA, *Indagine campionaria sul possesso e sull'utilizzo degli elettrodomestici*

ISTAT, *Rapporto sull'Italia 1997*, Bologna, Il Mulino, 1997

Legambiente*, Guida verde*, Bramante, Milano 1996

PA Consulting (1992): Eco labelling criteria for washing machines, UK Ecolabelling Board, London.

D.Pescovitz, ed., *Reality Check - The Future of Clothing*, Wired Magazine, 3.11, 1997

F.Sozzani, "Diario Minimoda", in *Pelle di Donna-Moda e Bellezza*, Piccola Biblioteca Stampa Alternativa, Roma, 1998

Vintage Vixen Clothing Co. , "Fashion History", web site, 1998

"Home Life", in "Vision of Future" Web magazine, Philips, 1996

Van Holsteijn en Kemna, 1996, Sensitivity Analysis of energy improvement for washing machines; research for the Commission of the European Communities, Delft.

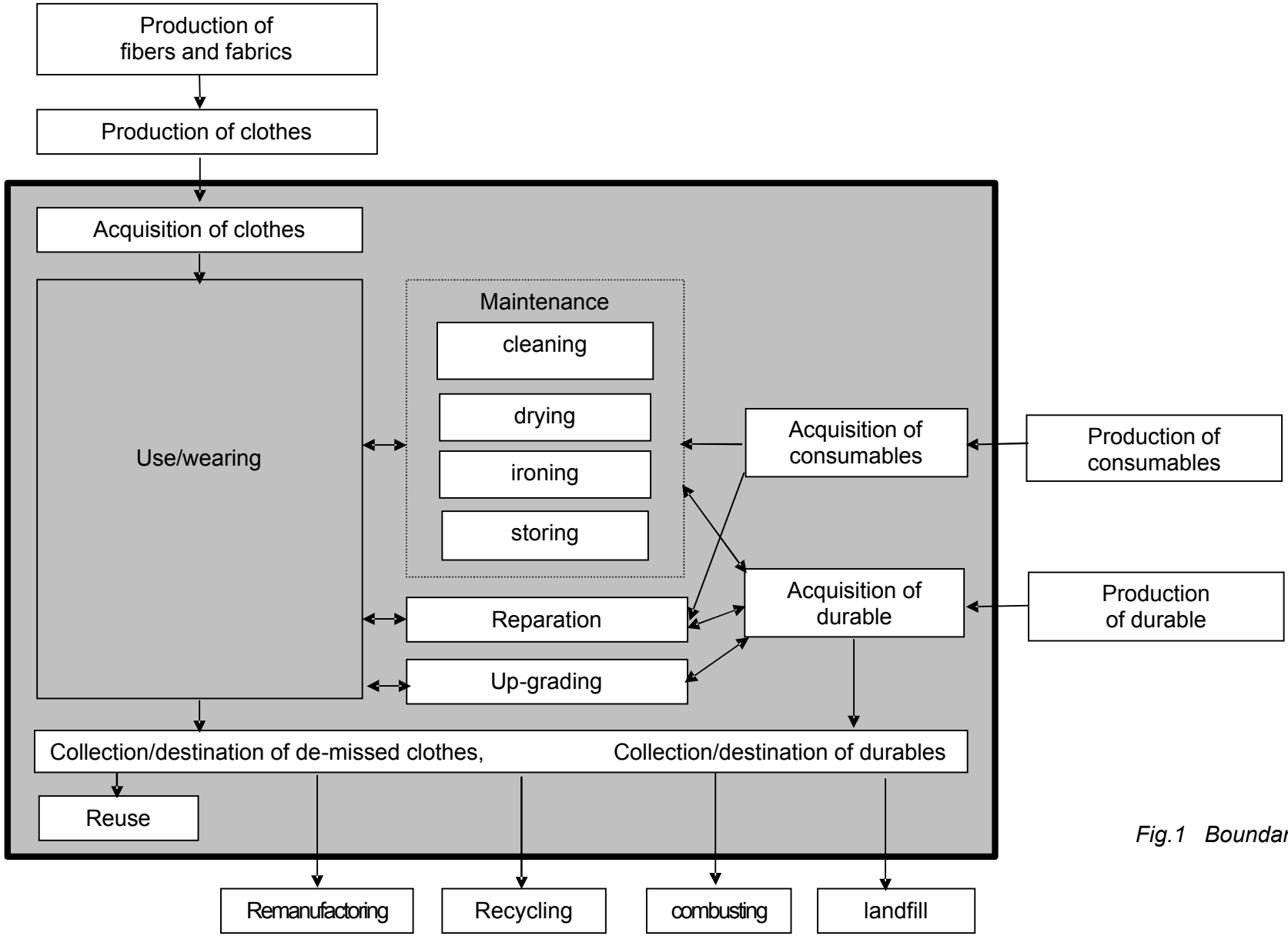

Fig.1 Boundaries for the system

Fig.2 Energy consumption in the clothing chain (%)

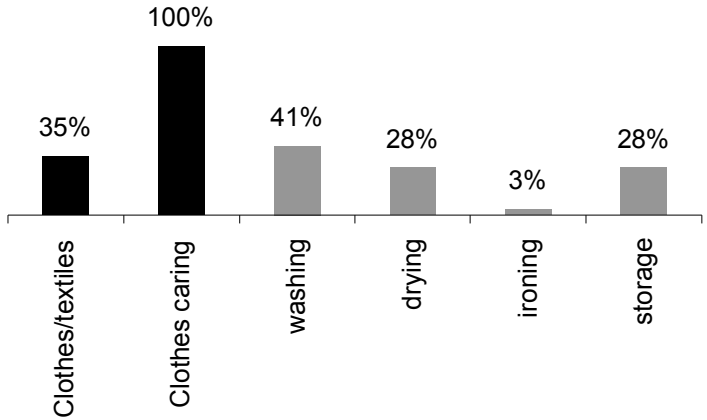

Fig. 3 Energy consumption in the clothing chain (%)

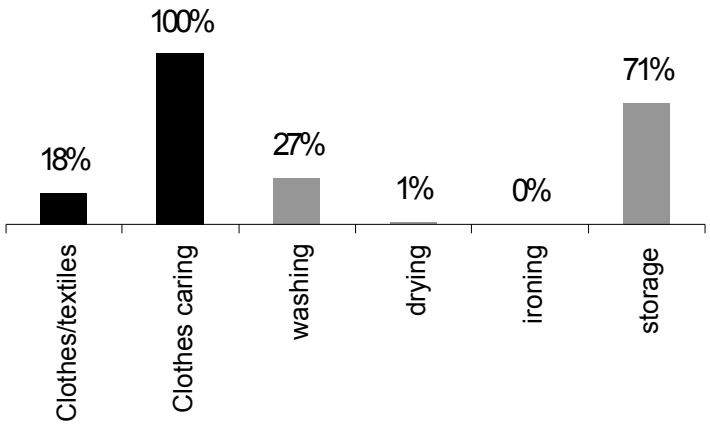

Fig.4 Material consumption in the clothing chain (%)

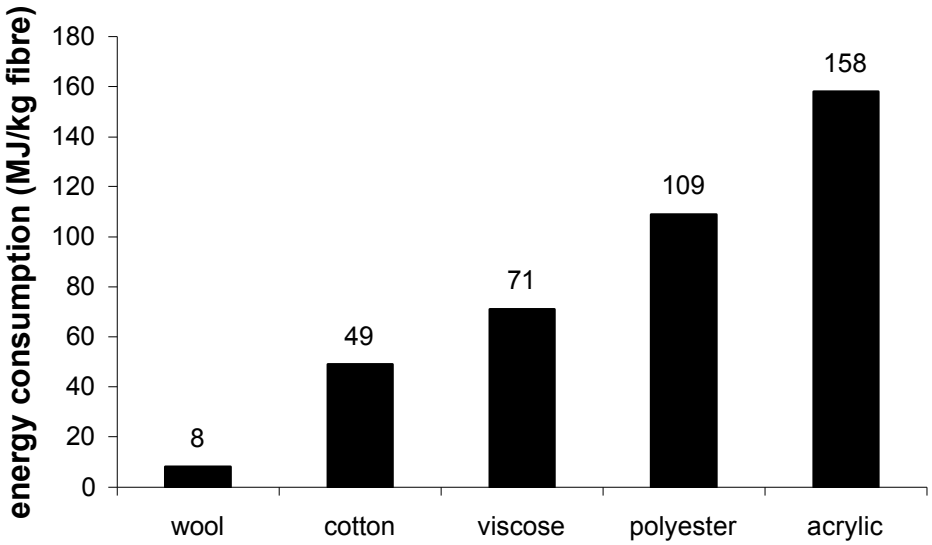

Fig. 5 Comparison of fibres in terms of energy consumption (production of raw material and spinning of fibre)

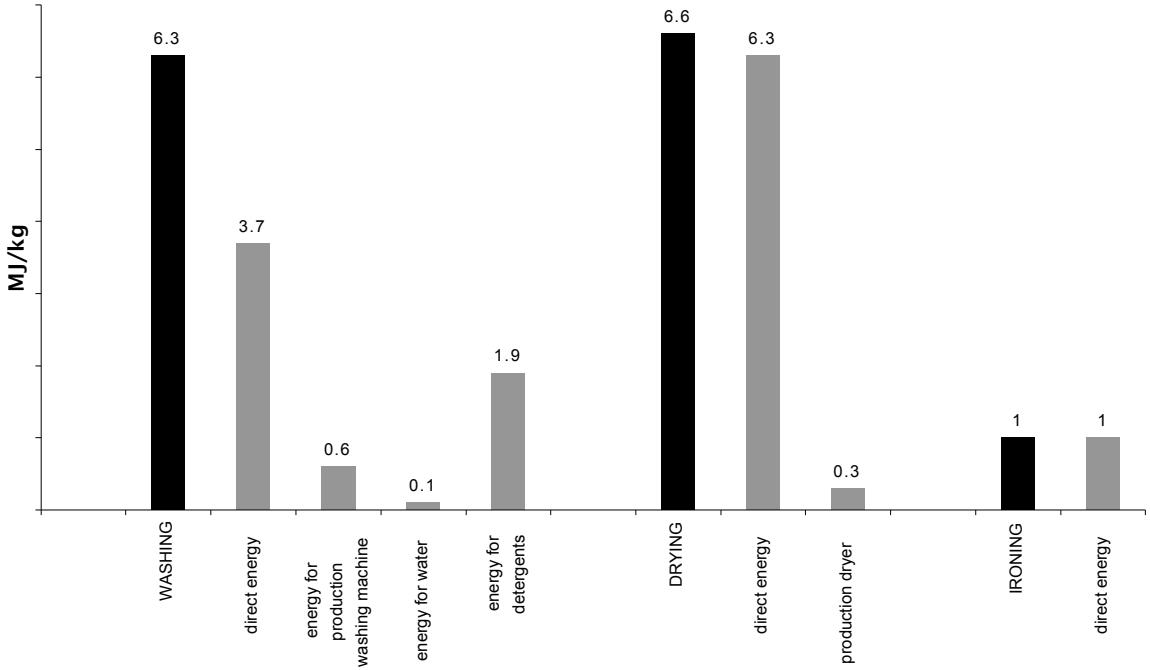

Fig. 6 Direct and indirect energy requirements for domestic washing, drying and ironing (MJ/kg)

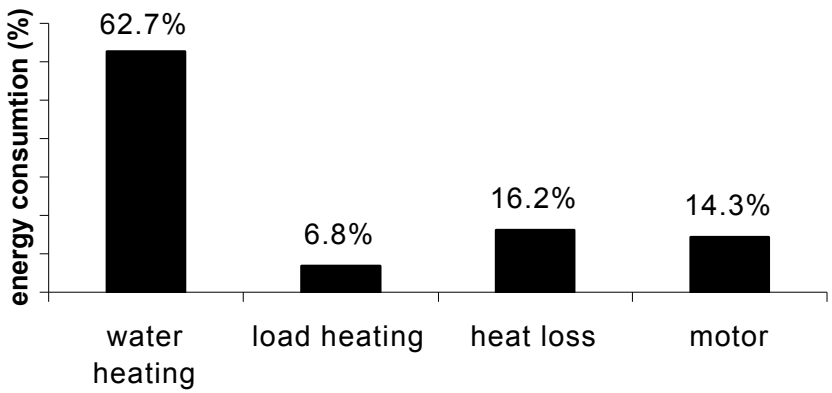

Fig. 7 Energy consumption breakdown for an average washing machine in Europe (60° C cotton cycle)

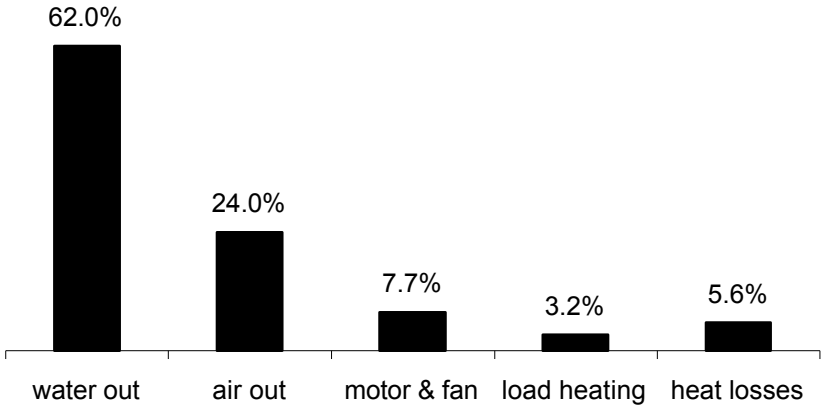

Fig. 8 Energy consumption breakdown (%) for an average air vented tumble drier in Europe (4.5 kg cotton load)

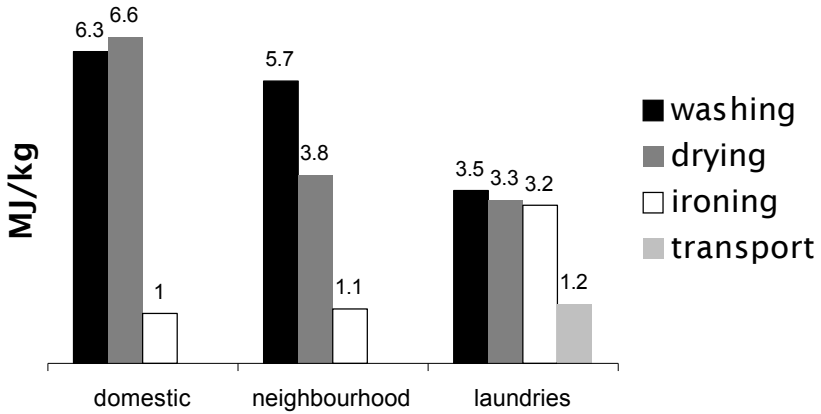

Fig. 9 Energy requirements for domestic washing drying and ironing, neighbourhood washing centres and laundries

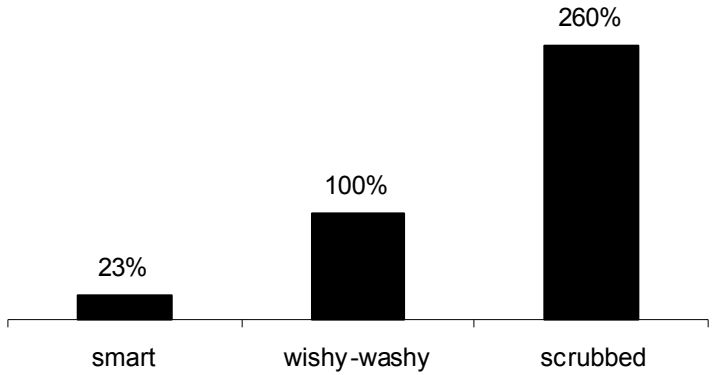

Fig. 10 Washing machine energy consumption per different household type (%)

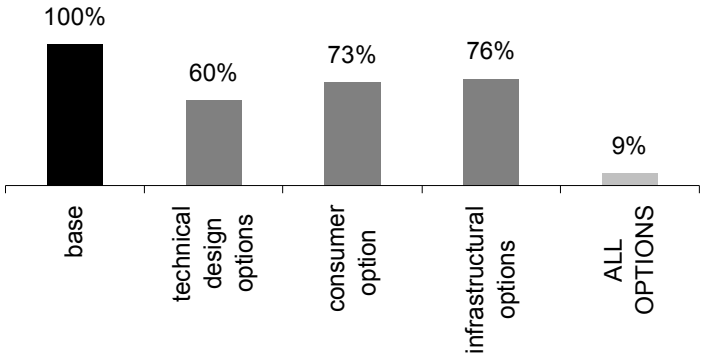

Fig. 11 Washing machine energy savings potentials: technical design, consumer and infrastructural options

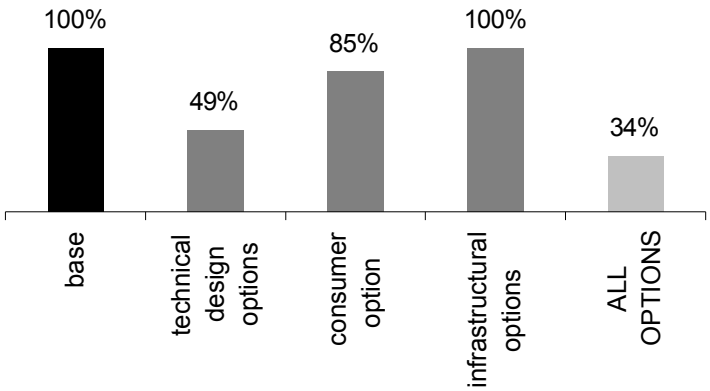

Fig. 12 Washing machine water savings potentials: technical design, consumer and infrastructural options

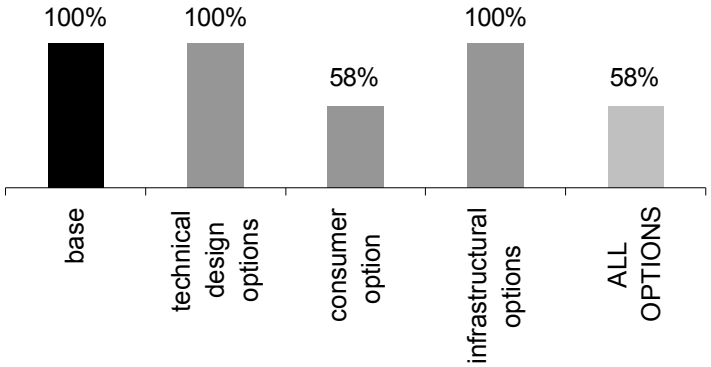

Fig. 13 Washing machine detergent savings potentials: technical design, consumer and infrastructural options

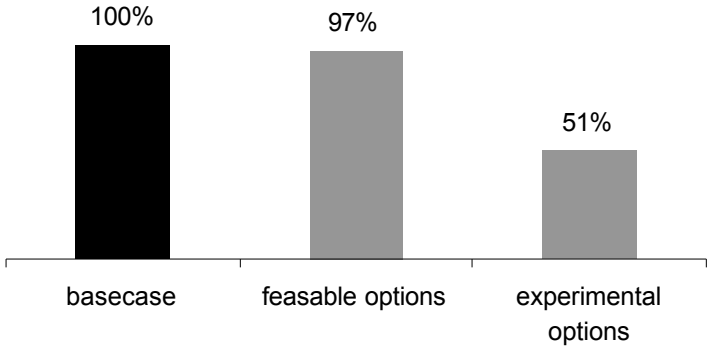

Fig. 14 Venting drier saving energy potential

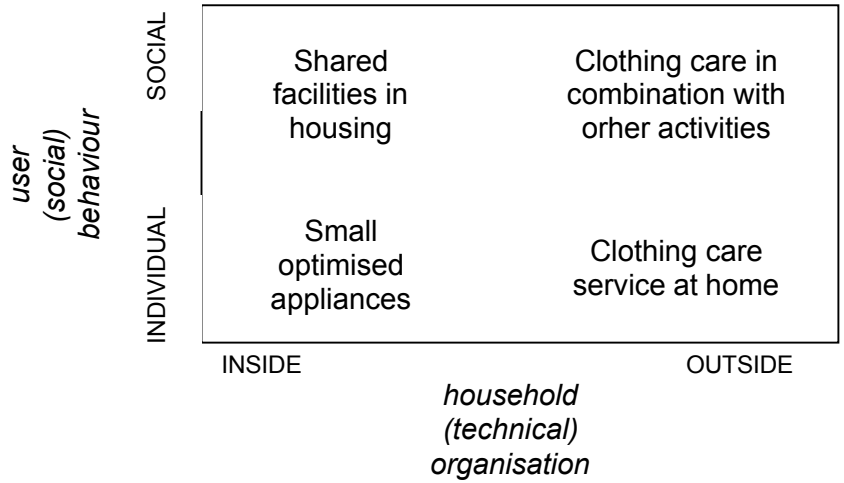

Fig 15 Socio-organisational map