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Regulatory support of entrepreneurs, researchers and Labor Unions networking for an eco-work friendly alternative to a monopolized trajectory - the innovative construction of plant-fiber insulation in Denmark

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Introduction

This is the innovation history of the development of a new kind of insulation bat on the bulk market, based upon well-known renewable raw materials: flax and hemp fibers. The focal innovation is the insulation bat, but co-dependent on both pawing through hindering regulation and on R&D along several steps in the product chain: from plant growing and harvesting techniques, plant treatment to product manufacturing. The new kind of insulation bat has been developed by Dept. of Plant Production, The Danish Agricultural Advisory Center whereas a consulting inventor in the network of the Department invented the fiber-air-fluff machinery. The Ministry of Food (agriculture) and the Ministry of Environment and Energy have economically supported the product development. EU-structural funds have provided capital and support for the establishment of the production site of a new insulation fabric based upon flax and hemp. The full-scale production to reach commercial successful innovation and establishment of the fabric took place between 1997 to 2000, thanks to a network of semi-public and private actors. A green construction entrepreneur *Egen Vinding og Datter* (EVD) and *Storstrøm Regionale Udviklingsselskab* have co-financed the new company, Danish Natural Insulation Lmt.. EVD and other green construction entrepreneurs have supported the market pull for the new insulation bats along growing interests among inhabitants in green or ecological housing. But the main drivers pushing for alternatives to synthetic mineral wool bats, has been Træ-Industri-Byg (TIB), a union for carpenters joiners and construction workers, in co-operation with eco-profiled insulation manufacturers.

The new insulation bat is an innovation by the fact that the all processes in the production chain from harvesting flax and hemp to forming bats has been developed in a entirely novel way, that is both environmentally in front and very cost competitive. The harvesting and pre-treatment techniques have been simplified for making free short-fibers of flax. The subsequent processing technology is an innovation as it handles fibers completely different to the standard

methods within textile industry in a new air-forming process making fluffy felt for mats or bats. The process is compared to normal flax processing, rather simple and it is expected that manufacturing will be for bulk markets on competitive prices, whereas existing flax insulation products are too costly. The new kind of bat contains only 5% PE fibers for dimensional stability, whereas the German flax insulation manufacturers as Heraklith have up to 18% of synthetic fibers in their products. A special flax harvesting technique has been developed and a dry fiber treatment process invented for producing free fibers (bale opening, hammer-mill treatment, bolting) and a new air-forming technology has been invented being able to fluff or felt fibers into a stabile bat with a high volume of insulating air. The bat is bonded by synthetic fibers fixated in a thermal process.

The outcome of the innovations is a soft wool bat that maintains its high level of initial dimensional stability. The product comes very close to the thermal insulation and technical profiles from the mineral wool products made from glasswool and rockwool, which cover app. 80% of Danish insulation markets. It fulfills mostly all safety-, insulation and technical criteria that Danish and European standardization organizations have developed for insulation materials in normal housing units. It can be that it is necessary to use fireproof gypsum plates behind the insulation according to fire-technical standards. Furthermore it has a respiratory capacity that preserves a natural indoor climate, allows transport of moist, so it might be that less vapor sealing of the construction is needed as normally used for humidity reasons. The product is made from plant fibers that are easy to grow and do not demand heavy use of fertilizers or pesticides. In comparison to normal mineral bats the plant based bat do not count for the same heavy amount of energy to make the fibers and it is free from all-chemical binders and additives. Thereby the insulation bats are biodegradable and easy to re-cycle, and also due to the shape and biological character of the fibers they are not supposed to cause lunge cancer. Finally the product is non-irritating to skin to work with. The Danish Agricultural Advisory Center has patented the new invention.

More than 5 million tons of man-made mineral fibers are produced annually in more than 100 factories located throughout the world. The mineral insulation materials used in Denmark are two kinds of multinational brands:

- Glasswool: molten glass spun into glass fibres and woven into large pieces in roles, but also bats with a Bakelite binder, from the multinational brand Saint Gobain/Isover, (in Denmark formerly Glasuld). In Denmark Saint Gobain/Isover employed 238 persons, produced 41.000 tons of glasswool, and had a turnover of ECU 47 million. They cover app. 30% of Danish market sales.
- Rockwool, molten, crushed rocks spun into rock fibres and woven into bats also with a Bakelite binder, from the multinational Danish Rockwool International. In Denmark Rockwool DK employed 800 persons, produced app. 180.000 tons of rockwool and had a turnover of ECU 100 million in 1999. They cover app. 50% of Danish market sales.

Both insulation types are based on non-renewable, but long-time available resources (basalt stone, clay, lime, sand, soda and dolomite) that take quit an amount of energy to be molded and spun[1]. Both types of insulation are based upon highly toxic and carcinogenic substances for the binder (Bakelite); Phenol is a suspected cause of cancer (skin, liver and kidney) and also considered forming allergies. Formaldehyde is carcinogenic and causes severe allergy. Formaline is also carcinogenic and acutely toxic. The molting processes cause evaporation of No, Sox and some HCL. When heated or incinerated

[1] Glasswool products 20.000 MJ per ton, rockwool 13.000 MJ per ton

on as low temperature as 200 degree Celsius the Bakelite binder from mineral wool have recently proven to form methyl isocyanate, an acute toxic substance that may cause chemical bronchitis, asthma and chronic diminishing of lung capacity. Glasswool slabs contain also a big amount of Borax serving as a fire retardant - a toxic substance suspected to endanger embryos.

Both types of insulation bats contains vast amounts of small particles/fibres (below my15), expected to cause bronchitis and stone lungs, and both are suspected to cause lung-cancer during manufacturing and insulating. Man-made mineral fibre products release airborne respirable fibres during their production and use. In general, as the nominal diameter of man-made mineral fibre products decreases, both the concentration of respirable fibres and the ratio of respirable to total fibres increase. Exposure levels in glasswool production have generally been 0.1 respirable fibre/cm^3 or less; in rockwool production, exposures have been somewhat higher. Higher occupational exposures may occur when man-made mineral fibre products are used in confined spaces, such as in the application of loose insulation.

The environmental innovation in insulation bats made from flax/hemp is a major social-market break-trough for a new product in a diapoly insulation sector that basically has maintained a very conservative product culture. When it comes to fundamental technology and substances used, the mineral wool products have basically been unchanged. The mineral wool industry has been proactive when it comes to housekeeping techniques and use of re-cycled material (Holm & Klemmensen, 1999). The insulation manufacturers Rockwool have especially put efforts into LCA-based green window dressing. The green profiling has predominantly addressed the LCA-based argumentation, that the energy and emissions used to produce energy bats will pay back by factor 1000 in energy savings. Not that much has been said about alternative materials obtaining the same profile, but not causing lung-cancer and other user- and occupational heath aspects. Rockwool and Glasuld (Saint-Gobain/Isover) insulation products have for 2 decades in fact been perceived as socio-environmentally benign products that helped Denmark fighting energy crisis and lowering energy loss/consumption from heating. A number of state subvention schemes - for insulation in old housing areas, in homes with electricity based heating, industry - have fostered the current path-dependency on mineral wool. Thus, no efforts up till 1998 within construction, energy or occupational health policy have been made to pose other kind of demands to the insulation bats besides functional insulation, fire proof technical value and the like. The co-dependency between the Fordistic insulation industry and the Danish state is not only related to energy-policy, but also all the technical standards settling and consultant advising in construction is said to be highly influenced from especially Rockwool industry representatives.

The history of the environmental innovation in new insulation bats/techniques, stems accordingly not initially from the superior role of public regulation, but from:

- workers and Unions against hazardous occupational conditions, leading to efforts for enhancing alternative insulation manufacturers
- growing number of eco-communities developing and demanding alternative insulation materials
- the up-coming of a new kind of environmentally oriented entrepreneurs

Thus the focal innovation on plant fiber insulation bats that is going to be analyzed in the following case-story will ask to find the positive background for the promotion among these factors. We will also present the supportive role of subventions for R&D in alternative insulation by the Danish Energy Agency, and R&D support for non-food bio-mass crops and products by the Structure-directorate,

Ministry of Food. Supplementary the support from the Ministry of Environment and Energy on financing key-persons from the alternative insulation actors in standard settling (EU-Flower, Danish Standard and CEN) and subventioning innovations in alternative insulation for the benefit of "green jobs". But before that we turn to give a rather deep description of barriers for any substantial transformation of the hitherto mineral wool-based insulation market in Denmark. This is due to the fact that the technical innovation has been deeply dependent on a legal, technical and discursive disclosure of the mineral wool favoring regulatory institutions - product and construction standards, occupational health rules, and technical insulation value scoring. Our paper follows then these headings:

1. Barriers and hinders to environmental innovation in the construction sector
2. The transitory push by workers, unions and role of occupational health regulation
3. The transitory push by ecological housing groups, entrepreneurs and beginning environmental orientation in the construction sector
4. Institutional and regulatory response on transitory push
5. The focal innovation in flax/hemp insulation
6. Final remarks.

We will focus on the specific flax/hemp innovation as the initial product of a few inventing actors and secondly commercial initiation by a unique mixed economy relationship between R&D units, subventions schemes and entrepreneurs. The innovation is in process of being implemented in a full-scale production within a new firm and the products are still to hit the sales market (ultimo 2000). Thus, a reconstruction of the development process will start from exterior events, stakeholders and networks to our focal company, Danish Natural Insulation Lmt (Dansk Naturisolering).

Barriers and hinders to environmental innovation in the construction sector

The bearing of the case is founded on the wide range of environmental problems related to the construction sector. The development of new insulation materials based on flax and hemp fibre is only one element in a number of transitory processes and the establishment of new developmental paths, aiming at a reduction of environmental load and the consumption of resources in relation to construction and housing in general.

To assess the conditions and opportunities of carrying through such environmental transformations in the construction sector, it becomes important to understand how the environmental effects are related to the economic and organisational development of the sector. And to understand, both the technological paths and the institutional setting (regulations, knowledge centres), which is produced as part of this development of the sector. All these elements can not be analysed in this study, but based on other studies we can examine some of the factors determining the conditions of a transitory process towards new insulating materials.

In 1997 the construction industry had a turn over of app. ECU 15 billions and had 140.000 employees. The industry has had the main part of its activities in the national market – and often the construction industry has been used as a socio-economic regulating means. The industry has been subject to large changes in turn over, and in particular the distribution between maintenance and construction has varied enormously (Dahl et al. 2000).

After the 2ond world war, the construction sector in a period with high growth rates went through a process of industrialisation. In parallel with this process a re-structuring of the sector was established, which now set the framework for efforts in an environmental transitory process. It encompasses the way the sector was integrated in the national economy, the structure of enterprises, relations between the different parts of the product chain, the strategies of product- and production development, the branch related knowledge institutions and the public regulation of the economic and technical conditions of the industry.

In the 1960-70'ties the industry was at its height. In the period 1960-79 820.000 new residences were built. In this period the industry was industrialised – and the production organisation was based on 1) that most parts were pre-fabricated (such as pre-cast concrete panels) and 2) the use of 'totalentrepriser' (all functions in a construction project gathered at one developer firm). The principle in 'totalentreprise' is that the development firm (based on requirements and ideas from the builder) forward a total project including projecting, the building process, financing and management of the process. This organisation reinforced the tendency to operate with standard solutions based on pre-fabricated elements and contributed to the establishment of relatively rigid technology paths. In addition the industrialised montage process introduced numerous new material and chemicals into the building industry leading to a new set of problems regarding indoor climate and the durability of the houses.

In the period 1960-79 the share of building based on montage grew from 15 to 70 %. As a result a major part of the work process was shifted from the building site to material industries where growing efficiency in mass production. The production of building components, such as the production of tile, concrete and insulation, was based on mass production of standardised goods. At the end of the period the main part of the construction work still was taking place in small enterprises, having small orders (small series) and performing labour intensive tasks. But in relation to montage building a high degree of standardising of tasks has taken place.

Looking at the insulating industry, the energy crisis in the 70'ties resulted in a very high expansion in the market of the insulation materials, both in new construction and in rebuilding/maintenance. Glasuld and Rockwool became dominant players in the Danish market to stuff houses with more insulation, and their turnover grew tremendously. The structure of the industry, the legal regulation of building (fireproof rules, insulation, and humidity) and the knowledge institutions of the sector all contributed to the maintenance of a certain dominating technological path. Although it is the functional aspects of the construction (housing) that is assessed, the dominant technological path has often been 'written into' the legal regulation.

The building regulations (Bygningsreglement BR-S 98 and BR 95) lay down the legal requirements in relation to the approval of new constructions/housings that were based upon the technical properties of mineral wool. Safety and health aspects were given priority, but indeed energy saving demands were superior. Concerning insulation, regulation prescribes directly, that in the construction of firewalls the insulating material has to be produced of non-inflammable materials – that is, according to the definition, materials produced of non-inflammable raw materials (favouring glasswool and rockwool and excluding flax and hemp). In this way a specific technology path were 'freezed' – when defining way of production instead of functionality. In the building regulations reference is made to the calculation of thermal insulation values (U-values), that are listed in Danish

Standard 418. The values in DS 418 are decided officially by the Danish Standard Organization, but in reality by a working group heavily influenced by members employed by mineral wool producers and a number of their "supporters" (interview, KS). Besides of the values in DS 418 it is possible to obtain insulation values from a public initiated, but private organisation, Varmeisoleringskontrollen[2](VIK). VIK is using testing and control methods for of the thermal properties of insulation products decided upon in the organisation Varmeisoleringsforeningen, dominated by consultants and managers from Rockwool and Saint-Gobain/Isover. The values from as well DS 418 as from VIK favor traditional insulation materials (e.g. mineral wool) by the fact that extra 25% penalty points are added to the latter from arguments like non-sufficient control, moist capacity and variation in quality (Esbensen, 99, Bisgaard, Miljø Isolering). As a result, based on the building regulation and the decisions in VIK, constructors using alternative insulation materials are obliged to operate with 1.5 thicker layers insulation compared to mineral wool– despite the fact that the materials has (measured) lambda values at the same level as mineral wool.

Another example of how the building regulation supports 'the mineral wool track' is the demand of an inner vapour barrier. This moist blocking layer is necessary when insulating with 'mineral wool', as it cannot absorb humidity and the vapour for this reason will liquefy and can cause damages in timber constructions. This is not the case with alternative materials, such as the paper granulates and flax and hemp insulation bats. The flax and hemp fibre can absorb and transport some humidity, and for this reason the problem with damp can be solved with less use of a vapour barriers (although it requires a proper design of the construction). Despite this – full use of vapour barrier still is common practise, also when using alternative insulation materials. The absorbing capability was exactly the property that lay behind the punishment points that VIK issued.

In addition, the dominating insulation path also influences the education of craftsman and constructors. Mineral wool has been the undisputed way of doing things – supported with free access to instruction manuals and books on the use of mineral wool for construction (Ulden i kanten, 1999).

The environmental load of construction is related to the organisation and dominating technology path of the industry. The construction sector is characterised by a huge flow of materials. In a life cycle perspective the sector is among the most resource consuming and environmental harmful activities in the Danish society. A key figure is that 30 % of the Danish produced raw materials are used in construction. In addition building involves the use of a large number of chemicals, leading to problems in the working environment, in the use (indoor climate) and in the disposal phase (Henriksen 2000:16). To day more than 6000 different chemicals, all hazardous substances, (Henriksen 2000:16), are used within construction. The point at stake is, that this increased use of chemicals relates directly to the driving rationality of the industry: cost reduction and efficiency in the construction process. This has spurred the introduction of new materials and of chemicals. Environmental impacts, occupational health and indoor climate problems have not been given corresponding attention in this process.

Construction of housing makes products with a high life time, thus environmental problems related to the phase of operation and use surpasses the loads related to the construction process. 30 % of the total consumption of energy and 60 % of our consumption of water takes place in the domestic

[2] .Established in 1978 by the Danish Ministry of Housing, the Danish Association of Manufacturers of Thermal Insulation Materials and the Danish Society of Chemical, Civil, Electrical and Mechanical Engineers (DIF). In 2001 VIK was taken over by Bureau Veritas Quality Insurance (BVQI)..

residence, as part of our household (ibid.p.16). On top of this, substantial problems are related to the outlet of wastewater and the disposal of waste. Thus, the main part of the existing housing was constructed in a period, where these environmental relations were given only marginal attention. The current construction of housing only introduces incremental changes to the technological path established in the Fordistic period (1960'ties and onward). SD

Looking at the disposal phase in relation to demolition and removal of houses, the construction sector is responsible of 25% of the total waste. In 1997 it amounted to 3.4 million tons of which 92 % went for recycling (including land fill), 8 % to waste disposal and less than 1 % to incineration. Looking at waste recycling and disposal the introduction of chemicals have jeopardised the potential of using recycling schemes (Miljø- og Energiministeriet, 1999).

Judged from an LCA perspective, improvements of the environmental performance of the construction industry are coming slow; economic and esthetical factors are dominating. Normally builders do not pay high attention to environmental issues, the industry lacks a clear vision on environmental objectives and the authorities give no regulatory pressure on the industry (except obligation to perform EIA if large constructions). Even on individual factors such as PVC the Danish regulation initiatives have been lax, and the enforcement of the few standards has not been efficient.

The barriers to introduce alternative insulation materials are thus deeply embedded in the general technological, structural and regulatory barriers. Besides, the education, training and commercial incorporation of entrepreneurs, carpenters, insulation firms into the mineral wool track is considerable. We have exemplified by referring to the building regulative, but indeed the occupational health regulation, energy-environmental regulation and the technical standard regulation have favoured mineral wool for insulation in Denmark too.

Transitory push by insulation workers and role of occupational health regulation

Working with mineral wool bats has a number of impacts that have been well known for decades. First of all, the cutting and handling of the bats scratches and irritates the skin and eyes, and makes protection equipment necessary to wear. But most dangerous is the potential carcinogenic impacts from fibers in lungs, and secondly from the chemicals used for the binder.

In 1974 the International Labor Organization, ILO, issued a convention on prevention and control of the health impacts from carcinogenic substances and materials (convention no 139, 1974, ILO). Denmark ratified the convention in 1978 (BKI nr. 75 af 01/06/1979). This convention laid the foundation for the dominant regulatory principles and rules in EU- and national regulation concerning handling chemical products and technology. A specific "list" of substances for use in labor processes was issued, whereof some were abandoned for use, others submitted to mandatory permits for use or under severe control. A certain procedure for specific exemptions was described; an obligation to find substitutes to dangerous substances on "the list", to protect workers from direct contact with the substances, and to provide full information. Denmark made these principles mandatory in 1982 in an occupational health order on use, handling and evaluating hazardous substances and materials (BEK nr 540 02/09 1982). Due to the this regulation the employers were obliged to look for and use alternative options, if the substance/material figured on any of the lists that environmental and occupational health authorities have issued on hazardous substances.

Within the United Nations institution, WHO´s cancer-research institute IARC[3] classified mineral fibers back in 1972 as potential carcinogenic (category 3A). In 1988 IARC made a follow-up announcement on top of a series of new research studies that classified mineral wool in category 2B, now *possibly carcinogenic to humans.* The European Mineral Wool Industry reacted already in 1976 by initiating a long-time exposure study of a cohort of European insulation industry workers (note glass wool was exempted due to stronger evidence of carcinogenicity) especially in Denmark, Sweden, Germany and Norway. During the 1980´s and 1990´s the initial studies showed a 40 to 50% raised mortality from respiratory cancer compared to local rates. Mortality from respiratory cancer increased with time since first exposure (Boffetta et al 99, 96). Danish authorities for occupational health (Arbejdstilsynet) were warned about the 1988 WHO evaluation and during 1987-88 the Ministry of Labor housed numerous negotiations with industrialists, unions and experts on the revision of the Danish cancer list, when it comes to mineral wool. The Danish cancer list did made a statement about mineral wool as carcinogenic in 1988, whereby construction entrepreneurs and other employers within the construction sector would have to look for alternative insulation materials. In principal an early warning was made for mineral wool industry to phase out the use of synthetic mineral fibers. But during the negotiations the national employer association, Dansk Arbejdsgiverforening succeeded in lobbying for a *lex mineral wool*: an exclusive exemption from the rules on mandatory substitution etc. for mineral wool, enacted by a statutory order on work with synthetic mineral wool (BEK nr 344, 09/06/1988). Thus, even though mineral fibers figured on the occupational health list as hazardous and possibly carcinogenic since 1988, the mineral wool bats were not seen as a material that of technical and economic reasons could be substituted. Accordingly planning constructors, technical consults and the employers within the construction sector were only obliged to maintain specific technical standards on labeling, planning of labor, handling etc. Thereby Danish occupational health regulation de-facto protected the Rockwool and glasswool industries from any efforts to substitute synthetic mineral wool bats with alternative materials. In 1992 mineral fibers were classified in Denmark as carcinogenic on the so-called “cancer list”. But still the special statutory order on working with mineral wool was and is valid, as no other economic feasible product has been marketed until recently. An initiative made by left-winged parties (see next chapter) in 1997 to subsidize R&D search for innovations that could lead to alternative insulation products, was thus also an effort that might influence this occupational health regulation.

With a near duopoly situation and a lack of innovative efforts to make substantial innovations in their insulation bats, Danish markets have suffered from alternatives that could have served as substitute for occupational health reasons. This is why an exemption is made in the Danish occupational health regulation, which demands use of substitutes if products or materials are carcinogenic. Accordingly regulation has fostered a threshold value, demands on "astronaut" equipment and fresh air masks to pave the way for continuous insulation. This have formed the background for some of the important actor groups behind developing innovations in alternative

[3] The International Agency for Research on Cancer (IARC) is part of the World Health Organization. IARC's mission is to coordinate and conduct research on the causes of human cancer, the mechanisms of carcinogenesis, and to develop scientific strategies for cancer control. The Agency is involved in both epidemiological and laboratory research and disseminates scientific information through publications, meetings, courses, and fellowships.

insulation, the unions of TIB and the union for insulation workers in SID. The insulation workers under the union SID put down their work with mineral wool in periods of 1988, as a reaction to WHO´s new announcement and as to stress the obligation for finding healthy product substitutes according to Danish rules. Additional campaigns were made in the years hereafter by the SID-insulation group and BAT-kartellet, the major umbrella organisation for unions representing workers in the construction sector. Thus during 1996 they visited entrepreneurs and construction units to inform about alternative insulation options, and had several delegates to the Minister of Labour (Aktuelt, 24.09.1996).

Referring back to the WHO announcement of a 2B classification of mineral wool as possibly carcinogenic in 1988, an EU adaptation introduced in 1997 a general entry on mineral wool into the list of dangerous substances[4]. The directive classified mineral-fibre bats in 1997 as carcinogenic (Commission Directive 97/69/EC of 5 December 1997)[5]. Due to the directive, mineral wool had to be labeled accordingly before entering into the market and subsequently national and EU-rules on occupational health may issue certain precautions as substitution. The draft for the adaptation was discussed for more than seven years among the Commission, experts and representatives from the industry involved. During the negotiations the European trade organization for mineral wool industry where looking to find a pas-way for mineral wool to keep up with the coming health regulation. The respond was to focus on a new manufactured type of mineral wool that contains very thin fibers that were biodegradable to a certain extent. The European technical committee for insulation materials, where Danish Rockwool and Saint-Gobain/Isover submitted 14 members, made a technical identification of these type of fibers in their work on defining technical products standards. They lobbied successfully in the Commission for an exemption to the carcinogenic labeling of mineral wool bats: "..*in the current state of knowledge, it seems justified under certain circumstances to exclude some man-made vitreous (silicate) fibers from classification as a carcinogen; whereas this possibility should be reviewed in the light of scientific and technical developments, in particular in the area of carcinogenity testing*." (Commission Directive 97/69/EC). The directive contained 4 positive test-results and one technical on fiber dimension that may resolve the manufacturer from a mandatory duty to label "carcinogenic" on their mineral wool products.[6] The exemption gives accesses to non-labeling if only one of the four short time experiments once have shown positive results. The exemptions on biodegradability and small fiber size have enhanced the manufacturing of very small nominal diameter fibres, whereby both the concentration of respirable fibres and the ratio of respirable to total fibres increase in working with the fibres (Socialisten, 1998). The term biodegradable seems somewhat misplaced; the resin covering mineral-wool fibres dissolves after a period but the stone-glass part cannot be biodegradable – it is just broken into smaller pieces.

The exemptions from being labelled (with an Andrea Cross and a short risk/danger text) have been vital for mineral wool manufacturers. By raising the amount of short- and very thin fibres, they

[4] All mineral wools are classified as carcinogenic, category 3, risk phrase R 40; and irritant; symbol Xi, R 38, or labelled with the symbol Xn, R 38-40, safety phrases S (2-)36/37

[5] Adapting to technical progress for Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances

[6] 1) "A short-term biopersistence test by inhalation has shown that the fibres longer than 20 ìm have a weighted half life less than 10 days. 2) A short-term biopersistence test by intratracheal instillation has shown that the fibres longer than 20 ìm have a weighted half-life less than 40 days. 3) An appropriate intra-peritoneal test has shown no evidence of excess carcinogenicity, or 4) absence of relevant pathogenicity or neoplastic changes in a suitable long term inhalation test (ibid). 5)The classification as a carcinogen need not apply to fibres with a length weighted geometric mean diameter less two standard errors greater than 6 ìm" (Commision 1999)

were able to boost the big German building markets - both Rockwool (the so-called Roxul 1000 fibre) and glasswool manufacturers. The EU-directive helped mineral wool through the German statutory order on handling hazardous substances and materials, where mineral wool were categorised as a carcinogenic substance that must be avoided and substituted. In Germany fire precaution rules do not, as in Denmark, hinder the use of polyurethane foam ('flamingo') for insulation in houses, and this is much more common than in Denmark. German chemical corporations as BASF and Bayer have vast interests in expanding the polyurethane insulation market and they have been active during the criteria discussions behind eco-labelling. Germany accordingly wanted to reduce the exemption hole in the EU´ directive on dangerous substances and mineral wool, by claiming a national derogation, but the Commission turned it down (Commission, 1999).

The EU-directive was among Danish labour unions hoped to bring an end to the Danish exemption from substitution rules on mineral wool. Accordingly the Danish statutory order *was* prepared for a modification during 2000 within the Ministry of Labour (Arbejdstilsynet), actually making it mandatory for entrepreneurs etc. to look for substitutions to mineral when technical feasible. Thus a rule within the mineral wool exemption-from-substitution rule that cancelled the exemption… The order was also to be modified concerning substitution, according to the Ministry of Environment and Energy, as the indoor skin irritation/eczema and indoor climate problems mentioned in the EU-directive, was a public environmental health concern. The national organisation for employers has recently tried to stop the process by lobbying the Prime Minister to withdraw the Ministry of Environments demand. Secondly by stating (again) that the EU-directive only concerns fibres and not ready insulation bats, and arguing that substitution cannot be a task for an order on mineral wool handling. While not all of these attempts will be backed up, probably the order will not make it mandatory to look for substitutes as the scientific documentation on alternative materials is said to be to poor concerning occupational health risks (Bent Horn-Andersen, Arbejdstilsynet, according to Michael Voss).

Many efforts have been made by mineral wool industry to lower the emissions of fibres like making the fibres less harmful, reduce the amount of fibres not attached to the binder, and by making ready-shaped bats for specific type of insulation, as this reduces the necessary cutting in mineral wool. The problems to the working environment from the fibres *are partly* technically to handle by coating or packaging the mineral wool bats, as stated in the mentioned statutory order and as has been done in Japan for several years. But the competition on the bulk market for insulation in the Danish Fordistic construction sector has been so strong and has been too cost-focussed to allow mineral wool bats prices raise from coating. Thus, in 1989 Glasuld actually tried to introduce such a new comfortable' coated product, but experienced that there were not much scope for manoeuvre in differentiating such a bulk-good; the sales were very low. But both Glasuld and Rockwool have made further investigations into packaging along the recommendations from the statutory order (344), also to keep up with new-coming competitors in maintaining an eco-friendly profile. Today Saint-Gobain/Isover delivers these kind of bats for acoustic insulation and for some type of roofing, while Rockwool having worked 8 years for developing a new coating, ultimo 1999 launched a silk-coated batch that is soft to touch, thus being friendly to the working environment. The innovation have been launched as a vital improvement for working conditions (se e.g homepage **www.rockwool.dk**). But the union of carpenters, joiners and construction workers TIB was suspicious about the coatings capacity to hold back the small micro-

fibres causing cancer etc. They issued their own investigation confirming no improvements in the evaporation of small fibres to the milieu; the micro-fibres that are expected carcinogenic are released through the silk coating, and TIB have accused Rockwool for fraud campaigning (Ingeniøren, 1.9 &15.9 2000).

Most recently the final results from the latest epidemiological research study, organised by WHO´s IARC, has been published (Bofetta et.al 2000). Initiated in 1976, and financed by mineral wool industry, app. 22,000 mineral wool manufactory workers from 13 plants in seven European countries since 1936 have been in the cohort research study. As mentioned previously, results from the research project maintained that there was increasingly lung cancer risk with time and amount exposure to rockwool fibres. From this cohort, 196 in four of the countries had developed lung cancer since 1971, and from this group a detailed case-control study were made. According to the report and press release the evidence of mineral wool fibres being carcinogenic has not been confirmed (Aktuelt, Politiken 8.12.00). On the other hand a Danish researcher from the project have claimed that the study still may hold data on a risk for lung cancer 20 to 30% percentage above average (Aktuelt, 13.12.00). [7] If the study´s own and press-announced conclusions remain it may be that the mineral wool will be withdrawn from the WHO list as presumably carcinogenic, secondly from the EU-directive and finally also from the Danish occupational health list on carcinogenic substances. Mineral wool industries seem to have all exit doors open. A) A precautionary negative response from WHO and EU to the mineral wool financed IARC-research results by a withdraw of the carcinogenic classification, will close the exemption from substitution in the Danish statutory order on mineral wool, and will make them market the thin fibre-bats. These products will as exemptions from the mandatory carcinogenic label in the EU-directive also be exempted from the Danish "cancer-list" related to occupational health. Secondly, if the re-percussion from the recently released IARC research project on carcinogenicity will be positive to mineral wool it may well be that the categorisation at WHO, EU and in Denmark will be modified for the benefit of the industry. In Denmark Rockwool still awaits the outcome of the modification of the statutory order and the re-percussion from the IARC-study on WHO´s list, before changing production and market the thin-fibre bats Thus, the scientific risk disputes and interpretation disputes in the regulatory complex have just begun again.

The transitory push by ecological housing groups, entrepreneurs and beginning environmental orientation in (regulation of) the construction sector

A large number of environmental problems has been raised and made a theme in relation to the development within the construction sector. Consequently, the sector has been subject a push for environmental transitions. The pressure has been a result both of the development in public environmental regulation and the development of social movements focussed on the development of ecological housing.

Looking at public environmental regulation, five main paths of environmental response have contributed to the build up of a transitory push:

- Kicked off by the energy crises and the rising prises on energy, an *energy path* was developed in the 70'ties. Within this path reduction goals on CO_2 have become increasingly more decisive. For this

[7] The statistical material is for to thirds based upon Danish data on short-time exposure showing very high risk scores, whereas data from Germany and Norway shows low scores.

reason, the government's energy plan, *Energi 21*, focused on both reduction and change of energy sources. The energy path has resulted in a massive rise in the use of insulation materials both in new houses and upgrading of the existing housing.

- From the mid 80'ties a *recycling path* focussing on the reduction of waste disposal has developed. In 1985 a set of targets were defined on the recycling percentages on construction waste. In 1987 this was complemented with fees on the waste from construction. Within construction the governments waste plan for the period 1998-2004, *Affald 21*, states that the effort has to be focussed on maintaining a high level of recycling, reducing environmental load from construction waste, and ensuring that life cycle assessments are implemented in future construction projects. In addition, new demands is going to be issued, requiring that a number of fractions containing environmental harmful agents is going to be removed from the construction waste stream (Miljø- og Energiministeriet 1999, Mortensen 2000).
- Substitution of hazardous chemicals has been addressed by the government's action program on chemicals (*Kemikaliehandlingsplanen*, 1999). In relation to the construction sector this path primarily has influenced the waste handling and the product oriented environmental effort.
- *The product oriented program* (1996) represents a general strategic approach referring to 'a strategy of a sustainable development. Concerning the construction sector, this program is about to ensure development and marketing environmentally more friendly construction goods, focussing on substitution and eco-labelling as means (Miljø og energiministeriet 2000).
- The most recent initiative, environmentally sound projecting (*Miljørigtig Projektering*, 1998), deals with ways of implementing life cycle assessment already in the early stages of the projecting. This work was initiated in the first part of the 90'ties, where DEPA funded 120 projects (total ECU 13 mill.) examined a large number of individual environmental factors related to construction of housing (Mortensen, 2000). The problem was however, that the knowledge obtained was too fragmented. In 1995-1998 DEPA funded the project on 'environmentally sound projecting' to get a comprehensive instrument enabling a systematic account of environmental issues throughout all stages in the projecting and building process. The outcome of this work was a 'manual on environmental sound projecting'. SBI and DTI elaborated the manual, but a number of stakeholders left their mark on the content. Danish Industry (represent the main part of major industrial companies) and Foreningen af Rådgivende Ingeniører (FRI) (Association of consulting engineers) in particular influenced the mandate and the result.

Besides the public programs, a major environmental push was build up by a number of initiatives among different social movements forwarding ecological housing. I the 1970's a large number of experimenting was taking place examining alternative energy systems, low energy houses, and alternative ways of building. However, it was not until the start of the 1980'ties that a number of initiatives on ecological construction were brought into being. Initially, the entrepreneurs were from grassroots movements integrating visions on alternative ways of living with the wish to build with use of fewer and eco-friendly resources, and reduced energy consumption. These visions, however, were difficult to convert to a consistent concept of ecological construction or housing. One problem was the lack of alternative material manufacturers and the lack of systematic tools to assess and compare the environmental load (in an LCA-perspective) of different approaches and materials. Despite these problems, a number of major pioneering projects were carried through, and the experiences from these projects came to define main elements in ecological construction and housing. Main elements were energy savings, energy systems based on renewable energy, local waste treatment systems and alternative sanitary systems (e.g. based on compost processing), and use of recycled materials. In this stage insulating materials did not play a central role, although recycling materials was targeted (Dahl 1999:37).

The 1990's brought forward a number of projects in which ecology was sought integrated within the traditional construction. Environmental projecting, where drawing offices and consulting engineering integrated environmental considerations, was marketed. Denmark experienced a beginning adoption of environmental competencies in the traditional construction sector. A small number of actors specialised on environmental consulting and construction, addressing a small market of ecological housing or partial-integrated ecological solutions in traditional projects. The red & green construction pioneer EVD has become one of the most experienced actors. Their competencies are based on hands on experiences combined with a strong network of relations to firms offering environmentally friendly alternatives.

Environmental considerations has become part of the traditional construction sector, however, it is still on the fringe of construction process. Despite the resources allocated to environmental sound projecting, this has not been made part of normal projecting. In fact, no construction projects have, so far, used the systematic environmental analysis and documentation instrument brought forward in the manual on environmental sound projecting. The push for environmental transitions still has a long way to go. Within the standard project – ecological housing has not been institutionalised.

Looking specifically at insulation, the movements on ecological building primarily questioned rockwool and glasswool due to the high consumption of energy related to the production and for the chemicals used for binders. For this reason a broad range of alternative products (such as paper, wool, and cellulose) were tested in ecological construction. By initiative of the Commission in EU the insulation trade was since 1994 into negotiations for criteria settling and eco-profiles for achieving the EU-flower, the eco-label on thermal insulation materials for houses. Denmark was chosen as residence and secretariat for the expert group to negotiate and discuss which criteria and which type of insulation classification the insulation products should fulfil. The process has shown great difficulties in achieving consensus on which parameters should be considered and how to rank the ecological effects internally; what is the worse, the contribution to the green-house effects or the depletion of the ozone-layer?

The umbrella labour union for construction workers Byggefagens Samvirke, the political umbrella federation for construction workers BAT-kartellet, The Union for Insulation Workers, and two unions for technical engineers went into the EU-flower institutional setting. They formed an alternative insulation material group and hosted a conference in January 1995 on alternative insulation materials (Aktuelt, 13.06.1996). A group of alternative insulation firms were involved: Miljø Isolering (paper), the trade organisations for plastics industry (expanded polyurethane), and Nordic Perlite. The working group assessed the alternative materials concerning economic and technical options, health-, resource and eco-profile and made further investigations into optional regulation and R&D that would stop disfavouring alternative insulation (Alternativ Isolering, 1996). The group co-financed also a delegate (Hans Dollerup) to the EU-flower criteria group, and formed the basis for identifying eco-friendly criteria's that would fit into their products. The mineral wool industry on their hand voted for listing the paper insulation problematic as they claimed boron-containing substances (fire retardant) to be a chemical agent as bad as led or mercury. But more seriously the mineral wool industry succeeded in making a comparative LCA-profile based upon SETAC´s principles for the measuring of energy consumption per m2 wall insulation. The feedstock value of paper, cellulose, polyurethane etc. for alternative use for incineration was accordingly included as a negative factor. Besides the energy

consumption for manufacturing, insulation bats was calculated in CO2-neutral nuclear energy units, again favouring the high-energy consuming manufacturing of mineral wool bats. Thus the report *Criterias for Thermal insulation Products for Walls and Roofs* made by the Danish dk-teknik for DEPA (dk-teknik, 1995), favoured mineral wool by a factor 5 to the nearest competitor: the cellulose products. These figures have since then been used for a handbook on eco-friendly projecting and for the current work on making environmental declaration on building products (se later). But the protests from competing industries and from unions have been very loud over the criteria book.

The conflicts among the many industrial interests in the criteria-settings for eco-labelling insulation, especially polyurethane and cellulose fibres versus mineral-wool industry, were intensified when the EU-proposal for a new classification directive on dangerous substances came to knowledge. The proposal's ranking of mineral fibres as suspected to cause lung-cancer was fatal to mineral wool manufacturers[8]. According to the EU directive on Eco-labelling, products that contain substances listed as toxic or carcinogenic in the EU-list[9] will not be able to achieve the EU-flower. Accordingly lobbyists from the European mineral industry urged to speed the process before the results from the classification negotiations on the health issue were known. But all member states in the working group and the Commission agreed to wait for the results before the labelling process could end. Secondly, as a result of the Danish labour union Snedker & Tømrerforbundet´s pressure, Denmark insisted and succeeded to sanction it mandatory for achieving the EU-flower, that insulation manufacturers accomplished national occupational health regulation. This position has to some observers' opinion blocked the commission into further implementation (Hans Dollerup).

The mineral industry has in turn tried to argue (like was the case on occupational health) for a differentiation between fibres and mineral-wool bats, as the latter in it self does not cause cancer; it is only when the bats are handled that the fibres actually cause danger! This somewhat philosophical effort did not seem to be acknowledged by the other partners in the eco-labeling expert group or the advisory group. But the criteria for achieving the EU-flower have been finalised and are still at the Commission. Rockwool International´s and Saint.Gobain/Isover´s launching of biodegradable fibres that fulfils the exception criteria from EU´s hazardous substance list, have also formed the argumentative basis for stating that they manufacture bats that are not carcinogenic, accordingly that may fulfil the EU-flower criteria (IDA-meeting, 1999, Rockwool International 1999).

During the process of influencing the EU-flower criteria the union for carpenters and joiners SNT had several meetings with the Minister of the Environment and Energy, and made public happenings and campaigns in the newspapers on "the mineral wool killer" (Politiken 09.03.1997). They pointed at the mineral wool-favouring technical standards from the public construction regulation and from the private label Dansk Varmeisoleringskontrollen. Hereby they succeeded in making public notion to a need for alternative insulation and to convince two left wing parties in the Danish parliament, Socialistisk Folkeparti and Enhedslisten. These parties became during 1996 involved in negotiations with the government on the annual financial act and were admitted a 3 years ECU 5 million R&D scheme in the Danish Energy Agency, DEA*: Development of insulation methods benign*

[8] In accordance with WHO's and IARC's classification. As mentioned before the Danish Working Health Agency have put mineral fibers on a list of cancerogeneus materials in 1992.

[9] Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances

to environment and occupational health. This scheme became a primary source to the industrial innovation of hemp and flax based insulation products. TIB became member of the advisory board of the scheme, together with the national association for ecological construction, LØB.

Institutional, market and regulatory response to the transitory push

The transitory responses within the construction sector have been diffuse, but now we see a number of initiatives to get more integrating responses.

By way of introduction we can note that current institutions designed to influence the environmental behaviour of the enterprises also do exist in the construction section. A characteristic example could be the efforts within the concrete industry to introduce environmental assessment methods, life cycle assessments, and cleaner technology elements. This work has been supported by the formation of a centre on 'Green Concrete´ (centre contract funded by the Agency of Development of Trade and Industry, ADTI) involving a co-operation of industry, universities and the technological service system. A number of enterprises have worked with the introduction of cleaner technology, environmental management, and environmental certification (DTI 2000). Introduction of formal environmental management systems primarily has taken place in the production of building materials, a fact which has been taken as an argument of a further industrialisation of the construction sector to obtain a faster introduction of formalised environmental management systems. Rockwool is an example of a Danish producer of construction materials, which has been environmental certified according to ISO 14000 and have elaborated environmental statements after the guidelines laid down in EMAS.

In the beginning of the 1990's, a number of isolated projects were initiated targeting a few of the environmental problems related to construction. From the mid-90 an effort was made to obtain a more comprehensive integration of environmental issues. One initiative was the attempt to institutionalise environmental sound projecting as described previously. The main outcome of this project was a comprehensive manual (900 pages) offering a systematic approach on how environmental issues could be taken into account. It offers an instrument, which can be used by the builders, but first of all it is a requirement that can be used by public builders in new construction projects. In this relation, it is seen as a specific problem that (public) builders are not well prepared to integrate environmental issues in the early stages of projecting of buildings. This barrier has been addressed by elaborating material designated to instruct builders in how they could integrate environmental issues (including future loads related to the use and disposal stages) in their projecting (BPS 1999). A number of examples of environmental protecting were presented on a conference September 2000. The main message was that environmental sound protecting primarily had served the purpose to be a pedagogic framework and an esthetical dimension of the construction, while no substantial influence in terms of environmental grounded choice of construction technique or material was observed (DTI 2000).

Rockwool can give an important example of how the actors relate to the concept of environmental sound projecting. The insulating company has elaborated a guideline on "Environmental sound projecting and insulating" (Rockwool 2000) giving an argument on how insulation, and in particular Rockwool, is part of an environmental sound projecting. In this guideline a

life cycle perspective is given including use of resources, use of energy in production and in the life span of the building, occupational health and disposal. As mentioned before, they have used the eco-label criteria groups findings (dk-teknik 1996) that favours mineral wool from energy LCA perspectives. Issues such as indoor climate and fire security demands are included too. The guideline outline Rockwool's role in a product chain perspective, emphasising it's participation in the development of new constructions and in a centre looking at ways to use insulating material in external facade insulating constructions on existing housing.

The most recent initiative is the constitution October 2000 of the product panel under the Environmental Council of Cleaner Product. December 2000 the Panel is going to forward an 'Action program for a sustainable development of the Danish construction sector'. Representatives make up the product panel from builders, development firms, consultants, research institutions and public authorities. In addition, the panel includes representatives from the Swedish Boverket and LØB (association of ecological constructors) (Byggepanelet, 2000). The long-term objective (30-50 years) of the panel is to enable 'factor 10 improvements' in terms of resource consumption and environmental load. The panel addresses environmental load related to constructions, existing buildings and new buildings in an LCA perspective – from extraction and production of building materials, construction, use and rebuilding, and demolition and disposal. Consumption of energy and materials are at the centre of the work, but in addition the panel has defined objectives on reduction/substitution of chemicals, improvement of indoor climate, safeguard of occupational health, reduced use of space in towns and landscapes and reduction of emissions and waste. These goals are going to be achieved by means focusing on planning instruments, function and design of construction and buildings and techniques and materials. More detailed a number of responsibilities has been defined to builders, development firms and users, to the supplier system and authorities. In short the anticipated division of work is that the builders (and development firms) takes responsibility all the way through, from integrating environmental concern in the first projecting stages and to the involvement of future users in the decision processes. The system of suppliers has to be industrialised to enable a systematic environmental management and the task of the public authority is to forward environmental demands on construction based on sustainability and environmental criteria.

An important prerequisite to environmental labelling and environmental sound projecting is that comparable data on environmental load of building materials can be provided. To this end a project 'Environmental declaration of building materials' has been initiated. The purpose of this project is to bring forward a proposal of how to establish Danish environmental declaration system on building materials. The data on environmental load is to be based on LCA and involves the establishment of a third part (independent) control institution. The idea is to establish a simple and international rooted organisation, making it simple to perform environmental declarations and thus ensuring a widely use of declarations. SBI is a central actor in this work, but in addition a number of firms is involved, including Rockwool (Klaus Hansen, August 2000). The planned environmental declaration gives a profile of the product accounting for the composition of the product, environmental load, use and the documentation of the certification and specifying effects in terms of energy consumption, material consumption, climate effects, air born pollution, toxicity and waste problems. In addition, the idea is to make the declaration comparable to other European declaration on building materials.

From the perspective of ecological housing, the problem of these initiatives - and the related build up of knowledge and competencies at the systemic level at knowledge institutions of the sector - has been that it almost entirely was related to the dominating traditional paths of technology. As a response to the transitory push, SBI now has taken up the task to elaborate manuals on how to use alternative materials in construction. A number of NGO's including LØB (National association of ecological housing) have been active in defining and performing these programs. The numbers of entrepreneurs, carpenters and building firms have grown stabile during the 1990´s and a number of ecological housing areas and constructions has been build. Additionally half a dozen of ecological housing seminars and fairs have occurred where the growing number of carpenters and entrepreneurs have succeeded in marketing alternative building materials (sun-dried bricks, flax/hemp insulation bats, recycled timber etc.).

One of the major pioneers among these groups has been the before mentioned "red & green" entrepreneur Egen Vinding & Datter. EVD was initially a carpenter collective established in 1975 that have grown into a more comprehensive business unit during the 1990´s. The EVD fund has supported and employees in EVD have helped the establishment of:

- Egen Vinding og Datter Bolig, a number of construction units that deploy ecological construction and building renovation
- Ecological paint fabrication (Dansk Naturmaling APS)
- Egen Vinding og Datter Window Manufacturer
- Insulation bats, stocks invested in Dansk Naturisolering (our focal innovation company)
- Egen Vinding og Datter Bricks (air dried bricks)

In 1998 the large manufacturing and housing collective Svanholm started by financial help from the Pool for green Jobs, Ministry of the Environment, a manufacturing of eco-friendly ready-made construction elements like roofing, timber-constructions and wooden plates for walls. Svanholm joined the kick starting of the national organisation for ecological construction, LØB, encompassing the major alternative building material producers and craftsmen in the building sector. LØB has played an important role for the establishment of marketing and making eco-constructions available. But of interest for our focal innovation they have from the alternative insulation scheme (see below) hired a consultant for the technical criteria development for alternative insulation within the Danish standardisation organisation DS and the European CEN. Hereby LØB have revealed that DS - as opposed to what they promised the Ministry of the Environment and the alternative insulation group within LØB - in fact did not make any progress in working for fair technical lambda values and other criteria for alternative insulation, that resembles other European standards. The Minister of Environment and Energy has reacted by demanding usage of the European CEN-criteria proposals, which are favourable to alternative insulation materials; thus LØB was economically supported again from the alternative insulation scheme (see below) to establish a full overview of the lambda values from alternative insulation, based upon the new EU standards (from mid 2001 to 2002).

Concerning insulation, the most important institutional responses have been the developmental program within the Danish Energy Agency (DEA) on 'Alternative insulation'. This program was shortly described previously as it was here the insulation and construction workers succeeded in getting on the agenda from occupational health reasons. Within this program 138 projects on the development and use of alternative insulation materials has been performed (SBI 2000,

Energistyrelsen 2000). Funding totals ECU 5 mill. in the period 1997-2000. The objectives were to bring forward insulation materials with better qualities in relation to environment and occupational health issues. Initially the focus (and main funding) was on insulation with 'paper wool', but 'crops grown insulation bats' is one of the projects which has been supported by the program.

R&D programs for alternative insulation and non-food bio mass

The R&D subvention scheme under DEA *Development of insulation methods benign to environment and occupational health,* was originally threatened by the Danish trade organisation for mineral wool, MB (Mineraluldindustriens Brancheråd), that lobbied during 1996 through the parliament's planning and environment body, and the political party Det Konservative Folkeparti. MB issued a booklet to the parliament on *Myths and Facts about Paper and Mineral Wool,* and handed out a scientific report: *Memorandum on health impacts from mineral wool*. The books were highly criticised for a non-scientific bias and the industry's efforts failed. It became a deliberate focus of the scheme to fund R&D in non mineral wool insulation, due to WHO´s categorisation of mineral wool as presumably carcinogenic. Rockwool then applied for an investigation in carcinogenic impacts from cellulose fibres but it was turned down. Secondly, the implementation of the program was sought captured by the technical standard institution for construction, SBI, for solely making strict thermal-, fire-technical and humidity technical calculations and experiments. But the labour unions within the federation BAT-kartellet in co-operation with alternative insulation manufacturers succeeded in forming an agenda for the scheme that additionally supported entrepreneurs and carpenters to work on alternative insulation methods and materials. A number of stakeholders to alternative insulation were placed as directors of various working groups within the scheme. Hereby our focal innovative firm Danish Natural Insulation Lmt had fair chances to success in applying for a grant to do an industrial pilot project of flax- and hemp based insulation bats.

The subvention scheme had the intention of promoting innovation of new insulation materials and methods in order to adjust the insulation sector to the development of ecological construction. Of primary focus was to fund projects in R&D of new sustainable materials and building methods, new combinations of well-known materials, new construction forms and new insulation methods. The aim was also to aid environmental documentation for alternative insulation materials and to document "*..non factual barriers in rules" (*Energistyrelsen, 1997); e.g. disfavouring technical standards for sustainable insulation from the Danish regulative on construction (Bygningsreglementet). The investigation in new insulation material was focused on the organic plant material and paper cellulose as it was considered recyclable and non-toxic. This focus was also due to the success of R&D in flax- and hemp fibres for insulation that was shown since 1996 from the Non-food Bio mass subvention programme (Structure Directorate, Ministry of Food, Agriculture and Fisheries). The alternative insulation programs also subventioned full-scale demonstration projects for construction, whereby a realistic assessment of environmental and occupational health impacts could occur. Besides, the constructions would serve as a base for monitoring indoor climate and technical capabilities of the products. The targeted information needed for the R&D in documentation of new knowledge, were occupational health impacts, environmental impacts, thermal insulation capacity, humidity, acoustic and fire-technical profiles, dimensional stability, construction, indoor climate.

Since the launching of the Alternative Insulation scheme in 1997, app. 138 projects have been subventioned. Of importance for the specific innovation in flax and hemp based insulation the following projects have been supporters for the enhancement of Danish Natural Insulation´s innovation in flax- and hemp insulation bats:

- Alternative insulation in buildings - technical monitoring of flax et. al based bats (4)
- Experiences from alternative insulation in Germany, Finland and Sweden (2)
- Impacts to brick and other constructions materials from use of alternative insulation materials (5)
- Mapping and evaluating toxicological data from organic fibres (1)
- Manufacturing insulation made of flax, hemp and wool and assessing environmental impacts (2)
- Thermal and humidity technical investigations of alternative insulation materials (5)
- Fire technical standards (2)
- Marketing and other hinders for alternative insulation materials (2)
- Technical insulation –alternatives to mineral wool (2)
- Fire retardants – environmental impoact asessment, alternatives to Brom (3)
- Insulation in industrial plants, new and in restored constructions -demonstration projects on humidity, thermal insulation (17)
- Dissemination of R&D results (2)
- Manual for construction projecting with alternative insulation materials (1)

The funds have stabilized the active networking among a number of actors within the alternative construction milieu. The items that have been researched have covered basic technical profiles; some technical problems were found in fire dissemination (thus a need for gypsum covering plates) and some advantages have been found to especially loose insulation granulates compared to mineral wool insulation bats. The environmental documentation of alternative insulation materials has been improved considerably since the EU-flower criteria group finished their work. New ways to handle the fire- and technical demands from the Danish construction regulative have been found for the use of among others flax and hemp mats and the results have been demonstrated for entrepreneurs. The potentials concerning cost-sale economy, consumer preferences, raw material and eco-profile have been investigated though related to the German HERAFLAX-technology for insulation bats (Esbensen, 1999). The technical knowledge on cellulose and flax/hemp insulation has increased and the technical experts have gained a larger professional attitude to the mineral wool alternatives (Jesper Lorenzen). According to the head manager of Danish Building Research Institute, what is still said to be missing is the impacts from the additive boron-substances to metal and constructions, dimensional stability of plant fiber insulation bats, and furthermore demonstration projects in acoustics, measurements and renovation. But also a number of fire technical studies will be run.

Along the establishment of various R&D activities came a series of seminars on the results from the various R&D projects, but also on technical, economic and institutional barriers for promoting alternative insulation. The technical building/construction institution SBI had the chair of organizing some of these seminars, whereas Palle Bisgaard from TIB was responsible for others. At the seminars a number of formerly non-related institutions, firms and organizations had the opportunity to get acquainted and a number of networks were established. Additionally the seminars and the whole R&D program contributed to give a professional normalization of the scattered activities and thereby install a self-confidence among the network actors but also respect in the professional construction milieu.

. The union TIB has actively used the outcomes from the R&D scheme to promote alternative options for the benefit to occupational health. TIB announced in their congress September 2000 that they would urge Saint Gobain/Isover and Rockwool to look for alternative insulation materials, and that their members would desert work with mineral wool bats from 2003 as alternative materials would be available then (hhhtp://tib.dk/kongres/-visartikel.shtml?250). But it is still open whether the Danish occupational health legislation will be adjusted according to the new findings of alternative insulation options and according to the recent results from the IARC epidemiological research. (see previous chapter).

The development of alternative plant-fibre insulation bats were as mentioned dependent upon basic research in plant fibres, that in turn was subventioned by the Structure Directorate within the Ministry of Agriculture (now Food), the Research Council Funds and EU since 1993. The background for the Danish R&D efforts was the Action Plan for Sustainable Development from 1991, where the potentials in non-food bio mass production in Denmark were seen as vast. The surplus production of food stocks in EU and the potentials in substituting imported non-renewable with renewable Danish raw materials was the political motivation. Thus, a number of R&D programs have been launched for the purpose of finding energetic and industrial non-food use of various plant fibres. The overall innovative efforts on industrial use of plant fibers have counted a series of projects among five focal plant fiber innovation centers in Denmark[10].

In 1992 the so-called act on Product Development was issued, enacting the minister's right to start subvention schemes for product innovation in primary agriculture, in industrial manufacturing and in food production. This act that was changed in 2000 into a so-called Innovations Act[11] has formed the basis for a number of action programs and subvention schemes. The so-called act on Structure development in agriculture has formed the basis for more healthy, organic and environmentally sound agriculture and food/non-food product initiatives. Under the latter a non-food bio mass program was launched in 1993 with a total subvention frame of ECU 6.1 million. It was from this program our focal innovation actors initially were supported: the Department of Plant production, Danish Agricultural Advisory Center were supported with ECU 0.2 million in 1993-97 in R&D in development of flax-harvesting and manufacturing technologies, e.g. cellulose. Besides, a Non-Food Center was established in 1995 to handle the overall management, planning and development of non-food agricultural production and to develop plans for research and development in the area[12]. In 1997 the R&D activities were prolonged *in Increased Use of Renewable Resources for Industrial Non-Food Applications* with a budget of ECU 5 million over four years. Here the flax processing was continuously subventioned within the category Plant fiber products - free-fiber processing, short and long fiber composites (ECU 1.5 million).

In 1995 a program from the Danish Research Council *Plant Materials and Products* was established with the overall aim to enhance the crops growing of new raw-materials for the industrial use of plant fibers for the production of well defined products. Among topics of importance for the

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[10] 1) Materials Research Dept. And Plant Biology and Biogeochemistry dept. RISØ; 2) The Plant Fibre Laboratory at the Department of Agricultural Sciences at the Royal Veterinary and Agricultural University; 3)The Centre for Plant Fibre Technology (R&D institutions and a company); 4) Department of Plant production, Danish Agricultural Advisory Centre; 5) Bio-Raf, R&D unit Bornholm.

[11] Lov om tilskud til fremme af innovation, forskning og udvikling m.v. i fødevare-, jordbrugs- og fiskerisektoren

[12] The Non-Food Centre comprises an inter-departmental committee of senior officials from the Ministry of Food, Agriculture and Fisheries, the Ministry of Environment and Energy, the Ministry of Research and Information Technology, the Ministry of Education and

focal innovation can be mentioned: mat forming, hot pressing in order to achieve dimensional stability, plant fiber mats as growth media, industrial design of composite surface, and chemical and physical analysis of plant fibers.

Parallel to these programs a non-food program for organic crops were initiated in 1997 (BKI 227, 22.04.1998), where a working group was established to develop and investigate new organic-green markets from organically grown biomaterial. The group has recommended a new organic labeling scheme parallel to the organic label for food, that kick-started autumn 2000. A number of products have been seen as potential for the green consumer segments, and have accordingly been supported for R&D in growing and manufacturing techniques – including flax based insulation mats (Strukturdirektoratet, 1998).[13]

Finally, under the Ministry of Environment and Energy a parliamentary programme initiated the *Pool for Green Jobs*, which have financed green-job initiatives, and efforts that seem to have a competitive advantage on the market. Such projects have included green tourism, ecological clothing and environmental management systems for SMEs (Vejledning, 1998). The scheme have funded about 12 projects related to eco-friendly construction and building materials, re-use of old bricks and timber, trading eco-building materials, manufacturing of new eco-constructions. The before mentioned socio-ecological entrepreneur Egen Vinding og Datter have been subventioned from this fund in the establishment of a air-dried and high-pressure bricks-manufacturing industry in Storstrøm County. But also our focal innovation company Dansk Naturisolering and the inventor of the fiber-forming technology have been granted ECU 0.2 million for the R&D and establishment of a fabric for flax/hemp-insulation bats.

The focal innovation in flax/hemp insulation

It was at the Department of Plant Production, Danish Agricultural Advisory Center, that R&D innovations in new harvesting techniques and manufacturing processes for free-flax fibers were made during 1991-96. Bodil Pallesen (BP) was since end of 1980´s a research entrepreneur in new harvesting and free-fiber processing techniques for fiber-flax, and since 1993 she continued her work including industrial utilization of the plant at the Department of Plant Production. The Department was interested to find new non-food market products in order to consult farmers in gaining incomes from non-food during rotating crops. The described subvention scheme from the Ministry of Agriculture, the non-food bio mass program, financed the flax/hemp project since 1993 with 0.2 Mio ECU in 1993-97. BP was looking for more competitive and efficient harvesting techniques and innovative options for industrial usage of plant fibers. She and her department have networked with several farmers, research units and industries along the process that mainly will be described in three stages: 1. The R&D in flax sort selection and harvesting. 2. The R&D in processing the plant for achieving free fibers. 3. The R&D in air forming fibers for insulation bats. The latter stages included extensive industrial usage of the free fibers that were the outcome raw material from the first innovations. The various industrial

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the Ministry of Business and Industry as well as a research committee and industry.

[13] Organic farming and eco-friendly manufacturing of plants for fiber mats, Christmas trees, flowers in pots, seed, ready grown potato plants etc., energy crops, flax for oil, petfood, potato starch, fertilizers, textiles (flax growing, eco-friendly dying etc.), leather, paints, plant paints for cosmetics, cleansing products, bio-packagings,

product-innovations were developed together with a number of industries, which also influenced the various ways of seeking for innovative solutions to produce free fibers.[14]

The R&D in flax sort selection and harvesting. Instead of the expensive traditional flax pulling of the straw and successive handling on the field for achieving long fibers for textiles, experiments with combine harvesting for attaining short fiber material showed positive results. After an initial close to the ground cutting or swathing, followed by 1 to 3 weeks natural retting on the field the straw was treshed and flax seeds harvested. After a new dew-retting[15] time on the field the straw was combine harvested and rolled into round bales. Besides, the Koldkaergaard Research Center under the Department of Plant Production experimented with mechanical weed control, finding that an efficient use of a "finger-harrow" could avoid the use of pesticides in crops growing flex. These experiments lasted for many seasons during 1990 to 1996 in co-operation with agricultural R&D units and farmers using different combine harvesting techniques, retting time of different sorts of flax.

The flax straw being combine harvested and rolled will not appear in a linear pattern when further processes, as is the case for long fiber flax harvesting for textile purpose. Thereby the normal.

The idea-generation and R&D networks in harvesting and innovation in a short-fiber process line of flax

Harvesting & Seed selection	*Bale opening and shredding*	*Cutting, scuthcing and grinding*	*Separating shives and fibers*	*Short-fiber line in toto*
Main actor Dept. of Plant Production Koldkærgaard Research Centre	*Main actor* Dept. of Plant Production	*Main actor* Dept. of Plant Production	*Main actor* Dept. of Plant Production Research Centre Koldkaergaard	*Main actor* Dept. of Plant Production Research Centre Koldkaergaard
Contractors,Networks Statens planteavlsforsøg Roskilde, Danmarks Jordbrugs-forskning Per Tvede, farmer	*Contractors, Networks* Skjold machinery Taarup machinery Kolind landbo-forening Silsoe Research Center (UK) Cormall A/S machinery Tekemas machinery United Milling	*Contractors,Network* Bioraf (R&D center in fibers) Biotechnological Institute Kamas Industries Tekniska Högskola in Karlstad Landbrugsuniversitet Sweden Silsoe Research Center, UK	*Contractors,Networks* Anton Nielsen seeds J.Haldrup machinery Morsø Seeds	*Contractors,Networks* Roskilde Forsøgs-station Danmarks Jordbrugs-forskning

scutching machines for preparing the separation of the fibers from the shives were non-usable. Thus, the processing of the straw had to be re-arranged in order to handle the filtered straw bales. Alternatively the farmers delivering flax were to have the straw bales opened and shredded before delivery to further treatment

The R&D in processing the plant for achieving free fibers. The straw was firstly to be dried by hot air puffing machines in order to lower the content of water, as to avoid the flax wool to get stuck

[14] This part of the study concerning free-fiber processes and insulation is based upon (Bodil Pallesen 1998, 1999, 2000a,b,c) and interviews (Bodil Pallesen, Marianne Eriksen, Erlin Ransby, Balder Johansen).

[15] The retting process:: microorganisms' dissolves by enzymatic processes the lignin that holds fibres and shives together

in the processing machinery. Subsequent experiments in bale opening and shredding techniques were to take some years as a number of options were available. The aim was to handle the bales so as to establish a continuo process line of straw treatment and prepare the straw for further free-fiber processing. The main actor was Dept. of Plant Production and R&D networks for these efforts were machine works or contractors as R&D institutions in Denmark, Sweden and UK. The experiments showed that various options for bale opening and shredding were available but rather costly. After the bale opening and shredding the detached straws were led to a straw hammer or cutting mill. Several experiments on these two kinds of mills were issued together with machinery works and contractors ending up with a preference for a high capacity hammer mill being adjusted with new types of shares and a 8 millimeter riddle. This machinery would cut the straw into the preferred fiber lengths, and scutch it - loosening the shives from the fibers. The subsequent processes to separate the fibers from the shives took a new period of experiments in different processing techniques networking with seed handling machinery contractors and farmers with competencies in screen processes. Thereby re-build machinery consisting of revolving screens with a 20% down sloping was found suitable when drawn of by suction. The result was a separation of 95 to 99% of the shives, usable for gardening or energy.

From all these separate processes the challenge for BP and the Dept. of Plant Production was to find a combination of the machinery and handling parts together with the optimal sort of flax and optimal retted straw, in forming a non-costly and continuo process-line with optimal fiber outcome. Five processing chains were examined in combination with tests of various degrees of retted flax looking for optimal results in fiber content, - length and quality. The end result was an innovation in a self-made combination of rather simple, but not easy to make up techniques deliberately using the shives for enhancing the shredding, grinding and scutching processes. A hot-air-drying, a hammer mill, and a revolving screen was the result. Problems from air-borne dust from the hammer-mill process, covering up to 15% of the fiber-mass were resolved by letting the fiber/shive mass pass a cyclone separating the dust in a fine riddle before being suck through the revolving screen. The shives are usable for main fiber plates, and the dust usable for auto-repair shops.

The short-fiber process for producing free fibers could be installed at different geographical sites for various product-chains, thus being pre-processing sites of raw material among farmers or specific fiber-manufacturers. Thereby energy and cost savings in transport would be achieved, as the majority of the straw is shives that may usable for specific products, but not insulation.

The R&D in air forming technique producing insulation bats. The continuation of the non-food biomass scheme in 1998-2001 gave investments to the further development of industrial usage of flax bats, among others for manufacturing insulation bats 2.4 million. The scheme also supported the optimization of the product chain from harvesting techniques to industrial manufacturing of insulation bats (*Increased Use of Renewable Resources for Industrial Non-Food).* The free short-fiber process innovation has been the basis for investigations in various options for industrial usage of the fibers: fibers for concrete, paper, insulation bats, composites for cars, etc. From the raw materials the Dept. of Plant Product searched for industrial usage together with a number of industries. Hereby insulation bats were found as one of the targets. A co-operation was established between Dept. of Plant Produktion, Bodil Pallesen and Marianne Eriksen (ME), inventor of the new forming technique, on the industrial full-scale commercial development. ME was experienced from textile and fluff pulp industries and had

the idea of how to use the whole plant without to many treatment processes and how to inflate the fibers by fresh air into a spongy felt.

At an early stage in the idea-development of fibers for insulation purposes the papers insulation firm ISODAN and Rockwool were contacted for co-development of flax based bats. ISODAN backed up the idea but wanted to keep a focal concentration on insulation granulates for cavity wall insulation, mainly paper. Rockwool backed out, probably because it was too radical a step-a-side, both technologically and institutionally.

Marianne Eriksen, invented the machinery for pneumatic felting of the plant fibers, inspired by the techniques used in fluff pulp industry. The Department of Plant Production applied successfully the Alternative Insulation scheme to finance a pilot project for experimenting with a continuos free-fiber processing and forming machinery. But ME had to use self-financing by private capital for joining the project.

The *principles* of the finally developed process are as follows. The primary innovation in the forming process was a pneumatic combustion of the free fibers into a fast-revolving rasping machinery that fluffs the fibers into a felt - that is opening the fibers surface into fibrils that bonds easily together and busting the mass with air. The fibers are thereby mixed together in fiber to fiber bondings and subsequently by air-pressure pressed down to a running band conveyer. Hereby the condensed mass is formed by broad from the shape of the process-box and by thickness from the distance of box to conveyer. Fire retardants are added in this process, most likely an old sort of water glass -still in research.[16] Synthetic polymer fibers are mixed into the fiber mass in the initial process. After the forming process the conveyer runs under a subsequent Celsius 100-degree thermal treatment in few seconds, whereby the polymers are fixated to the flax fibers. This process serves to secure dimensional stability of the bats. Hereafter it is post-treated and either the insulation mass is rolled or it is cut into bats also in new process technology. Finally a packaging ends the process.

The whole process from pre-treatment of straw to final forming is purely based upon mechanical and pneumatic processing technology, thus giving no wastewater or chemical waste. We do not know much about the few partners in this kept secret innovation process. The development work by Bodil Pallesen have been focussed on "…*finding the right fire retardant, the best combination of binder and matrix, the best binder for form stability, reducing the amount of synthetic polymers in the product, acquire sufficient documentation of the product specifically concerning fire-retardance, affinity to humidity, persistence of the product, affinity to attack from rodents etc*." (Bodil Pallesen, 2000). The major innovative steps in these initial R&D processes were made in a small-scale pilot process that were installed at Koeldkaergaard Research Center under the Dept. of Plant Production during 1998-99 by means of subventions from the alternative insulation fund. With this process Bodil Pallesen could kick-start a number of projects on fiber forming and making technical profiles at the respective standard- and R&D units.

[16] MiljøIsolering financed from the alternative insulation scheme

The ide-generation, process R&D in air-formed bats and the establishment of a full-scale fabric

Idea-development of product flax for insulation	*R&D in air-felting and thermal treatment machinery*	*Developing an eco-friendly fire-retardant*	*Establishing a group of investors, finding a site*	*Fund raising for machinery et al*	*Full scale experiments*
Main actor Bodil Pallesen, inventor Dept. of Plant Production	*Main actor* Marianne Eriksen, inventor	*Main actor* Marianne Eriksen, inventor	*Main actor* Erlin Rensby SydTek	*Main actor* Erlin Rensby SydTek	*Main actor* Marianne Eriksen, inventor Bodil Pallesen, inventor
		Contractors, Networks Bodil Pallesen, inventor Dept. of Plant Production Consult companies	*Contractors, Networks* Henrik Høegh Jørn Nordstrøm (farmer-associations) Kaare Rasmussen, Green party Holeby ISODAN among others	*Contractors, Networks* Storstrøm Regionale Udviklingsselskab Egen Vinding og Datter Storstrøms County Business Dept. and Target-2 group Danish Competition Authority	*Contractors, Networks* Workers on the fabric Local tradesmen Machinery Bodil Pallesen, inventor Dept. of Plant Production

The next step was to form a continuo process in full scale. The group of network actors close to the Department of Plant Product helped making contacts to farmers and risk willing R&D capital for investments in a new fabric. ISODAN, involved in the pre-feasability studies of flax/hemp materials, and being located at rural Lolland in Storstrøm County, the southern part of Zealand, made contacts in 1997 to a network of local farmers in the county of Storstrøm. Hereby 12 farmers were partly involved in the project and serviced by Bodil Pallesen started to grow flax on contract basis for experiments at Department of Plant Production. Bodil Pallesen made hereafter contacts to a number of actors in the region. A steering committee was made for the establishment of an insulation industry; besides ISODAN, municipal politicians and mayors were involved, as were two representatives from local farmer associations (Familielandbruget på Lolland/Falster, Landboforeningerne i Storstrøms Amt). The committee contacted SydTek, a local innovation R&D unit that became a major driver in the subsequent processes. Director of SydTek Erlin Ransby applied for funds from *The Pool for Green Jobs* and made possible the preparation and design of the new fabric that was going to be build in the region.

The idea to locate the fabric in this area was probably related to some attractive options. The majority of local farmers were adjusted to grow sugar beets for Danisco Sugar, and were eager to find future alternative crops as when EU sugar quotes would be down-sized in the future. In the region stake-holders to agricultural based products were already organised for nearly 12 years within a so-called Green Centre for R&D, training, education and campaigning with the purpose of encouraging resources for developing new markets, products and technologies that would benefit local trade and jobs. The Green Centre had some negative experiments on developing new food projects, but positive results were expected from a hemp-project, in principle similar to the flax-projects described but not with same innovative partnerships. Finally the region, the County of Storstrøm covers one of the few Target 2 regions where EU´s regional funds have been and still are in function in Denmark. The capital available in the Target 2 funds was crucial for a fabric project mounting in toto ECU 4 million.

The task was to convince the ministerial committee for EU´s Target 2 funds that the Flax fiber insulation fabric was an innovation, secondly those private/local investors would join. Then the Ministry of Trade and Industry was to supply doubling up- according to EU-rules. A private investment fund for agricultural projects, Agroinvest initially joined the project but went off, and a regional development fund Storstrøms Regionale Udviklingsselskab gave support in the last minute. Agroinvest and Syd-tek wanted to include the ecological housing builder Egen Vinding og Datter (see previous description) as an socio-ecological construction actor who knew of the market options, had the networks, would become an important purchaser and who could keep the R&D investments on a pragmatic level (Balder, interview). Velux were actually contacted beforehand for investment and marketing, but they refused to go into the alternative insulation business. The outcome of negotiations and analysis were that the Danish Ministry of Trade and Industry and the County of Storstrøm invested (administering EU-Target 2) app. ECU 0.65 million for all the machinery investments in a closed thermal power station. EVD, the regional fund and a company attached to SydTek (EnviroTech) invested a smaller amount of money.

The fabric was initiated in 2000 in an old straw incinerating power plant in Sakskøbing. Here Marianne Eriksen became a leading manager, though formerly a consultant to the company, and began in 2000 to work on installing and mantling machinery etc. She has by her self and by help of two employees and local tradesmen been doing all kinds of practical and experimental working for the last year.[17] Bodil Pallesen has by her own spare time been the midwife for the commercial, technical and PR-related systems: contract business developer, economy calculations, crop contracts, managing marketing, arranging fairs and PR, fireproof, demo-projects, technical documentation. Erik Ransby from SydTek has been the networker between Marianne Eriksen and a number of local administrative, financial and political institutions.

The Danish Agricultural Advisory Center has patented the new invention, that is the whole processing of flax into free fibers and bats, but also the final insulation bat product is patented. Marianne Eriksen holds the patent of the air-forming filter-bat machinery.

Final remarks

The production is expected to kick-off by march 2001, and the request from different purchasers and off course the Labour Union TIB have been told to be immense. The market pull thus stems immediately from ecological housing groups, green entrepreneurs and labor unions. But if the project is going to succeed then up scaling of the production is needed, meaning high sales rates. Thereby processing costs per product fall to very competitive prices compared to mineral wool, but high demands for flax will also make crops growing more attractive to farmers. Whether Danish farmers from e.g. the Storstrøm region subsequently have an option to grow flax depends upon the quota from EU on flax. The Danish quota has been very low since textile industry gave up linen in Denmark, and in Europe French and Austrian industrial interests have maintained the majority of the flax quota in toto. But success in sales will indeed depend upon whether the eco-labour profiling in marketing will be perceived green and safe by customers, and also how the products from Rockwool and Saint-

[17] Even though she (ME) has been involved in the innovation process since 1998, she only gained symbolic salary from the many fundings. Thus, she have taken loans from the bank to gain income during the period.

Gobain/Isover will be perceived in the future. As mentioned before, research on 22,000 mineral wool workers has just claimed to free mineral wool from suspicions to cause lung-cancer. This is a serious attack on the alternative insulation markets. NGO´s, Labor Unions and entrepreneurs may anyhow make use of the precautionary principle when it comes to mineral fibers, concerning the evaporation of fibers, formaldehyde, formaline. But at the same time they will have to show a risky principle when it comes to use flax fiber bats, as they have not been examined properly for carcinogenicity. Probably not a big issue if not Rockwool will make it so…Anyhow, R&D in flax/hemp insulation and indoor climate, health, fire protecting, and comparative LCA-profiles will probably be done within a short period of time. Meanwhile pre-marketing is going strong by networking with trade unions, news-paper covering, and environmental, housing and occupational health authorities are often paid visits.

Currently SydTek have applied for a new Target 2 and product-development funding from the Ministry of Trade and Industry, in order to develop special dimensioned insulation for technical items. This may be an initiative for enhancing sales into a market where Saint-Gobain/Isover and Rockwool may not feel challenged, and where high profits are available from the high-value products (Hør, SydTek 1999).

As a follow-up to a ministerial report for the region Lolland (Lollands-redegørelsen, Ministry of Trade and Industry) a regional committee consisting of mayors and local business-, trade and R&D interests are about to establish a regional Center of Fiber Manufacturing. The involved are regional R&D and industrial interests into innovation within plant fiber based products. Besides a network of training, research and education departments are going to be linked into the center. Danish Agricultural Advisory Center, ME-consulting, Risø-material research Department and SydTek are current the involved partners. Thus the industrial utilization of local grown flax and hemp have become a comprehensive effort beyond specifically insulation goods.

The policy, regulatory and R&D subvention stimuli for environmental innovation was complex, but quite important to learn from. The policy on energy, housing, occupational health and environment were *hindering* alternative technological innovations - a path dependency was institutionalised. Thus, the active motivation for an eco-oriented change came from tradesmen involved in thermal and technical insulation work, persons that had their daily experience from handling insulation bats. But in spite of clever political campaigning and use of policy networks the labor union did not succeed in altering the mineral wool favouring institutions. But with the establishment of contacts to green alternative insulation companies and networking with R&D units for plant fiber production, an effective constellation for a break trough was made. This had also to do with a maturing of the ecological building market, where a growing number of housing communities began to demand ecological constructions. But with a political articulation of alliances between formerly very loosely related actors an option for a discursive communication on sustainable insulation was made. Thus, unions, lobbying and public campaigning for "a good cause" concerning their own health; green entrepreneurs working for resource friendly, re-cyclable and non-toxic building materials, and eco-oriented small communities purchasing green materials.

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REFERENCES

Acts etc.

Begrænsning af luftforurening fra virksomheder, Guidelines from National Agency for the Protection of the Environment, no 6 1990

Grænseværdier for stoffer og materialer, Arbejdstilsynets anvisninger 1985, 1988 og 1992.

Vejledning om arbejde med stoffer og materialer, Arbejdstilsynets meddelelse nr 3.02.5, april 1989

BKI nr.344 af 9.6 1988, *Bekendtgørelse om arbejde med montering og nedrivning af isoleringsmaterialer der indeholder syntetiske mineraluldsfibre*, Arbejdstilsynet

BKI nr. 540 af 02.09.1982 *Bekendtgørelse om stoffer og materialer*

Bekendtgørelse af ILO-konventionen af 1974 om forebyggelse og kontrol med sundhedsmæssige farer på arbejdspladsen forårsaget af kræftfremkaldende stoffer og midler, BKI nr. 75 af 01/06/1979, Arbejdsministeriet

Raadets direktiv 67/548/EOEF af 27.juni 1967 om tilnærmelse af lovgivning om klassificering, emballering og etikettering af farlige stoffer,EF-Tidende nr. 196 af 16.08.1967

Bygningsreglement (1995), www.retsinfo.dk/delfin/html/B1995/0400249.htm

EC 1999/836/EC: Commission Decision of 26 October 1999 on the national provisions concerning mineral wool notified by Germany derogating from Directive 97/69/EC adapting to technical progress for the 23rd time Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (notified under document number C(1999) 3490) (Text with EEA relevance.)

Commission Directive 97/69/EC of 5 December 1997 adapting to technical progress for the 23rd time Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (Text with EEA relevance)*Official Journal L 343 , 13/12/1997 p. 0019 – 0024*

Energistyrelsen (1997), *Miljø og arbejdsmiljøvenlige isoleringsmetoder*, Udviklingsprogram udsendt af Energistyrelsen, oktober 1997.

Energistyrelsen, (2000), Det Faglige Udvalg – Energistyrelsens tilsagn til projekter år 1997-1998-199-2000, unpublished overview

Fødevareministeriet (2000) *Lov om tilskud til fremme af innovation, forskning og udvikling m.v. i fødevare-, jordbrugs- og fiskerisektoren.* L177, 2000

Strukturdirektoratet (1998), *Udredning vedrørende fremme af økologisk non-food produktion og introduktion af grønt Ø-mærke*, Ministeriet for Fødevarer, landbrug og Fiskeri.

Strukturdirektoratet (1998a), Non-food Sekretariatet, Forsknings- og udviklingsaktiviteter 1997

Miljø- og Energiministeriet (1999*): Natur- og miljøpolitisk redegørelse*, København.

Commercial, strategic documents

Saint-Gobain Isover A/S, årsregnksab 1999,

Rockwool International, Beretning og regnskab 1999

Miljøredegørelse 1997, Rockwool International

Saint Gobain in the Nordic Countries, information papers from S.G., 1993

Olaf Smith-Hansen: *Livscyklusvurdering og markedsføring*, paper from IDA-seminar: Produktorientering af miljøindsatsen, 03.05.1999 Copenhagen

Erik Ransby: HØR - om investering i produktion af ALTERNATIV ISOLERING. SydTek, 1999.

Newspapers

Aktuelt, 13.06.1996, 27.10.00, 27.04.00

Politiken, 09.03.1997, 31.05.99, 16.01.00

Børsen 29.08.2000

'Ingeniøren' p.18-19, no. 42, october 1993 and p.9 & 16 in no.11 march 1994., 1 and 15th september 2000

Søren Kirk Christiansen: *Giftige dampe*, Teknikeren nr. 9, 2000

Træ & Byg 14.08.00, 03.05.00

Lolland-Falsters Folketidende 10.03.99

Articles

Umgang mit Mineralwolle-Dämmstoffen, Handlungsanleitung, Fachvereinigung Mineralfaserindustrie a.o., 0ctober 1993.

dk-teknik and Miljøstyrelsen, (1995) *Criteria for Thermal Insulation Products for Walls and Roofs,*.

Giftige dampe, in Teknikeren no.9, 2000

BPS Byggecentrum: (1998), *Byggeriets planlægningssystem: Håndbog i miljørigtig projektering*, BPS publikation nr. 121, Hørsholm.

BPS Byggecentrum (2000), *Miljørigtig projektering – bygherrevejledningen*, publikation nr. 129, Hørsholm.

Byggepanel under den produktorientede miljøstrategi (2000*), Handlingsplan for en bæredygtig udvikling i den danske byggesektor*, Miljørådet for renere produkter

Bjerg, Niels Strange (1999): *Miljørigtig projektering*, Institut for Teknologi og Samfund, Danmarks Tekniske Universitet.

Dahl, Astrid og Jonas Holbech, Kim Hilding Hansen, Karen Hegelund Møller, Martin Clement Pedersen og Rasmus Peder Christiansen (2000): *Kampen om Munksøgård – en undersøgelse af udviklingsmulighederne for økologisk og bæredygtigt byggeri i Danmark med udgangspunkt i Munksøgårdprojektet*, Institut for Miljø, Teknologi og Samfund, Roskilde UniversitetsCenter.

DTI (2000), Konference: Byggeriets Miljødag, 25. september 2000)

Bent Lund Nielsen (1998): *Erfaringer med alternativ isolering i Tyskland, overheads*, SBI

Hansen, Klaus (2000), *Miljødeklaration af byggevarer*, Statens Byggeforskningsinstitut.

Pallesen, Bodil Engberg (1999), Slutrapport. *Formstykker baseret på hør- og hampefibre*, Landskontoret for Planteavl., Landbrugets rådgivningscenter.

Rockwool (2000*), Miljørigtig projektering og isolering*, Rockwool A/S.

Statens byggeforskningsinstitut (2000), "*Alternativ isolering*". Miljø og arbejdsmiljøvenlige isoleringsmetoder, SBI.

J. Szepma: (1982)*Toxic Hazards Duiring Fire*, Insulation products, Dantest

Energistyrelsen (1997): *Miljø- og arbejdsmiljøvenlige isoleringsmetoder*, Udviklingsprogram

Tom Nisted (2000): *Alternative isoleringsmaterialer - brandtekniske egenskaber*, SBI

Holbæk Bygge Center (2000): *Miljø- og arbejdsmiljøvenlig bygningsisolering af fåreuld og hør* - Feasabilitystudier vedr. mulighederne for at opstarte produktion i danmark på danske råvarer, SBI

Opfølgning og videreførelse af aktiviteter indenfor miljø- og arbejdsmiljøvenlig isolering, mødereferat af 25.05.2000

Boffetta P., Saracci R, Ferro G. (1995) *International Agency for Research on Cancer Historical cohort study of man-made viterous fibre production workers in seven European countries Extension of the mortality follow-up until 1990*. Lyon: IARC, 1995

Boffetta P., Andersen A, Hansen J, et al (1999). *Cancer incidence among European man-made fibre production workers. Scand J Work Environ Health* 1999;**25**:222-226

Boffetta. P. et al. (2000) *A case-control study of lung cancer among european rock and slag wool production workers.* Final Report. IARC International Report N0. 00/004, IARC Lyon

Bodil Engberg Pallesen (1998) *Økonomi og dyrkning af spindhør til korte fibre*, Landskontoret for Planteavl, Landbrugets Rådgivningscenter,

Bodil Engberg Pallesen,(1999) *Slutrapport - Formstykker baseret på hør- og hampefibre*, Landskontoret for Planteavl, Landbrugets Rådgivningscenter,

Bodil Engberg Pallesen (2000a) *Produktion af hørfibre til industrielle formål*, Landskontoret for Planteavl Landbrugets Rådgivningscenter

Bodil Engberg Pallesen (2000b) *Fremstilling af korte hørfibre til industriel anvendelse, ,* Landskontoret for Planteavl Landbrugets Rådgivningscenter

Bodil Engberg Pallesen (2000c) *New invented mats from hemp and flax for i.e insulation purposes*, paper for 3.e international Symposium Biorecouece Hemp 2000 and other Fibre Plants, Wolfsburg september 13-16.12.2000

BAT-kartellet m.fl.: *Alternativ isolering*, 1996

Ulden i kanten, video film by Søren kirk Kristiansen, Net-produktion, 1999 Kbh.

http://www.who.int/regions/iarc.html
http://www.ens.dk/tilskud/alt_isolering/altudvk.htm
http://www.lr.dk/planteavl.htm
httpp://www.sbi.dk/forskning/bogp/materialer/isolering/alternativ.htm
http://tib.dk/kongres/visartikel.shtml?250
http://www.dffe.dk/publokationer/biomasse/biom0004.htm
IARC, WHO (1988): *Man-made mineral fibres*, Summary of Data Reported and Evaluation L.: 43 (p. 39)

Interviewes
Balder Jørgensen, Egen Vinding og Datter
Bodil Pallesen, Plantecentret, Landbrugets Rådgivningscenter
Jesper Lorentzen, Energistyrelsen
Hans Dollerup, LØB – national organisation for ecological construction
Palle Bisgaard, TIB - Labour Union
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