

Science Shop Examples

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These examples were collected for the Science Shop of Queens University Belfast. They give a broad overview of projects carried out by science shops in the natural sciences, medical sciences and engineering. The overview is random, incomplete and based on information available on the websites of the science shops. When longer information was available in English, this was copy-pasted into this document. Copyright on these summaries is with the publishing science shops. The overview was made in 2007; a few examples were added in 2010. This document can be used to illustrate the type of projects that science shops can do. It can be used for those participating in activities of the PERARES-project, including its Science Shop Summer Schools. This document can be shared, but is not to be officially published externally.

1. Contents:

2. Project Examples: Chemistry	4
2.1 Crops for industrial use: how green is green chemistry?.....	4
2.2 Towards small scale use of asphalt as a fuel - An application of interest to developing countries.....	4
2.3 Emissions fibre glass factory	5
2.4 Odour and health issues around carpet factories in Steenwijk	7
2.5 Phosgene-free processes for the production of polyurethane and polycarbonate (1997).....	7
3. Project Examples: Applied physics/chemistry/risk analysis	9
3.1 Seen in the wind... Risk analysis of a planned wind turbine park near Delfzijl, supplemented with an initial effort towards a more fundamental risk analysis of energy supply technologies.....	9
4. Project Examples: Biology/Environmental technology/Public Health.....	13
4.1 Biological mechanisms behind Legionella control.....	13
4.2 Fish protection systems and power plants	13
5. Project Examples: Biology/Environment/Spatial planning	15
5.1 Climate change and biodiversity patterns in Dutch dune ecosystems	15
5.2 Ecological value of allotment parks	16
5.3 Land to River	16
6. Project Examples: Nutrition/Food	17
6.1 Sugar	17
6.2 Local Organic Food	17
6.3 Old Farmstead Cheese	17
6.4 Fried Cassava.....	17
6.5 Probioticum EM.....	17
6.6 Assessment of Diet for people with multiple disabilities	17
7. Project Examples: Animals.....	19
7.1 Welfare and 'the good life of animals' in pig husbandry systems.....	19
7.2 Regulatory Animal Testing.....	19
7.3 Pigeons in towns	21
8. Project Examples: Social Medicine	23
8.1 Living with facial paralyses: what is the quality of life?.....	23
8.2 Gluten intolerance and diabetes type I.....	23
8.3 Social support and quality of life for ADHD patients	23
8.4 Tinnitus	23
8.5 Green in elderly care.....	23
8.6 Overview of genetic counselling in the Netherlands	24
8.7 Inter-sexuality	25
8.8 The impact of stroke on lay carers.....	25
8.9 Improved health care elderly immigrants	26
8.10 Patients experiences in switching to generic medicines	26
9. Project Examples: Medical Studies	27
9.1 Evaluation of Buteyko Breathing Technique	27
9.2 Effectiveness of laser-treatment for psoriasis.....	27
9.3 Connective tissue diseases and auto-immune diseases with women with silicone breast-implants and their offspring.....	27
9.4 Multiple sclerosis and metals.....	27
9.5 The relationship between traffic related air pollution and respiratory health and exhaled nitric oxide in Dutch schoolchildren	28
9.6 Bulbs, pesticides and residential	28

9.7 Bacteriophage therapy	29
10. Project Examples: Pharmacy	30
10.1 Early-deaf persons and drug information	30
10.2 Ramadan and medicine use	30
10.3 ‘Multiple sclerosis. Experiences with prednisolone, interferons and Copaxone®’	30
10.4 Autism and medicines.....	31
10.5 Information brochure Addison’s disease and AGS	32
10.6 The prescription of the first anti-epileptic in recently diagnosed epilepsy.....	32
10.7 Missing a pill: Go on or catch up?.....	32
10.8 Side-effects of gadolinium.....	32
11. Project Examples – Electronical and Electrical Engineering and Mechanical Construction, Architecture and Building.....	33
11.1 Simple voting system.....	33
11.2 Auction clock.....	33
11.3 Speaking clock.....	33
11.4 Sound box Nature Museum	33
11.5 Architecture 1	33
11.6 Architecture 2	34
11.7 Bus and Transport Terminal	34
11.8 School and flows of pupils	34
12.1 The effects on health from high-tension wires	35
12.2 Health effects of large radio transmitter	35
12.3 Sound of windturbines (1)	35
12.4 Sound of windturbines (2)	35

2. Project Examples: Chemistry

2.1 Crops for industrial use: how green is green chemistry?

The Chemistry Shop Groningen got this request: The farmers in the north of the Netherlands are looking for ways to rotate the crops they are growing. For them, it would be good to grow plants that either have compounds in them that could be used directly or to use the carbon from the plants to build new chemicals, as an alternative to using the carbon from a depletable source such as oil. Green chemistry we call that. The environmental organisations wanted to know whether the green route really was more environmentally friendly.

We can compare both production routes with Life Cycle Analysis (to calculate all environmental impacts from the cradle to the grave, so from winning the oil, transporting and refining it, making products in industry and getting rid of the product, such as plastic, after consumer use; and compare it with the route from sowing the seeds, fertilizing the soil, harvesting the crops, extracting the products from it and finally seeing it end up as waste). All environmental effects were scored on 9 or 10 environmental impacts, such as green house effect (through energy use and CO₂ emissions), pollution, ozone depletion, toxicity, etc, aggregated over the whole life cycle.

A first student compared potato sprout inhibitors (a pesticide used to prevent potatoes from sprouting during winter storage). As it turned out, on 7 of 9 environmental scores the synthetic product was better! So, green was NOT always green. Most important factor was the use of fertilizer and the requirement to use a relatively high dosage of the natural product (compared were CIPC and IPC with the natural carvone, which is made from caraway seed). This was nice student work that delivered counter-intuitive results. We published them in a report for the NGOs and in a scientific paper as well.

The next question was "is this an incident or would it be general"?

A second student compared two ways of making a red dye for textiles. The natural colorant was alizarin, which is extracted from Madder. This was generally used in the 1930s. With the rise of chemical industry this route was abandoned in the 1960s; there is now synthetic alizarin and a similar chemical colorant called NaphtolTR.

Also in this research, the synthetic products were more environmentally friendly. Even if one would be able to save 25% energy, 50% fertilizer and increase extraction rates from 30 to 80% this would not help the green route becoming better than the chemical route. All chemical processes were very efficient... On madder, no research has been done since the 1930s...

An alternative to reduce the environmental impact would be to use the rest of the Madder-plant as well, so you could attribute some of the environmental impact of growing it to some side products as well. Unfortunately, even the use in fodder proved not feasible; it led to purple milk... (maybe it would be a nice project for students to see if there is a market for purple milk, though...)

So as it turns out we could give a good answer to the environmental NGOs. The student, received the annual prize for best thesis in environmental chemistry from the Dutch Royal Chemistry Society... We followed these projects up with a more broad study on how the farmers in the North could be involved in sustainable development and started cooperation to try and improve the green route.

We did a similar research on comparing real mink fur with artificial fur. The mink industry had claimed natural fur was better for the environment; one of our students proved them wrong. A good PR success for the animal welfare organization that had requested this research.

So, what the students did was a nice combination of literature surveys, expert interviews, data retrieval, and make educated approximations for data unknown, before using computer modelling to calculate all results. (Chemistry Shop Groningen)

2.2 Towards small scale use of asphalt as a fuel - An application of interest to developing countries

This survey deals with the feasibility of the combustion of asphalt instead of firewood. Or, to put it more generally: the small-scale usage of asphalt as a fuel. On the seashores of the numerous islands of Indonesia, especially on those of south and southeast Sulawesi, mangrove forests are endangered by extensive logging, lately on an increasing scale by locals for whom firewood is the sole resource of energy.

Urged by Yayasan-Sama, an Indonesian non-governmental organisation of South East Sulawesi, the Dutch foundation Zephyr-Sama has prompted research on the feasibility to use asphalt from deposits on the island of Buton as a domestic fuel. This research was thought to possibly lead to the development of a porous plug stove, or to a stove in which carbonised bamboo containers filled with asphalt are used as fuel elements.

This survey consists of a literature review and an overview of possible routes for controlled combustion of asphalt. Attention has been paid to the environmental effects of the combustion as well.

The literature mainly shows side effects of combustion of asphalt, which provide some knowledge on the combustion process. No direct studies on the combustion of asphalt were found.

To explore the bottlenecks of the combustion process, an asphalt candle was made, because the taper seemed an ideal capillary active carrier for fluid asphalt. However, this experimental candle did not burn, likely due to high viscosity at the base of the taper and clogging of carbonaceous residue at the liquid/gas interface of the taper.

An increase of the porosity of asphalt gives a better chance for a propagating combustion. The pores may increase the diffusion rate of volatile components, thus increasing the combustion rate. However, if asphalt is heated it will melt and the fluid will block the pores.

Its melting at a relatively low temperature is a big handicap of asphalt. To overcome this handicap, asphalt could be transported by capillary forces into the combustion zone and combust at solid/liquid/gas interfaces – like is happening in a burning candle. It can be investigated whether this condition could potentially be created in a porous plug stove, or in stove where carbonised bamboo containers filled with asphalt are used as fuel elements. However, it remains to be seen whether this would also solve the cracking problem of asphalt. The main conclusion is that further research should be focused on two processes that control the combustion of asphalt: transport of asphalt to the combustion zone (viscosity) and cracking of the asphalt in combustion.

(Chemistry Shop Groningen, 3-week project in M-eng studies/Chair of Combustion Processes)

<http://chemie.wewi.eldoc.ub.rug.nl/root/rapp/2002/C-102/?pLanguage=en>

2.3 Emissions fibre glass factory

Already in the seventies, people living in the neighbourhood of the fibre glass plant PPG Hoogezand experienced inconvenience as a result of the atmospheric emissions of that plant. After measures had been taken, it became quiet for years. In 1999 however, the complaints returned as a consequence of a technical adjustment in the production process. This led, among other things, to a request of the *dorpsvereniging* Westebroek (situated in the surroundings of PPG) to the Chemistry Shop of the University of Groningen. The *dorpsvereniging* asked for an evaluation of the production process of PPG to obtain more insight in the emissions of the company and the possibilities to deal with them. The request has led to this report.

The question of the *dorpsvereniging* has been included in the objectives of this investigation, as mentioned in chapter 1: *Obtaining insight in the composition, magnitude and possible environmental effects of the emissions of PPG. Comparing these emissions (and the immission concentrations in the surroundings) with the present-day environmental legislation – and policy. Making an investigation of possible emission reduction techniques and judging the emission reduction plans for the future of PPG grounded on this investigation, the results of the mentioned comparison and actual legislation.*

The inquiry starts in chapter 2 with an inventory of the (fibre)glass production process in general and the production process of PPG in particular. The PPG process doesn't deviate from the common (fibre)glass production process. Chapter 3 establishes the emissions to air of the glass- and fibreglass industry. Besides SO_x and NO_x, some specific emissions appear within the fibreglass industry: fluorides, B₂O₃ (in dust) and Volatile Organic Carbon (VOC). Next, it has been attempted to determine the emissions of PPG quantitatively by means of mass balances. Since this appeared to be impossible, analytical results of other references have been used to obtain the quantitative values of the emissions. The PPG emissions (SO_x, NO_x, dust (B₂O₃), fluorides and VOC) turned out to be the same as the general fibreglass industry emissions mentioned above. The immission concentrations around PPG are presented at the end of the chapter.

The most relevant environmental and health aspects of the established emissions, as well as their environmental standards in force are described in chapter 4. In high concentrations, all emitted substances can (by exposure through inhalation) cause damage to human health. Especially fluorides can cause damage to plants.

Chapter 5 deals with the for a company like PPG most relevant environmental legislation and environmental policy. A distinction is made between general legislation and specific policy making regarding the environmental permit, the emissions and the immission concentrations. The conditions accompanying the permit can be found in chapter 8 of the Dutch environmental law. The most important requirement that the emissions need to meet is known as the ALARA-principle (As Low As Reasonably Achievable). Companies can meet this demand by using either BAT (Best Available Techniques) or BATNEEC (Best Available Techniques Not Entailing Excessive Costs) for the reduction of emissions. The immission concentrations around a company need to satisfy current environmental standards concerning the ambient concentrations of contaminants.

In chapter 6 the actual PPG situation, with regard to the environmental permit, emissions and immissions concentrations, is compared with the in chapter 5 determined demands. The environmental permit doesn't comply with some essential conditions as described in the Dutch environmental law. The permit has therefore to be updated. The emissions of dust and fluorides of both ovens (named 608 and 609) of PPG are too high and don't comply with the ALARA-principle. The same applies, although to a lesser extent, to the SO_x and NO_x-emissions of oven 609. The emissions of VOC are probably too high as well, but these emissions can't be tested to the ALARA-principle as a result of a lack of data. The extent to which the PPG emissions have to be reduced can be

found in table 1. The reduction factor is the quotient of the PPG emissions and the emissions that are applied when BAT is used for emission reduction. If this factor is smaller than 1 no reduction of the emissions will be required.

Table 1: required reductions of the PPG emissions

component	oven	PPG emissions (kg/ton glass)	Emissions when BAT is used	Required reduction of emissions	
				reduction factor	reduction in %
SOx	608	1.98	0.9 - 3.6*	0.6 - 2.2	0 - 55
	609	3.82		1.1 - 4.2	6 - 76
NOx	608	0.55	0.5 - 1.5	0.4 - 1.1	0 - 9
	609	1.73		1.2 - 3.5	13 - 71
Fluorides	608	0.73	0.023 - 0.068	11 - 32	91 - 97
	609	0.45		6.6 - 20	85 - 95
Dust	608	5.79	< 0.14	> 42	> 98
	609	3.61		> 26	> 96
VOC	Finishing	0.92	unclear	unclear	Unclear

When the immission concentrations around PPG are compared to current standards, the following exceeding of these standards appear:

Table 2: Summary of the cases wherein exceedings of current standards take place

Component	Exceeded standard	Exceeding factor	Remark
Fluorides	MTR (year)	10	
	MTR (day)	33	
	Aim value (year)	1020	
SO2	Aim value (day)	4.6	
NO2	Aim value (year)	70	Exceeding MTR (year) Possible
	Threshold value (hour/98%)	Not evident	
	Guiding value (hour)	Not evident	
Dust	MTR (year)	Not evident	Value balances around MTR (day)

Especially the fluorides MTR (Maximally Tolerable Risk)-standards are heavily exceeded. Testing of the PPG VOC emissions is again impossible because of lack of data. Since the use of immission concentrations is not allowed for this purpose, the results of the emission testing will be regarded normative in the rest of the investigation.

Chapter 7 inventories possible techniques and measures that the glass fibre industry can use to generate the in table 1 calculated reduction levels of emissions. The chapter ends with an enumeration of the BAT for emission reduction of the regarding components.

Chapter 8 finally checks whether the emission reduction plans of PPG are sufficient to reach the in table 1 mentioned necessary reductions. The method of approach for oven 608 can be considered as suitable, provided that the installed techniques (wet scrubber) reduce sufficiently. The approach of the emissions of oven 609 is inadequate. In the short run, the same measures as undertaken for oven 608 should be taken for this oven, that is: a transition to a gas/oxygen fired system and the installation of a wet scrubber. The same applies to a third oven, oven 607, if this one is brought into use again. It's also possible to use other techniques than the ones mentioned, on condition that they are able to reach the required reductions. No method of approach can be indicated now for the VOC emissions. Therefore these emissions have to be compared with the ALARA-principle and subsequently, if necessary, tackled.

Finally, it is concluded that especially the PPG fluorides and dust (mainly B2O3), and to a lesser extent the SOx and NOx-emissions are too high because they don't comply with the ALARA-principle. In some cases environmental standards are exceeded. The shortcomings of the valid environmental permit are an important cause of the high emissions. The emissions reductions as presented in table 1 are therefore necessary. A variety of proved techniques that are able to bring about these reductions exist. However, PPG's present planning for emission reduction (for oven 609 in particular) is insufficient. It's recommended that PPG transforms all ovens (607 included) as soon as possible into gas/oxygen fired systems. Moreover, the waste gases need to be cleaned by means of wet scrubbers. It will be required to place electrostatic precipitators and/or to produce glass with low fluoride contents in case these wet scrubbers turn out to be not effective enough in cleaning the gases. It's also possible to use other emission reduction techniques, provided that these are able to reach the same emission levels. At last, it's necessary to obtain more insight in the character and magnitude of the VOC emissions and to apply these emissions on the ALARA-principle (possibly followed by taking measures to restrict these emissions). (Chemistry Shop Groningen, MSc student Energy and Environment, 6 months)

2.4 Odour and health issues around carpet factories in Steenwijk

The residents of two neighbourhoods in the city of Steenwijk experience odour pollution and health problems. According to them two carpet factories south of the neighbourhoods cause this. One company - Crilux - paints carpets, whereas the other company - Betap - adds rubber backing to carpets. In the past, both companies commissioned studies. The residents asked the Chemistry Shop to give a second opinion with regards to the odour pollution and health problems in their neighbourhoods.

In this report we investigated the odour emissions and immisions of toxic (and potentially carcinogenic) compounds. For this, calculations were made with the National air pollution dispersion model "PluimPlus v2.1". Some attention was also paid to the wastewater problem, because of the sewage overflows present.

Odour immision was calculated cumulative for both factories, something which had not been done before. This gives a better indication of the total odour annoyance that can occur in the area. The maximum odour immision at the nearest home was 6.5 Dutch odour units (equal to 3.25 English odour units) as 98-percentile.

The chimney at Betap was calculated to be the largest source of odour emissions, the wastewater pond at Crilux came in second. The emissions from both factory halls were negligible.

Two options to reduce the odour pollution were investigated: enlarging the chimney and increasing the temperature of flue gasses. Neither solution would render a 100% solution.

As mentioned above, the inhabitants also experience health problems. They fear that dangerous, carcinogenic compounds are emitted. Therefore, we calculated the immision of some of these compounds. All concentrations turned out to be far below the Maximum Immission Concentration MIC. Thus, there is no direct health problem associated with these emissions.

We paid attention to the wastewater of both companies, because of sewage overflows (which overflow in times of heavy rain). In such cases, direct contact with pollutants in the wastewater becomes possible. The wastewater from Crilux contains colorants and a number of heavy metals, such as chrome, copper and zinc. For the latter, the maximum allowable concentrations for surface waters could be surpassed in ponds in the neighbourhood during overflows. More detailed analyses of concentrations in the water during overflow, and soil analyses could thus be worthwhile.

The final findings are:

The factories of Crilux and -especially- Betap are causing an odour problem in their surroundings, with all consequences thereof for the well being of the inhabitants of the area (these problems fall under the rubric of 'health', according to the World Health Organisation definition).

The emissions of toxic substances by Betap and Crilux (as measured by RIVM and DTFi) do not cause dangerous concentrations in the neighbourhoods.

A more detailed assessment of the sewage overflow problems could be made, especially with respect to colorants and certain heavy metals

(Chemistry Shop Groningen, 3 month BSc final year student Environmental Sciences)

2.5 Phosgene-free processes for the production of polyurethane and polycarbonate (1997)

Most commercial production processes for polyurethane (PUR) and polycarbonate (PC) polymers are based on phosgene. Environmental and health risks of phosgene ask for alternative production pathways. This report presents a literature search on phosgene-free processes for PUR and PC. The research was done on behalf of the Federation of Environmental NGOs in the Province Northern-Brabant, in which General Electric Plastics is located, too. GEP currently plans PC production at its Bergen-Op-Zoom site.

PC

Polycarbonate is usually produced by poly condensation of bisphenol A and phosgene. Transesterification of diphenylcarbonate and bisphenol A is an alternative option. Recent advances of this melt process have overcome its technical drawbacks, especially the limited polymer weight of the product. Asahi (Japan) has improved the process on a pilot scale by solid- state polymerization and obtains an excellent product at lower cost, as compared to the poly condensation process. The multi- stage melt process will likely be used on an industrial scale in the near future.

Diphenylcarbonate (DPC) is a feedstock for the PC melt process and usually produced from phosgene. The transesterification of dimethylcarbonate (DMC) is an alternative route for DPC production. Phosgene-free routes for the production of DMC are already in use on an industrial scale. The Asahi process utilizes the transesterification route for the production of DPC and is therefore phosgene-free; it also avoids the use of chlorinated solvents.

Another interesting aspect is the possibility to use carbon dioxide, which may be recycled from the exhaust gases of (f.e.) power stations (thus diminishing the emission of greenhouse gases). So, possibly the use of phosgene in the production of polycarbonate can be avoided in the near future.

PUR

In the production route of polyurethanes phosgene is used in the production of the diisocyanates feedstock. Various interesting phosgene-free routes for the synthesis of diisocyanates are demonstrated on a lab scale, as well as routes for the direct production of polyurethanes, thus avoiding toxic diisocyanates. In 1985 Asahi has successfully produced diisocyanates on a pilot scale in a phosgene-free cracking process using diurethanes. However, for unknown reasons this process was not scaled up to commercial production. So phosgene-free processes for the production of diisocyanates and polyurethanes seem to have good possibilities on the longer term, but in the near future phosgene processes will be dominant.

(Chemistry Shop, Groningen, 4 week project MSc student Chemistry)

Recently updated, see: <http://irs.ub.rug.nl/dbi/4bc2d0287f385>

3. Project Examples: Applied physics/chemistry/risk analysis

3.1 Seen in the wind... Risk analysis of a planned wind turbine park near Delfzijl, supplemented with an initial effort towards a more fundamental risk analysis of energy supply technologies.

The Dutch government has made an agreement with the different provinces concerning the further implementation of wind energy. The regional plan of the province of Groningen of 1994 assigned areas where large wind turbine farms are basically allowed.

A location south east of the industrial estate of Delfzijl is one of those areas.

Early 2001, Foundation "Windhoek" requested the Chemistry Shop of Groningen University to do research on the potential risks related to the construction of a wind farm on this location near Delfzijl. The wind farm will consist of 37 wind turbines with a rotor blade height of about 120-m.

Foundation Windhoek is concerned about the potential risks of some wind turbines near an ammonia storage of the company Elektroschmelzwerk Delfzijl (ESD). The Foundation is also worried about the potential risks of wind turbines near the transportation route for hazardous substances.

There are more wind farms in the Netherlands, which have the same potential risks. In general, risk profiles of energy generation technologies are not well available.

The research question to be discussed in this report is:

"Does the placement of wind turbines at the intended location in Delfzijl meet the general risk standards?"

Elaborating on this theme, a first step is made to come to the development of chain-risk-profiles for energy production systems.

The research question is answered in separate steps:

First, a general survey on risks and risk standards is presented.

Second, safety and the occurrence of incidents with wind turbines discussed in general. For the risk standards governmental reports and regulations are applied. The risks of wind turbines are determined with the help of literature and experts.

After this, the consequences of potential incidents with wind turbines at the specific location are determined. This includes a discussion of the number of hits per m² in the surroundings, calculated with formulas on the basis of the occurrence of incidents per wind turbine. Special attention is paid to the consequences a hit on the ammonia storage tank of Elektroschmelzwerk Delfzijl (ESD, located next to the wind farm. These potential consequences are determined on the basis of two independent literature sources. Next, special attention is also given to the risks for passing vehicles at the N362 en Warvenweg along the wind farm. In this risk calculation extra attention is paid to the consequences of hits on transports of hazardous substances. Besides calculation formulas different literature sources are used. In principle, both the hit of the ammonia storage tank and vehicles with dangerous substances will cause indirect (health) damage, because people can be exposed to ammonia or other dangerous substances, or to an explosion.

The obtained risk analysis results are compared to those of an ECN report concerning the same wind farm, which came available during this study.

Finally, a more fundamental risk analysis of energy generation technology is discussed. For this, an inventory and assessment of literature to make a chain risk analysis for wind turbines, solar cells and STAG/CG-STAG was made.

1. Risk standards

The risk assessment in this report exists of two components: the chance and the consequences of an incident.

The assessment framework exists of individual risk (IR, which is location bound), group risk (GR), individual passer-by risk (IPR), socially tolerable risk (STR) and the route-standards (standard/km) for transports of hazardous substances.

Table 1 shows an overview of the assessment framework. The risks calculated in this report will compared to these norms.

Table 1: Overview framework risk assessment wind farm.

Assessment framework	Standard (mortality risk/year)
Individual risk (1 person)	10 ⁻⁶

Group risks: 10 persons	10^{-5}
100 persons	10^{-7}
1000 persons	10^{-9}
Individual Passer-by Risk (1 vehicle)	10^{-6}
Socially tolerable risk (all passer-by)	$2 \cdot 10^{-3}$
Route-standards (10 persons; per km)	10^{-4}

The risk standards only apply to mortality. There are no fixed standards for the maximum number of wounded or economic damage. Wind turbines have to comply with many safety rules, for example as a result of the certifying of wind turbine components. In these safety standards there are (yet) no risk standards for rotor blade break off, etc. Currently, there are no *specific* legislative minimum distances for wind turbines to other infrastructure and buildings based on safety considerations. However, there are provisional rules for minimum distances in order to prevent noise nuisance, light reflection and shadow nuisance. These are mentioned in the draft decision 'Facilities and Installations' of the environmental Law (VROM, 1999).

There is no central registration of accidents with wind turbines in the Netherlands. Occasional reports often contain confidential information. In general, the lack of central registration and/or reporting obligation can possibly cause an underestimation of incident numbers. For this report, information from, e.g., the Danish WindStats is used.

The following incidents are selected for the risk assessment of the wind farm:

- Break off of whole rotor blade;
- Partly break off of rotor blade;
- Launching of ice projectiles;
- Falling over of wind turbine.

Table 2 gives an overview of the chances for these different types of incidents as they are used in this report.

Table 2: Overview different incident chances per year.

Incident type	Chance/year
Whole rotor blade break off	$6.96 \cdot 10^{-3}$
Partly break off of rotor blade	$2.6 \cdot 10^{-4}$
Launching of ice projectiles	Unknown
Falling over of wind turbine	$1.5 \cdot 10^{-4}$

2. Risk assessment wind turbine farm

Both chance and consequence are calculated in a step-by-step way, in order to establish the total risk of the wind turbine farm on the planned location. The "chance" factor consists of the chances of hitting the ammonia storage tank at ESD or passing vehicles at the N362 and Warvenweg. The "consequences" factor consist of (mortal) casualties through the release of ammonia from the ESD storage tank or through a direct hit on a passing vehicle or indirect through a hit on a transport vehicle with hazardous substances.

Calculations (based on the required force and mass) showed that in principle only a few to a few tens kilograms is needed to punch a hole in the ammonia storage tank of ESD or a tank lorry with hazardous substances, when objects are launched from the wind turbine when it operates with a normal number of revolutions.

Practice shows that it is possible that a projectile of this size can be released from a rotor blade. The most important conclusions from the risk assessment are given below.

a. Ammonia storage tank ESD

An existing assessment of the consequences of uncontrolled release of an ammonia cloud from the storage tank showed that at large distance (1 – 1.8 km) loss of life is possible (however, this depends on specific circumstances, the weather and contingency plans). Moreover, up to 6.5 km from the storage tank a large number of people may suffer (irreversible) health damage.

Wind turbines 1, 2 and 3 have a chance of causing a hit on the ammonia storage tank. The responsible incidents are partly rotor blade break off, which can both reach up to 630 m from the turbine. Whole rotor blade break off or falling over will not affect the storage tank, based on our assumptions.

The most important conclusions are summarised in Table 3:

Table 3: Overview results risk assessment ammonia storage tank ESD.

	Individual risk	Groups risk
--	-----------------	-------------

Employees	No	No
Neighbours	No	No ¹

Explanation: No = no norm exceeding

¹ Value exceeds the group risk standard only if 250 casualties after a hit on the storage tank is seen as a realistic (found chance: 1.78×10^{-8} per year)

Table 3 shows that none of the group risks are exceeded.

Passing vehicles

The following vehicles passing the wind turbine park are taken into consideration in the risk assessment: cars, busses, cyclists and tank lorries with hazardous substances. For the risk assessment, all vehicles are assumed to pass by on both the N362 and the Warvenweg, except busses, which only pass by on the N362.

When these vehicles are hit, there is a direct risk for the driver and/or passengers. Once a transportation vehicle with hazardous substances is hit, this causes additional indirect risks for surrounding passers-by, neighbours, employees and those present at the recreational sites nearby. The potential risks for neighbours is determined for houses along the Ideweesterweg and the Kloosterlaan (other houses are not taken into consideration because of the large distances to the N362 and Warvenweg). For employees, the risk is determined for the industrial estate next to the Warvenweg. Finally, the potential risks for those present at the recreational sites are calculated for the cross-country course at 150 m west of the N362.

The results of this assessment are summarised in Table 4. This table shows that there is no violation of the maximum risk standards for passers-by, neighbours, employees or people at the recreational sites, neither as the result of a possible direct hit nor through the indirect consequences of a hit on a tank lorry with hazardous substances.

Table 4: Overview results risk assessment passing vehicles

	Direct hit cars	Direct hit busses	Direct hit cyclists	Indirect through hit of tank lorry with dangerous substances		
				Neighbours	Employees	On recreational sites
Individual risk	--	--	--	No	No	No
Group risks	--	No	--	--	--	--
IPR	No	--	No	--	--	--
STR*	No***	No***	No***	--	--	--
route-standard**	--	--	--	--	No	--

Explanation:

No = not exceeding norm.

-- = not applicable (groups risk are only present for a possibility of 10 or more casualties at once)

* STR is only applied to passenger transport and not to transport of (dangerous) substances.

** Route-standard is derived from groups risk norm and drawn up for transport with (dangerous) substances.

*** Also STR for cars, busses and cyclists together will not be violated.

b. Comparison with risk assessment in ECN-report

There is a difference between the group-risks calculated in this report and those in the ECN-report. These differences stem from the choice of incidents to consider, the number of vehicles passing by, the method of calculating of the surface that is affected by a hit, as well as the safety philosophy that is used:

- The ECN-report does not account for wind turbines falling over, and partly break off of rotor blades; as a result, a lower risk is calculated in comparison to this report;
- The ECN-report is based on a lower number of vehicle movements; as a result, a lower risk is calculated in comparison to this report;
- This report does not take into account situations in which the wind turbines have a higher number of rpm than their normal maximum operating speed, therefore the maximum hit distance is underestimated;
- This report does not correct for so-called border effects, therefore in this report a lower possibility of hitting is calculated in comparison to the ECN-report;

- The ECN-report does not account for indirect consequences through a hit on the ammonia storage tank at ESD or on a transport lorry with hazardous substances. It only states that the additional risk is relatively low. In this respect, there is a clear difference with the safety philosophy for risk analysis as used in this report.

Since this report does assess possible further consequences, a better overview of the potential number of indirect casualties is obtained. Without this further assessment, an underestimation of risks can occur. From this point of view, it is more obvious to map out the consequences and to assign them to the "new activity" (like a wind farm near existing houses, factories and other infrastructure).

One of the principles applied in safety policy is the ALARA-principle¹. With this principle, a fair balance is sought between (financial) costs and (risk mitigation) benefits, to achieve the lowest possible risk. For the planned wind farm, it appears possible to reposition three wind turbines (no 1, 2 and 3) in such a way that group risks decrease even further (moving turbine 1 and 3 over more than 150 m, turbine 2 over more than 400 m). It seems more obvious to reposition the wind turbines than to make adjustments to the ammonia storage tank, since the wind farm is the new activity at the location, which causes the additional risks. It also seems that a position change will not lead to extra costs or loss of energy output².

Based on the ALARA principle, one could also decide to reposition the wind turbines along both transportation routes (i.e. put them at a larger distance from the roads), if this is possible at minimal extra costs or yield loss.

The final conclusion concerning the risks of the intended wind farm is that the wind farm meets the existing standards. Also, based on the ALARA principle, potential risks can most likely be lowered even further.

3. Chain-risk-analysis

A literature survey showed that for wind turbines, solar cells and STAG/CG-STAG risks occur on different positions along the chain. For wind turbines and solar cells, the risks predominantly appear on the first part of the chain, while for STAG and CG-STAG the risks occur mainly in the exploitation phase (through fossil fuel usage, including its mining and emissions).

The survey shows in the first place that sufficient literature is present to undertake a chain risk analysis of energy production. Important points to consider are the choice for system boundaries and the distinction between human and environmental risks.

To draw a good comparison between different chain risk analyses, it is necessary to choose similar system boundaries, otherwise a false risk representation is possible.

A clear and strict distinction between human and environmental risks is difficult. Risks for the environment can also cause indirect risks for humans and the other way around.

As an example, one can think of the exchange of substances between the different environmental compartments and exposure routes.

If one does not account for indirect risks it is also possible to underestimate the risks in a chain risk analysis.

Finally, it can be recommended that risk assessments are made of wind farms, including potential indirect effects though hits on hazardous objects as storage tanks and transports. Also, group risks for bus passengers deserve some more attention. This aspects have received little attention so far, but can be very relevant, especially in areas that are more crowded and busy than north east Groningen.

Currently, ECN is working on a handbook that should lead to standardisation of risk assessments for wind parks. The fail-date that are used in a draft received at the end of December 2001 are in the same order of magnitude as used in this report.: whole rotor blade break off: $8.4 \cdot 10^{-4}$ (compared to $7 \cdot 10^{-4}$ used in this report), part of rotor blade brake off $2.6 \cdot 10^{-4}$ (equal), falling over of wind turbine $3.2 \cdot 10^{-4}$ (compared to $1.5 \cdot 10^{-4}$ in this report).
(Chemistry Shop Groningen, MSc thesis 6 months, Chair of Energy and Environmental Sciences)

¹ As Low As Reasonably Achievable

² The minimum distances between the wind turbines have been taken into account (turbines take each others wind if placed too close together, resulting in loss of energy output).

4. Project Examples: Biology/Environmental technology/Public Health

4.1 Biological mechanisms behind Legionella control

An overview was made for LegioFreeWaterSystems Inc. The bacterium *Legionella pneumophila* is the source of the disease 'Legionellosis', better known as Legionnaire's disease. Although the illness can be treated with the right antibiotics, *Legionella* has led to a good number of deaths in the Netherlands alone. *Legionella* thrives in water of 20 to 50° Celsius, and therefore occurs in all sorts of (warm) water systems and water installations.

In order to prevent *Legionella* contamination, several methods have been developed with which the bacteria can be killed in (tap) water. The most common method is thermal disinfection, with which the bacteria are killed through heating. Other methods use different techniques to kill *Legionella*, such as the use of UV-light, copper-silver ionisation or oxidizing substances. In this literature study, the specific biological mechanisms behind several methods of *Legionella* control were studied. Each method has its advantages and disadvantages in effectiveness. Of course, all methods also have advantages and disadvantages in terms of cost, utility, safety and so on, but these are only marginally referred to in this research.

UV-light only has an effect on the DNA of the micro-organism: the DNA is damaged and becomes dysfunctional, due to which the *Legionella* bacteria die. When using UV-light, it is of importance that the dosage and duration of the radiation is sufficient. With a short exposure, a high intensity is needed to provide enough energy. The dosage emitted by the UV-lamp can moreover damage only a limited amount of DNA. If the *Legionella* are located in protozoa that have a large amount of DNA (in the nucleus as well as the mitochondria), possibly less damage is done to the DNA of the *Legionella* bacteria.

Copper-silver ionisation is a cheap method and an effective way of killing *Legionella*. However, as with UV-light, the *Legionella* bacteria can be protected by the protozoa and/or a bio film. Another disadvantage is that the use of heavy metals in waterworks brings with it risks for public health.

Besides above mentioned methods, there are oxidizing substances that can kill off *Legionella*. Of these, chlorine is especially suitable in preventing the spread of *Legionella*, as a supplement to other methods. Disinfection with ozone is more effective, but has the disadvantage that ozone is quickly deactivated in water.

Peroxides are also used extensively in waterworks disinfection. Similar to UV-light and copper-silver ionisation, the oxidizing substances must penetrate the protozoa that harbour the *Legionella* for a proper disinfection. Whether these methods of disinfection have a sufficiently lethal effect on *Legionella* is not yet known.

With thermal disinfection, *Legionella* bacteria that have infected the protozoa are also reached, as well as the *Legionella* bacteria located in a bio film. The temperature increases without as well as within the protozoa, and leads to damage to the *Legionella* bacteria present. A second point that supports thermal disinfection methods is that, through heating, multiple parts of the cell are destroyed. The chance that *Legionella* survives this combination of factors is in this way reduced to a minimum.

(Science Shop for Biology, University of Utrecht)

4.2 Fish protection systems and power plants

Mortality of fish at cooling water intakes and hydro-electricity plants is a major problem. The cumulative survival-rates can be very low when fish pass through multiple plants, which implies that the recovery of some endangered fish species populations is at risk.

In the Netherlands, energy companies are still not legally obliged to apply fish protection systems. This situation will change in the near future. In December 2002, the Dutch government accepted a resolution, which will oblige owners of hydro-electricity plants to apply fish protection at existing plants and at plants to be built in the future. However, it is obscure which fish protection technology is suitable for application in the Dutch river systems. The technology to be selected for application is topic of the debate at the moment.

While this debate continues, measurements to protect fish are still not operational. Each day, a lot of fish dies when passing hydro-electricity plants. Mortality rates of up to 23% were for example measured for eel. Agreement on this subject should soon be reached: this situation will not change as long as effective fish protected systems are not installed.

In this research, an inventory was made of the fish protecting technologies that have been developed worldwide. These systems were evaluated according to biological, technical, and economic criteria.

It was also investigated, which is the most effective solution to fish protection for the Dutch situation. The systems' capacity to protect as many species as possible and to reduce mortality rates to a maximum, were considered most important in this respect.

From the research it appears, that no fish protecting system can be developed that guarantees a 100% guiding efficiency for each fish species. Due to technical reasons, but in particular because the behaviour of living

organisms cannot be predicted nor influenced completely, a 100% guiding efficiency for all fish species is not feasible. The sensitivity to damage differs for each fish species and length, while measurements taken to protect fish against damage are also species dependent. Therefore, it is inevitable to set priorities regarding the fish species to be protected. A choice should be made as to which species deserve protection (the so-called target species). The selection of the fish protection system depends on the priorities set for the protection of fish species. When determining the target species, the protected status of fish species due to legal measures or policy, should be taken in to account. The consequences of damage on different fish species populations should also be taken in to account, when selecting the target species.

Fish protection systems of which the functioning is based on physical blocking, collecting fish, and guiding fish (the so-called 'mechanical systems') were found to be more effective than those fish protection systems of which the functioning is based on the behaviour of fish (the so-called 'behavioural systems'). According to the evaluation criteria used in this report, mechanical systems such as the modular inclined screen and the inclined plane screen appeared to be the most effective systems. Application of behavioural systems only provides a solution in situations where the protection of only one or a few fish species is needed, such as salmonids or eel for example. Despite a number of existing studies on fish protection in The Netherlands, it can be concluded that these do not provide sufficient insight to enable a proper selection of a fish protection system that would be suitable for application in the Dutch rivers. This is due to a lack of field experiments and the focus on too few target species. Considering the fish species, which deserve protection in relation to legal measures, policy, and ecological and biological grounds, it is recommended to take the modular inclined screen or the inclined plane screen in combination with a trash-rack as the starting point. Before proceeding to the possible implementation of these systems, further research on potential problems with waste in the Dutch rivers is required.

The Netherlands should implement fish protection systems as soon as possible in order to mitigate the current fish mortality. Further research on the functioning of fish protection systems in practice is needed to make progress towards a final selection of a fish protection system, which is suitable for application in the Netherlands.

Furthermore, future research into fish protection should focus on the following aspects:

- The behaviour of fish and methods to influence fish-behaviour.
- The widening of the focus of research. It is recommended to test the effectiveness of fish protection systems on the basis of the impacts on a broader range of river and migrating fish species with a protected status, instead of one or a few fish species.
- For each fish species, a safe standard should be determined for cumulative fish mortality, which considers the entire migration area of that particular fish species. The fish mortality caused by plants outside the Netherlands should also be taken into account when determining safe standards, as well as population data.
- The influence of waste in the Dutch rivers on the effectiveness of fish protection systems.

Foundation Reinwater was able to influence the definition of 'green electricity' with this report.

(Science Shop for Biology, University of Utrecht)

5. Project Examples: Biology/Environment/Spatial planning

5.1 Climate change and biodiversity patterns in Dutch dune ecosystems

This report provides insight in changes in distribution patterns of higher plants, butterflies and dragonflies in the Dutch coastal dune area, which can be related to climate change. The results will be used by the Dutch Society for Dune Conservation in their communication with policy makers.

Since the 20th century the climate is changing: the sea level rises, the mean annual precipitation increases and there is a tendency towards more extreme precipitation. Beside this, there is a world wide temperature rise going on through the increase of greenhouse gas emission caused by human activities: the global warming effect. The mean annual temperature in The Netherlands increased with approximately 1°C in the 20th century and this will increase further until 2100. Because of the temperature rise isotherms move northwards, the water circular course intensifies and subsequently climate patterns change. Climate change has a direct warming effect on flora and fauna as well as indirect effects due to changing habitat quality. Populations, which can't adjust to these changes, want to move to more suitable habitats.

Due to the geographical position from South to North, the Dutch coastal dune area has in this context an important potential corridor function. But the area has become fragmented because of the many functions it has to fulfil for human activities. It is unclear whether flora and fauna can keep up with the speed at which the current temperature rise is taking place. The Dutch Society for Dune Conservation therefore asked the Science Shop Biology of Utrecht University to investigate current distribution patterns of flora and fauna in the coastal dune area. The society wants to get more supported argumentation about this subject with the intention to improve the quality of the corridor function.

The focus of this research was to analyse changes in the distribution of higher plants, butterflies and dragonflies in the 20th century. The following research question was therefore studied: Which changes in distribution have taken place for populations of higher plants, butterflies and dragonflies in the Dutch dune area that can be related to the temperature rise? The research has been carried out on the base of literature and field expertise of land managers and monitoring volunteers. The research was restricted to the special areas of conservation as outlined by the EU-Habitat Directive in the mainland dunes (from Hoek van Holland to Den Helder).

The distributions of 31 higher plants, 12 butterflies and 12 dragonflies, which are selected as potential climate indicators, have been researched. These developments could be related to the temperature rise for six new species in the research area, one extinct species and ten species with a distribution change. Beside the temperature rise, acidification, desiccation and nutrification have played a role on the distribution of 12 species. The latter caused the extinction of two species and the change in distribution of ten species. Changes in distribution have been noticed mainly in northern direction. Specialist species with limited dispersal abilities seemed to develop more negatively than generalist species with great dispersal abilities. Seven species didn't experience obstacles during their migration throughout the research area. Eleven species are seen in the most southern (Voornes Duin) and most northern (Den Helder-Callantsoog) dune area, but their distribution over the other dune areas is not optimal. Eight species may experience obstacles (North Sea canal, natural segregation in calcium richness of the soil nearby the North Sea canal) from the Noord-Hollands Dune reserve northwards. On the base of this research the main following recommendations are formulated:

- * Defragmentation: create dry verges, shores and wooded banks/ canals as important provisions (food/ reproduction) to facilitate migration of butterflies. Small ponds, which dry out at the surface in summer, are necessary as a habitat for the reproduction of dragonflies and improve the natural resilience of the populations.
- * Adaptation of nature policy: develop buffer zones around protected nature areas. Flexible prescriptions for these zones allow adjusting land use and land exchange when circumstances in future ask for it. Regulate or reduce extra stress factors from outside the nature reserve to improve the natural resilience of the system. Enclose juridical unprotected nature in the spatial structure of nature areas, to facilitate migration and the natural resilience of populations.
- * Adaptation of spatial policy: arrange the areas for water storage that is necessary in the context of climate change, in such a way that they can fulfil a function for migrating species or temporal habitat for species as well. Thereby, it is possible to include climate in policy instruments as the Watertoets and Environmental Impact Assessment. In this way, new interventions in the landscape can be examined on the climate resistance of the area where the intervention is planned.
- * Further research: detailed analysis of current available datasets about the presence of species on kilometre-scale is possible and valuable.

(Science Shop for Biology, University of Utrecht)

5.2 Ecological value of allotment parks

Allotment parks, a number of hobby gardens considered as one entity, are situated in close vicinity of villages and towns. The continuation of Dutch allotment parks is often endangered by town and country planning in their near surroundings. The negative planning developments concerning allotment parks are often approved by the local authorities from the perspective of economic growth by other activities. To make a more sustainable policy decision in future projects concerning both economical and non-economical interests, the Dutch national organization for allotment parks (AVVN) is interested in a method to determine the natural value of allotment parks. A short literature study was carried out at the Science Shop for Biology, Utrecht University, to explore the existing instruments for nature valuation.

A lot of research has been done on the valuation of nature since social awareness grew about the negative effects of urbanisation and infrastructure on the natural environment. Numerous methods are developed to express the value of nature. Depending on different visions, these nature valuation methods can be separated into two main streams: the social economic value of nature and the ecological value of nature.

The quality criteria for nature valuation find their origin in an anthropocentric and eco-centric approach of nature. The social economical value of nature is about human interests and welfare (anthropocentric) and its nature valuation methods are based on the functions of nature for human beings. Ecological values of nature are based on the intrinsic value of an organism (eco-centric). The ecological nature valuation methods are based on criteria from physical, a-biotal and biotal entities, but their ranking is man-made.

The social economic values of nature in general and urban nature in particular can be expressed in money. In this report several of these valuation methods are commented. The contingent valuation method reflects the willingness to pay for greenness supplies, moreover all functions that nature can serve are involved in this method. This method is expected to be suitable for the social economic valuation of allotment parks.

For ecological nature valuation methods, single species are the most important entity. In this report ten valuation methods which use biological data are commented. The combination of three of those methods will give a rather complete ecological valuation of allotment parks. These methods are:

- The ecological capital index is a valuation method on ecosystem level, based on the scope and quality of a certain area;
- The species group trend index is the quantity of separated species belonging to a specific group of species, compared to a determined year;
- The red list indicator determines the rareness of species and describes the extinction rate of a species group.

The nature valuation methods mentioned above are considered to be suitable to apply to allotment parks. Within the protocols of these different valuation methods some adaptations may have to be carried out to come to fully operational instruments for the natural valuation of allotment parks. The combination of social economic and ecological valuation of nature may give a rather complete perspective on the overall natural value of allotment parks.

Follow-up was done through Wageningen University, on behalf of a Local Gardeners Association: their gardens were threatened by building of homes. They wanted to show their value for the neighbourhood. A group of students did a lot of interviews with stakeholders and Gardeners Associations elsewhere. It seemed value could be expressed on three aspects: ecological (local plants/trees and small animals/reptiles; gardens can be part of migration zones as well); cultural (historic landscape, old plants), and social as a meeting place. The latter required more attention, since some gardeners were afraid to open the garden to the public (or had bad experiences). Given some best practices elsewhere, solutions were found. The report was handed to the Mayor and the Gardens were saved. It is an example for other cities as well.

5.3 Land to River

As you know, the Netherlands is mostly below sea level. Over the last decade we had some river floodings. To prevent floodings in cities, we need to have room for floodings elsewhere. Which means given rural areas back to the water... Inhabitants in one of those areas asked the science shop to help develop and evaluate alternative plans. Even though they did get a lot of media attention, and had well prepared debates, the authorities continued with their own plans. It shows that the science shop is not a magic stick with a guarantee to get what you want... (Wageningen University – Science Shop)

6. Project Examples: Nutrition/Food

6.1 Sugar

On request of the Foundation Consumer and Biotechnology a six week literature study was done on the uses and health aspects of sugar and the history, production, genetic modification of and the European policy on sugar beets. This study is meant to be used as an objective background source for the Nutrition Information centre (Voedingscentrum). The study is performed for the Science Shop for Biology of Utrecht University with aid of Maaïke Lürsen of the Science Shop and professor Sjef Smeekens, of the Department of Molecular Plant Physiology of Utrecht University. The literature study was carried out by a student as part of his academic curriculum at the Faculty of Biology (Science Shop for Biology, University of Utrecht)

6.2 Local Organic Food

About 6% of farms sell products along the roadside or in small farm shops. Their annual turnover is between 5000 and 25000 pound. Some organisations wanted to have a market survey, so they would understand better their customers. These type of more business oriented studies are done more regularly, e.g. for a ecological demonstration farm, the attractiveness of ecological food for adolescents, etc (Wageningen University – Science Shop)

6.3 Old Farmstead Cheese

This cheese is made from raw milk and needs a couple of years to ripen. In the current Europe of open borders and free trade, it is sometimes difficult to survive with these regional products. The farmers association asked the science shop to look at their production chain to see if there were improvements possible, and also if subsidies could be received without interference from “Brussels”. Many advices are now implemented. Production-chain studies have also been done for potatoes, pig-meat, etc (Wageningen University – Science Shop)

6.4 Fried Cassava

Cassava is a root much used in Latin-American cuisine. A group of immigrant women (women@work) wanted to see if they could start selling cassava products in The Netherlands as well. Since the Dutch like different food, a lot of lab work was done. So, as a student you'd be in the lab trying to make nice fried cassava products, you'd add herbs, or even fish, and see if any Dutchman would eat it... (Wageningen University – Science Shop)

6.5 Probioticum EM

The EM stands for Effective Micro organisms. Probably you know all these new health drinks with good bacteria in it. There are also companies trying to sell products like this to farmers, for a healthier soil, or if you mix it into your fodder, for a healthier live stock. There is some anecdotic evidence for the claims that are made, but the organization Ecological Living and Growing would like to know more. So, a student project is proposed to 1) review all literature and see if there is any fully sound research confirming the claims; 2) review anecdotic evidence and see if there are any amateur scientific researchers that do abide by scientific criteria; 3) assess the potential ecotoxicity (you do introduce exotic micro organisms), and 4) make a cost-benefit analysis. Is it really worth all the money? (Wageningen University – Science Shop)

6.6 Assessment of Diet for people with multiple disabilities

Many double-handicapped children have digestive problems (constipation, diarrhoea, reflux, vomiting, which can lead to inflammation of the gullet and they also cry more). A diet was introduced 20 years ago, based on macrobiotic ideas. It shows effect, and dietists wanted to know why and whether there are any side effects (such as vitamin and calcium deficiency often associated with macrobiotic diets). The students did a large literature survey and calculated nutritional value of the diet. The add-on of sea weed and humus may counteract deficiencies, but was difficult to calculate. The students compared the diet to a control group diet. They also did a questionnaire, which showed very significant differences between diet and control group. The use of boiled rice is one of the

factors prohibiting constipation by acting as fibre. The special way of boiling the rice adds to the formation of resistant starch (which seems to be in the picture more widely these days).
(Wageningen University – Science Shop)

7. Project Examples: Animals

7.1 Welfare and 'the good life of animals' in pig husbandry systems

Animal welfare may be measured by different methods. One method is judging factors of the animal's environment. Another method concerns the state of the animal itself, for instance by looking at aspects of health and stress of the animal. Methods of measuring animal welfare may be used for different goals. They may be used to inform consumers about animal products, or to assist authorities in their decisions on animal welfare, or even as tools for farmers to give insight in strong and weak points of their husbandry system.

This research aims at elucidating the underlying assumptions of the different methods to measure animal welfare. The animal welfare debate is clouded by many issues. An analysis of the animal welfare debate could give insight in the underlying assumptions of the animal welfare problem. The analysis reveals two different aspects of animal welfare that are often confused. First, there is health and physiology of animals. Many people consider the health and physiology of animals as a measure for animal welfare. Some farmers for instance feel that their livestock has a high level of welfare if the animals are healthy and in good shape. These farmers consider health and the physiology of the animal to be very important aspects of welfare. Second, there is 'the good life of animals'. An animal living in its natural surroundings is often considered an animal with a good and happy life. Even if the animal doesn't have an optimal health status, people often feel that the animal has a high level of welfare. In this view of animal welfare the naturalness of the animal is more important than the health and physiology of the animal. These two assumptions often get mixed up. When discussing animal welfare it is not always clear whether the main focus is on the health and physiology of the animal or on 'the good life of animals'. Of course both are important for animal welfare. This mix-up accounts for most of the confusion surrounding the animal welfare debate. This research is an attempt to clear up the muddy waters of the animal welfare debate.

The different methods of measuring animal welfare are often thought to be based on the same assumptions. This is not true. Among existing methods for measuring animal welfare, the underlying assumptions about animal welfare may differ substantially. While one method's measurement is based on health and physiology of the animal, another method is based on 'the good life of animals'.

This research discusses the Tiergerechtheitsindex-35L (TGI-35L), Tiergerechtheitsindex-200 (TGI-200), Dierenwelzijnsindex (DWI), Decision Support System (DSS) en de Behavioural Deprivation Index (BDI), and compares their underlying assumptions on animal welfare. For analytical reasons, differences between methods to measure animal welfare were quantified. Because of different underlying assumptions on animal welfare our perceptions of animal welfare may differ. A measurement that is based on scientific evidence is different from a measurement based on expectations of what might be important for the welfare of the animal. This difference is accounted for by a focus on 'the good life of animals' on the one hand and welfare on the other hand. In this research three perceptions of welfare are discussed: Romantic, Common sense and Evidence based.

Romantic perception of welfare: The main focus is on the good life of animals. The good life of animals is often confused with welfare. The BDI measures welfare by this perception of welfare.

Common sense perception of welfare: Welfare is confused with the good life of animals, but not as much as in the romantic perception of welfare. The TGI -35L, TGI-200 and the BDI measure welfare by this perception of welfare.

Evidence based perception of welfare: Experience, physiology and health are the main focus of this welfare perception. The good life of animals is irrelevant. The DSS measures welfare by this perception of welfare.

This research also gives insight in views of animal welfare in society, what consumers and citizens think of animal welfare. Because of this, a number of organisations were interviewed. The interviews show that most organisations have a positive view towards different measuring methods for animal welfare. The interviews also showed that even the organisations confuse different aspects of animal welfare (welfare and 'the good life of animals'). For further research a public debate between different animal welfare- and consumer organisations is suggested. This could give more insight in the animal welfare problem.

7.2 Regulatory Animal Testing

Thirty percent of the animal tests conducted annually in Europe are performed to meet regulatory requirements pertaining to the authorization and release of a substance or product onto the European market. Regulatory animal testing is often repetitive in nature and more likely to cause severe suffering than other types of animal testing due to the procedures used. Because of these characteristics, regulatory animal testing is very interesting in terms of the 3R policy (Replace, Reduce and Refine).

The Science Shop for Biology at Utrecht University asked the Utrecht School of Governance to conduct a survey into the actors and factors that affect regulatory animal testing. The project was commissioned by the 'Regulatory Animal Testing' Research Project Group, which consisted of representatives from industry, science and an animal welfare organisation. The study was conducted in the framework of the ZonMw 'Limits to Animal Testing' programme.

This study surveys and describes the factors and actors that influence the use of animal testing to comply with regulatory requirements. Wherever possible, the research focussed on animal testing required by protocol for the authorization and release of pharmaceuticals. The research findings are based primarily on interviews with representatives of the main stakeholder groups (legislators, regulators, industry, science and NGOs). In other words, this study provides a survey of perceived influences. These findings are meant to help identify possible follow-up projects at the European level in order to reduce regulatory animal testing wherever possible.

Regulatory animal testing is a persistent element in the assessment procedures for registering a substance or product for release onto the market. Even though the number of alternative test methods keeps increasing, these new methods are not automatically included in assessment procedures. In order to increase the use of alternative methods to comply with regulatory requirements, a number of obstacles must first be overcome. What follows below is a list of the most obvious factors influencing the implementation of the 3Rs in assessment protocols. These factors have been grouped into the following categories: technical, political/administrative and social.

Technical factors

Respondents indicated that most alternative test models developed so far are intended to replace relatively simple tests. However, most animal experiments are part of complex tests for which it is difficult to find alternatives. Science is facing the task of developing such complex alternative test methods. Opinions on the feasibility of this task are divided. In terms of the 3Rs, respondents expect the most from developments aimed at reducing the number of laboratory animals used to test scientific hypotheses and refining tests to limit the suffering of laboratory animals. In this field the greatest gain is expected from so-called strategic test approaches, data sharing and retrospectively analysing existing data.

Another factor influencing the implementation of the 3Rs in regulatory animal testing is that legislators (policy makers) and some regulators (regulatory authorities) have limited technical expertise concerning alternative methods which makes it difficult for them to evaluate the merits of alternative test models, whereas scientists may have little understanding of regulating processes. Experts on the 3Rs can play a key role here by providing legislators and regulators with the information needed.

Political / administrative and social factors

Once a new method has been validated, it usually takes many years before this test method is actually accepted by legislators and regulators.

The slow pace of acceptance is caused by a combination of factors. To begin with, legislators and regulators are facing increasing demands for consumer safety and risk minimization. When compared to these concerns, animal welfare has relatively low priority. Legislators and regulators are expected to take this increasing demand for safety into account when developing and implementing policy. In the area of policy implementation, it is the regulators in particular who are reluctant to implement the 3Rs in evaluating protocols, according to respondents. One main reason for this is the heavy responsibility regulators bear for the safety of the products they allow onto the market. In addition, regulators are often relatively unfamiliar with alternative test methods and they therefore tend to adhere to existing models. Along the same lines, the industry is identified as a conservative force, preferring to play safe by anticipating the strict registration requirements regulators will set. As a result, more animal tests are conducted than strictly necessary.

Finally, coordination between policy makers at the European level -- and hence between various legislation and regulations in different policy areas - is not optimal. This leads to unnecessary testing. Harmonization of legislation and regulations is a precondition for reducing regulatory animal testing.

This survey identifies and describes the various opportunities and threats for the implementation of the 3Rs in regulatory animal testing. As mentioned before, this study is the basis for a follow-up project focusing on one or more of the factors identified. To this end, this report makes the following recommendations:

Invest in data sharing, retrospective analyses and strategic test approaches;

- Use risk communication in order to influence the level of risk acceptance;
- Make the costs of conducting animal tests transparent;
- Widely publicize available alternatives;
- Improve communication between stakeholders;
- Strengthen the policy network;
- Harmonize various laws and regulations.

7.3 Pigeons in towns

In response to a question of the Dutch Pigeon Pest Workgroup, a literature study on is conducted into the affectivity and animal welfare of the current methods to reduce or to combat pigeon pest. This report describes the outcome of the literature study..

The relationship between men and pigeons exists for at least a few thousand years. The pigeons were used for their meat and dung and for transmitting messages over long distances. At present large populations of pigeons are common in large cities. The worldwide population of pigeons is estimated at 500 million. In many cities it is estimated that the amount of feral pigeons is about 1-10% of the citizens. Pest caused by pigeons can be looked at from two different angles: objectively and subjectively. The objective side of pigeon pest is that squares, window-frames and walls of buildings are soiled with pigeon droppings. The costs for cleaning and repairing can be noticeably high. The subjective side of pigeon pest is characterized by the fact that people criticize the presence of pigeons in a different way. Many people experience the presence of pigeons as annoying and consider pigeons as a pest. There are also people who experience the presence of pigeons positively. Feral pigeons offer entertainment and can provide a sensation of wealth.

There are different existing methods to reduce or to combat pigeon pest. Firstly, there are deterring methods. Due to these methods pigeons will not appear on certain places. The deterring methods can be divided in chemical, physical and biological deterring mechanisms. However, these methods will not solve the problem permanently, because the pigeons will move to another place which means that the problem will reallocate. Secondly, there are combative methods. With the help of these methods measures will be taken to (temporarily) reduce the number of pigeons. Two forms of combative measures can be distinguished:

1. Measures which combat the symptoms, i.e. the presence of too much pigeons.
2. Measures which handle the source of pigeon pest.

The population ecology is described to obtain insight in the functioning of a population of feral pigeons. Several aspects of the population ecology are considered, like the social structure of a feral pigeon population, the dispersal, the breeding biology, the regulation of the population size and the food-supply.

Based on the population ecology of feral pigeon, different methods have been viewed more thoroughly with regards to effectivity and animal welfare. It appears that killing feral pigeons by means of poisoning, narcotics or with the help of cages and catching nets is not a method which will be effective in the long term. Research has shown that the population of feral pigeons increases very rapidly after reduction of the population by killing the pigeons. In this investigation no attention is paid to the discussion about the killing of animals. This does not mean that this discussion is irrelevant, but that it is a discussion of another level and that it is out of range of the objectives of this investigation.

The aim of the two objectives of pigeon control, i.e. to deter and to reduce the population of feral pigeons, is to create a small and healthy population on a suitable and desirable spot. Before this aim can be achieved, a period to reduce the amount of pigeons should precede. Measures to reduce pigeon pest can be considered from a population ecological point of view. Regulation of food-supply is the most important factor to reduce the population of feral pigeons. Research has shown that food-supply predominantly affects the size of a population of feral pigeons. In the centre of the city feral pigeons are often totally dependent on food which is thrown away on the street by people and on food which people feed them. The food-supply for feral pigeons can be regulated by restricting food waste on the street and by creating fixed forage spots where pigeons can be fed. These fixed forage spots can be realized in two ways:

1. The assignment of fixed spots in the city where people can feed the pigeons.
2. The construction of pigeon houses on buildings where pigeons can be fed.

The use of these pigeon houses can be combined with egg manipulation or the administration of the steroids Levonorgestrel en 17- α -Ethinylestradiol.

To deter pigeons from for example window-frames or balconies low-voltage wires or nest can be used. These deterring methods, contrary to the methods mentioned above, will not solve the problem permanently. The pigeons will move to another place which means that the problem will reallocate.

Every city has its own characteristics concerning the composition of the pigeon population, the environment and the lifestyle of the citizens. Therefore, every city should investigate which method or combination of methods is appropriate to reduce or to combat pigeon pest. The priority should be to reduce the food-supply. The local authority who seriously wants to reduce pigeon pest needs to have a structural task in pigeon control with a matching budget.

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8. Project Examples: Social Medicine

8.1 Living with facial paralyses: what is the quality of life?

A patients association wanted research on the quality of life factors for patients with facial paralysis. A group of 85 patients treated at the Plastic Surgery Clinic was interviewed. Most people were quite happy with the results of their treatment, though about still 1/3 of the patients avoids certain social events. A large group of patients developed a coping strategy that enables them to enjoy a good quality of life. This will be further investigated to be able to advise patients with a different coping strategy.

(University of Groningen/University Medical Centre Groningen; Science Shop for Medicine and Public Health)

8.2 Gluten intolerance and diabetes type I

Gluten intolerance and diabetes type I often come together (genetic association). Nutrition plays a large role for both diseases. The Dutch Coeliac Disease Association (DCA) wanted a research into the quality of life for both patients and their partners. A questionnaire was used. Practical and social limitations were most present. Female patients scored higher on GSRs (Gastro-intestinal Symptom Rating Scale) and DSC-r (Diabetes Specific Complaints). Both male and female patients scored relatively low on quality-of-life appreciation compared to other patient groups (6.7 (SD1.7)). A large part of the female patients showed signs of depression (41.3%, based on CES-d Centre for Epidemiologic Studies Depression scale). Quality of life for partners is good. DCA can draw more attention to the position of these patients now. A similar question also addressed (in a previous project): should all patients with gluten-intolerance be screened for Diabetes type I as well? (There are still pro's and cons, no definite answer)

(University of Groningen/University Medical Centre Groningen; Science Shop for Medicine and Public Health)

8.3 Social support and quality of life for ADHD patients

The influence of social support on the functioning and the quality of life of people with ADHD; on request of Impulse – the Dutch patients association of adults with ADHD: Electronic and telephone survey; 105 respondents.

Questions were taken from the AAQoL (Adult ADHD Quality of Life-Scale), expanded with other questions from existing questionnaires and own questions. Average appreciation is 6.8 (SD 1.9), which is below average. The research helps to create awareness for this patient group and its problems in daily life.

(University of Groningen/University Medical Centre Groningen; Science Shop for Medicine and Public Health; in co-operation with the Department of Sociology)

8.4 Tinnitus

Research on factors affecting the hindrance from Tinnitus. On behalf of the Dutch Tinnitus Platform (in co-operation with the Research Group on Cognitive and Behavioural Psychology (University of Groningen/University Medical Centre Groningen; Science Shop for Medicine and Public Health)

8.5 Green in elderly care

This report deals with the question whether nature perception can have a beneficial effect on elderly people. An inventory was made of what kind of 'green' activities are currently being organised within intramural care facilities. The research was conducted at the request of the Stichting Natuurlijk Genieten (SNG, literally 'Foundation Natural Enjoyment' but also means 'Foundation Of-course Enjoyment'). This foundation advocates nature perception by elderly in hospital health care, which it does amongst other things by teaching courses for activity organisers and volunteers.

The foundation would like to know whether the perceived value of nature perception by elderly can be supported scientifically. Also, they would like insight into what kind of nature or green activities so far are of have been organised in the Netherlands. These two points are combined in the research question: What is the surplus value of nature perception by elderly and how is this organised within care facilities?

As a result, the project contains two focus points. The first investigates the surplus value of nature perception by elderly (75+ in hospital health care). Whether this surplus value can be supported scientifically, has been

researched with a literature study.

The second focus point is an inventory of current initiatives in nature activities in care facilities. This inventory was made by doing telephone interviews with activity organisers of forty intramural care facilities (nursing and convalescent homes) across the Netherlands.

The literature study shows that elderly people are in general more sensitive to their surroundings than younger people. Dementia, depression and loneliness are common within this group. Therefore, they could benefit from nature activities such as a special nature room within the facility, garden therapy and / or contact with animals. The positive effects of nature activities can be divided amongst six categories: Memories; Fulfilment of social needs; Sense of self value; Stimulating senses; Curation; Gaining knowledge. These categories were used to process the results from the telephone interviews.

It turns out that 88% of the interviewed homes organise nature activities. Most common activities include flower arranging (95%), watching nature documentaries, walking (68%) and creating seasonal displays (60%). By arranging such activities in the six categories mentioned above, it becomes clear that not all possible positive effects of nature activities are exploited. For example, there are few activities organised that fall under the categories of 'gaining knowledge' and stimulating senses.

From the data collected in the literature study and the telephone interviews, it can be concluded that nature activities certainly do have important positive effects on the participating elderly. But, whether nature activities have a surplus value as opposed to other activities depends for the most part on the individual participant. Therefore, intramural care facilities are advised to offer both nature and other kinds of activities to the people in their care. Activity organisers mentioned that they are in fact interested in information about the possibilities and effects of nature activities.

The report concludes with recommendations for future actions by the Stichting Natuurlijk Genieten. For example, the foundation could facilitate nature activities within care facilities by developing and maintaining a central database with (examples of) nature activities. The foundation is advised to continue the inventory of nature activities, so an overview of possible activities can in the future be supplied to professionals and volunteers who wish to organise these. Some practical questions have been added to the questionnaire that was used in this research project, to facilitate use by the Stichting Natuurlijk Genieten when collecting further practical information on nature activities that are of have been organised in the Netherlands. Suggestions are also made for additional broadening of the research field, such as conducting further research into the wishes of the elderly with regard to nature perception. (Science Shop for Biology, University of Utrecht)

8.6 Overview of genetic counselling in the Netherlands

This report describes the process of genetic counselling at the eight clinical genetic centres (Klinisch Genetische Centra, KGC's) in the Netherlands. The clinical genetic centres are all connected to academic hospitals. People who (may) have hereditary afflictions themselves or in their family can turn to such a centre for genetic counselling.

The current research project was conducted at the request of the Foundation ERFO-centre (Erfocentrum). The Erfocentrum is an independent non-profit organisation, which aims to supply easy-access information about hereditary diseases and health to the general Dutch public. The Erfocentrum would like to know what approach the clinical genetic centres use in their counselling activities, what they would like to alter in the current genetic counselling, and how the Erfocentrum can best support and service the clinical genetic centres. The central research question is therefore: How can the Erfocentrum offer optimal support to the clinical genetic centres on genetic counselling about hereditary afflictions and prenatal diagnostics, in accordance with the desires of the several clinical genetic centres in the Netherlands? In order to present an overview of the way the several clinical genetic centres do genetic counselling, the researchers interviewed members of its staff. The interviews discussed the goals, procedure and practice of counselling.

In general, policies within the clinical genetic centres are about the same. The genetic counselling varies marginally between centres. Consultations with patients are always the most important means of giving some one the appropriate information and counselling. Written materials (if used) are used to support these consultations. In answer to the question how the Erfocentrum can support the clinical genetic centres, most centres don't just mention the production of extra written materials. They also feel that the existence and method of working of the Erfocentrum should be better known, both among the general public and among (para)medic professionals (in

training). The clinical genetic centres believe that if the Erfocentrum improves its familiarity among these groups and if it stresses its own distinctive features, there could be more attention for 'heredity' within Dutch society. At this time, both the clinical genetic centres and the general public are insufficiently aware of what the Erfocentrum is, and what it has to offer. Clear positioning of the Erfocentrum within the field of genetic counselling is therefore of great importance. Thus, the recommendations to the Erfocentrum are to produce additional written materials, to seek publicity for the practice of the clinical genetic centres, and to work at improved familiarity of both the general public and (para)medic professionals (in training) with the Erfocentrum. (Science Shop for Biology, University of Utrecht)

8.7 Inter-sexuality

The Dutch Society of Addison and Cushing Disease (NVACP) approached the Science Shop for Biology, Utrecht University. The NVACP requested a literature study about the diseases that lead to ambiguous external genitals. This research study offers a review of the causes, medical problems and treatments of / with inter-sexuality. Only the biomedical side of ambiguous external genitals is subject in this research. The research question was: What is known about the causes, medical problems and treatments of inter-sexuality?

First a definition of inter-sexuality was formulated: "A blend of both male and female characteristics occurring in the same individual caused by errors in sex determination and differentiation. The causes lie in changes or less function of the sex chromosomes, genes or sex hormones and their receptors, during the development of the embryo." After this, the sexual development and the sexual development of people with inter-sexuality were described. The most frequent diseases that lead to ambiguous external genitals are: Congenital Adrenal Hyperplasia (CAH); Androgen Insensitivity Syndrome (AIS); 5 α -reductase deficiency; 17 β -hydroxysteroid dehydrogenase deficiency (17 β -HSD)

These diseases are for this reason described extensively in the report. The different forms, genetics, diagnostic and treatment of these diseases are mentioned.

The next diseases that lead tot ambiguous external genitals are less frequent among inter-sexuals: Mosaics of the sex chromosomes; Denys-Drash syndrome; Swyer syndrome; XX-males; True hermaphrodites; Gonadal dysgenese; Leydigcel hypoplasia; Androgen producing tumours; Drug use by the mother during the pregnancy. These diseases are mentioned briefly in the report

There are a lot of scientific articles and chapters in various books that deal with the subject of inter-sexuality. However, this literature can be difficult to read for someone who is not a doctor. This is mostly because the books and the articles often use more than one name for the same disease. Also, general terms like male and female hermaphroditism are used without telling which diseases these are. Some literature (mainly from the internet) even contains false information. For these reasons, it is extra difficult to determine what sources are useful for making a list of diseases that cause ambiguous external genitals.

Inter-sexuality is a very wide theme. The next topics however are not a part of this research: The frequency of the diseases in The Netherlands; The issue around choice of sex; the issue around gender choice; the effect of testosterone on the brain in the context of inter-sexuality; the psychical problems around inter-sexuality (Science Shop for Biology, University of Utrecht)

8.8 The impact of stroke on lay carers

Northern Ireland has one of the highest rates of stroke and heart attack in Europe. The Northern Ireland Chest Heart and Stroke Association (NICHSA) have been trying to improve its services for lay carers. In this research the following questions were answered:

- What are the issues carers have to deal with in caring for a stroke patient?
- What are carers' needs with regards to services and support?
- How can NICHSA meet these needs?

A literature review was done and a semi-structured interview was designed. Eight lay carers were interviewed about their problems and needs. The results showed that the more severe the stroke had been, the more often

carers felt down in mood, felt their role in life had changed, and the less guilty they felt asking others for help. Some carers felt frustrated with the patient from time to time as a result of the patient's physical and cognitive disabilities. The most important factor in the support network of carers was their family. But even though most carers felt they received great support from their families, they felt guilty sometimes to ask them for help. They felt the patient is their own responsibility. The opinions on professional support were divided, though most carers were not very satisfied with the information and support received in hospital. Especially the preparation for the time directly after discharge and on the longer term was unsatisfactory. They also felt professionals didn't consider carers enough and therefore felt forgotten about. They didn't know whom to turn to for practical help, support and benefits. More information about this is necessary. Carers felt down in mood from time to time as a result of the caring role. Often this was a result of being bound to the house because of the patient's physical disabilities. They expressed a need for a break from caring, to relieve stress. Some of the carers that expressed a need for a break didn't know how to realise this. More information about services available to them should be provided. The changed character of patients had an effect both on the relationship between carer and patient, and on the carer's social life. It led some carers to get frustrated with the patient. The relationship between carer and patient had an effect on how the caring was perceived by the carer. Carers felt uncertain about the future. Carers mentioned feeling worried about becoming less able to cope with caring, either because of deterioration of the patient, or of their own health. Recommendations for NICHSA are made. (Science Shop for Biology, University of Utrecht/Science Shop, Queens University Belfast)

8.9 Improved health care elderly immigrants

Research has shown that the quality and the effectiveness of health care have been divided unevenly between immigrants and natives. Immigrants feel less healthy, have shorter consultations with general practitioners and they take more prescribed medicines than indigenous Dutch people. Nevertheless, requests for medical care by these migrants often end up with the wrong medical workers (doctors and nurses), which means that their request is not answered properly. [Dutch Council for Health and Care, 1999]. The medical profession is gaining understanding that effective health care for immigrants requires adaptations, both in health education and in health care itself. This literature study aims to answer the question how Homecare City Utrecht (Thuiszorg Stad Utrecht) can use health education to ensure that Turkish and Moroccan elderly can use the Dutch general health care adequately. To answer this question, the following research questions have been phrased: · for what reasons do Turkish and Moroccan elderly not yet use Dutch general health care adequately? · Which aspects should receive special attention when making health education for Turkish and Moroccan elderly? · What is a suitable health education model for Homecare City Utrecht? An answer to these research questions was found by combining a literature study with the gathering of information from organisations who are also working on health education for (elderly of chronically ill) immigrants. The problems that general health workers (doctors and nurses) experience when caring for immigrants are: · Patient and medical workers often don't understand each other, or there are misconceptions, because communication is problematic. This is due to a difference in their frame of reference. · Immigrant patients often lack insight into the organisation of Dutch Health Care. · Immigrants often have different expectations of health care. This is due to their experiences in their place of origin. · There is a gap between the knowledge of the immigrant patient and that of the medical worker. This is caused by differences in world view. To ensure that health education is effective, there will need to be more cooperation with other organisations dealing with chronically ill immigrant elderly. To improve the effectiveness, it is advised to include the target group in the development of health education. When developing health education for immigrants, it is also a good idea to use the PEN-3-model. This model pays more attention to diverse culturally established determinants than the more widely-used ASE-model. From the PEN-3-model, it can also be deducted that the family of the patient should be included in the health education. But health education alone will not solve the problems. Doctors and homecare workers will also have to make adaptations to ensure that health care will be more accessible to the target group, for example by using interpreters, or by planning extra time for a consultation.

(Science Shop for Biology, University of Utrecht)

8.10 Patients experiences in switching to generic medicines

Investigation of patients experiences in switching from Ritalin to a generic alternative
(Science Shop pharmacy, Utrecht)

9. Project Examples: Medical Studies

9.1 Evaluation of Buteyko Breathing Technique

Buteyko is a breathing technique for asthma prevention and relief. This alternative technique was put to the evidence-based medicine test, on behalf of the Buteyko Centre Netherlands; through critical study of literature. There are suggestions for a possible benefit in the treatment of asthma (CO₂ possibly plays a role in the serenity of asthma), but certainly not for its prevention. A sound scientific basis was not yet found in the published literature; an analysed trial had methodological shortcomings and errors. Only after a better trial this alternative technique might get wider recognition.

(University of Groningen/University Medical Centre Groningen; Science Shop for Medicine and Public Health)

9.2 Effectiveness of laser-treatment for psoriasis

Dutch and US protocols differ; in The Netherlands lasers are not used in Academic Hospitals. On behalf of the patients association for psoriasis, literature was reviewed and recommendations regarding types of lasers and patient characteristics critical to the choice for laser treatment were given. The association can now further negotiate with Health Care Insurances and the Medical Authorities.

(University of Groningen/University Medical Centre Groningen; Science Shop for Medicine and Public Health)

9.3 Connective tissue diseases and auto-immune diseases with women with silicone breast-implants and their offspring

A literature update was done on requests of patients to update the report of the Health Advisory Council (5 years old) and check for possible new findings in literature. 17 studies were found and analysed. Ten studies did not find relations, the others did point to associations but these were weak and their clinical implementations were not always known. There was no reason to challenge the previous findings of the Health Advisory Council.

(University of Groningen/University Medical Centre Groningen; Science Shop for Medicine and Public Health)

9.4 Multiple sclerosis and metals

Multiple sclerosis (MS) is the most common cause of neurological disability in young adults. Generally MS is believed to be an immune-mediated disease that occurs in genetically susceptible persons. Contributing environmental determinants (possibly including infectious agents) appear important in aetiology but remain unidentified. Although there are treatments like beta-interferon or glatirameracetate that may favourably modify the course of the disease, there is no fully effective treatment of MS. Therefore a high number of MS-patients use alternative therapies, although there is insufficient knowledge about efficacy and safety of a lot of these therapies. 'MS-Remedies' is a foundation that collects (scientific) information and personal experiences about alternative therapies. In this way, the foundation wants to help MS-patients in making a well considered choice from all available alternative therapies. One of the alternative therapies that MS-patients use is chelation therapy. In chelation, a metallic ion is sequestered and firmly bound into a ring within a chelation molecule to enhance excretion of the metallic ions. Chelation therapy has been approved for the treatment of different heavy metal intoxications.

'MS-Remedies' asked the Science shop for Biology to investigate the effectiveness and possibly risks of chelation therapy for MS-patients. For the time being there is no scientific literature available that supports a beneficial effect of chelation therapy for MS-patients. The present clinical experiences indicate a number of side effects; therefore patients should be examined thoroughly before starting and during the therapy. Further research is needed to fully understand the role of metals in MS. When this relation is clear, the possible effect of chelation therapy for MS patients can be evaluated.

(Science Shop for Biology, University of Utrecht)

9.5 The relationship between traffic related air pollution and respiratory health and exhaled nitric oxide in Dutch schoolchildren

In recent decades there has been increasing concern about possible adverse effects caused by pollution from motor vehicle emissions. This study was designed to test the hypothesis that exposure to exhaust from traffic related to childhood respiratory health. The study was requested by two citizen groups that are concerned about possible adverse health effects due the nearness of motorways to their homes and schools of their children. Respiratory health of children from 9 Dutch schools, situated within 400 meters of a motorway, was studied. Exposure to traffic-related air pollution was assessed by using specific traffic-related characteristics (individual car and truck traffic counts, and distance from homes and schools to highway). Data of respiratory symptoms were collected by parents-completed questionnaires and exhaled nitric oxide measurements were collected by the offline-method. Further, outdoor air samples were analyzed for air pollutants and in a preliminary laboratory test design the immunotoxic potency of these samples were studied. Respiratory symptoms were increased in children that live near motorways with high truck traffic counts; especially when mean weighted Odds Ratio's were calculated by combining data from other similar Dutch studies. Nitric oxide values were higher in children with respiratory symptoms as compared to children without respiratory symptoms. Near motorways with high car and truck traffic counts, exhaled nitric oxide levels were higher. The results of this study demonstrate that high truck traffic counts in particular, are related to children respiratory health. Children attending schools near motorways with high traffic counts experienced more respiratory health problems and showed higher exhaled nitric oxide values than children attending schools near motorways with low traffic counts. The study was initiated based on two requests from different local groups of concerned citizens. (Science Shop for Biology, University of Utrecht)

9.6 Bulbs, pesticides and residential

The use of pesticides for crop protection and bulb disinfections is extensive in bulb farming. The bulb growing sector has grown considerably during the last decade in some areas in the Netherlands. In Zijpe, a community in Northern Holland, residents are concerned about possible health effects caused by exposure to pesticides. This study has been conducted in order to assess the possibility of residential exposure to pesticides. House dust samples were collected in 27 residences in Zijpe (12 bulb farmers, 15 non-farmers) in March and April 2002. The active ingredients of seven pesticides commonly used in this period were targeted for analysis: Chloro-IPC, Pyramin, Monarch, Goltix, Sumisclax, Rizolex and Ronilan, active ingredients chlorpropham, chloridazon, flutolanil, metamitron, procymidone, tolclofos-methyl and vinchlozolin, respectively. Samples were extracted and analysed by gas chromatography and mass spectrometry.

Except for metamitron, all active ingredients could be detected in house dust. Pesticides were found less frequently in non-farmer homes, three different pesticides could be detected in non-farmer homes whereas six different pesticides were found in farmer homes. Chlorpropham-concentrations were found to be four times higher in farmer homes ($p < 0.03$) compared to non-farmer homes, and the Odds Ratio for detecting chlorpropham in a farmer's home compared to a non-farmer's home is statistically significantly higher ($p < 0.02$). No statistically significant differences in pesticide concentrations in house dust were observed for the two other pesticides which were found in both farmer and non-farmer homes (flutolanil and vinchlozolin). These results, however, are based on a single observation in time and a small dataset, which limits the statistical power of the test. The Odds Ratio for detecting flutolanil in a farmer home compared to a non-farmer home is significantly higher ($p < 0.03$). The differences between farmers and non-farmers could not be explained odds by potential confounding factors such as presence of animals, type of floor covering etc. Therefore, the most plausible explanation for the presence of these pesticides in farmer homes seems to be that farmers (and possibly their family-members) bring pesticides into their homes more frequently or in higher quantities than non-farmers.

The distance of a residence from pesticide treated farmland was weakly associated with detection of chlorpropham in house dust. Chlorpropham was found more often in homes that were close (< 66.7 ft. / 20 meters) to pesticide treated farmland than in more distant homes ($p < 0.08$).

Discussion and conclusion

Some aspects of the method used in this study may have affected the measured pesticide concentrations. Results for our control samples show that the effect of the used method on the results of the analysis was relatively small. However, because of the investigative nature of this study the exact concentrations are not directly relevant. The main focus of this study was on possible detection of pesticides in house dust. The conclusion of this study is that residents of Zijpe are potentially exposed to pesticides used in bulb farming, but statements about the exact height

of the levels of exposure can not be made. Pesticides are found more often in farmer homes than in non-farmer homes, and the concentration of chlorpropham is higher in farmer homes. The distance of a residence from pesticide treated farmland also appears to be of importance.

Recommendations for follow-up studies

In order to determine the exact exposure levels of the residents of Zijpe a large scale study is necessary. In such a study measurements should be taken over a longer period to obtain information regarding variability of the exposure in time. Other environmental compartment than floor dust alone should be included as well in order to be able to obtain dose estimates. Research involving blood-and /or urine samples could be very useful in determining whether any health risks occur from potential exposure to pesticides. Such samples give a more direct insight in the exact height of exposure levels. It would then be possible to see if there is a possible relation between exposure and health effects. (Science Shop for Biology, University of Utrecht)

9.7 Bacteriophage therapy

The use of viruses against bacterial infections was evaluated on request of Foundation bacteriophages.

Around 1920, a mysterious factor is discovered in Paris. When this factor is added to bacterial cultures, all bacteria are destroyed. Very soon after the discovery, researchers try to use the factor to fight bacterial infections in humans. However, the therapy is not always successful. After mixed results and the rise of antibiotics, there is no more interest in this kind of therapy.

It is not until the 1940s that it becomes clear that the mysterious factor is a virus. The virus keeps the name it received in the 1920s: the bacteriophage. One of the reasons that bacteriophage therapy did not work, was the lack of insight into the properties of the virus. A second reason was that most studies did not include a control group. It remained unclear whether bacteriophage therapy could be effective.

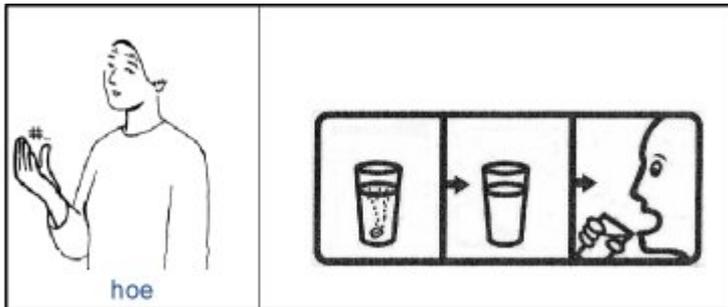
Currently, there are many bacterial strains that are resistant to several, or all antibiotics. This resistance of bacteria to antibiotics causes life-threatening situations. Recent research in animal models suggests that bacteriophage therapy still could be an alternative way to treat bacterial infections. Although the experimental data are limited, a number of different studies show that administration of bacteriophages to animals, which have been infected with a known bacterial pathogen, effectively prevents disease development. Sometimes, bacteriophage therapy is even more successful than different treatments with antibiotics. There are also studies that describe how the effectiveness of bacteriophage therapy can be further improved on.

A recent study reveals the therapeutic power of purified bacteriophage enzymes called lysins. Recent application of bacteriophage therapy in humans has only been described in a series of articles from Eastern Europe. These articles all give a positive picture of this therapy, although the scientific validity (control experiments) of these articles is insufficient. The conclusion of this literature study is that bacteriophage therapy, to fight microbial infections, certainly offers possibilities. However, the expected applications do not lie in the large-scale production of ready-to-use, commercial substances. Antibiotics remain the first choice for the treatment of bacterial infections, because of their broad spectrum and effectiveness. But bacteriophages could play an important role in treating bacterial infections in hospitals that are difficult, or not at all, curable with antibiotics. (Science Shop for Biology, University of Utrecht)

10. Project Examples: Pharmacy

10.1 Early-deaf persons and drug information

For early-deaf people Dutch is like a foreign language; especially for those that also have a mental disability as well (double handicapped). The science shop for pharmacy developed, together with the science shop for language and communication, visual aids for this specific group of patients, often living in 'shared homes'.



GPs were a bit reluctant at first, but their patients told them they did not feel treated as small children. For the pharmaceutical industry, the target group is too small to consider general information with each box of drugs. It is up to GPs and pharmacists to use these symbols for deaf patients. One and a half year of interdisciplinary research delivered a CD-Rom for them to make their own print-outs!
(University of Groningen, Science Shop for Pharmacy)

10.2 Ramadan and medicine use

A PhD project: Muslims are not allowed to eat and drink from sunrise to sunset during Ramadan. To some, this means that they will also not take their medication. Others would take their medication, but on an empty stomach. GPs and pharmacists are usually not aware of this patient behaviour. Muslims are not always aware of the exception to the rules laid out in the Koran for those who are ill. The project focuses on improved communication and understanding, potential side effects, etc. It is done in co-operation with a Turkish university. It builds on previous projects concerning minorities and medicine use; for immigrant students this research line is very attractive as well and given their language possibilities, some research can not do without them. Previous research e.g. showed that immigrants from a number of countries expect to have a pill for whatever complaint, whereas Dutch GPs are normally very reluctant to prescribe pills for complaints that will go away soon anyway; the prescription of anti-biotics being an example. These projects also lead to better mutual understanding.
(University of Groningen, Science Shop for Pharmacy)

10.3 'Multiple sclerosis. Experiences with prednisolone, interferons and Copaxone®'

Multiple Sclerosis (MS) is a chronic disease that affects about 16.000 people in the Netherlands. There are four different types of MS: benign (BMS), relapsing-remitting (RRMS), secondary-progressive (SPMS) and primary-progressive (PPMS). There are no medicines to cure MS, but there are some that can have a positive influence on the course of the disease. Prednisolone, interferons (Avonex®, Betaferon® and Rebif®) and Copaxone® positively influence the attacks of inflammation in the central nervous system (known as exacerbations or schubs). Prednisolone acts to decrease the severity and duration of the exacerbation, while the interferons and Copaxone® act to decrease the frequency of exacerbations. All these medications are registered for RRMS. Prednisolone is also registered for SPMS and BMS and Betaferon® is also registered for SPMS.

This report contains an inventory of experiences with prednisolone, Copaxone® and the interferons among people with MS. This inventory might help people with MS decide on one of these medications, when they have chosen to start medical treatment.

This research was carried out for the editors of Msweb (www.msweb.nl), in association with the Dutch MS Society (MSVN). People with MS were informed about this research, and asked to participate, through the magazine MenSen (issued by the MSVN) and the website of MSweb. Two questionnaires (one about prednisolone and one about interferons and Copaxone®) were used to accumulate information about the diagnosis, the drug-administration, the side-effects and the satisfaction with respect to the different (types of) medicines.

431 people participated, of which 91 completed both questionnaires. 304 questionnaires about interferons and Copaxone® and 218 questionnaires about prednisolone were completed and returned. An estimated 8,5% of all Dutch users of interferons and Copaxone® completed the questionnaire. Because of the low number of responders, the low number of users per medicine and the varying experiences, it was not possible to find any statistical significancies in the outcome. Therefore, we were only able to give a global account of the experiences.

Over 76% of the responders were female. Age varied between 15 and 72 years and in 71,8% of the cases the diagnosis MS was made between the ages of twenty and forty. RRMS was the most prevalent type at the moment of diagnosis (64%). Responders get their information about MS mostly from the internet (88%) or their physician (80%). Almost all the responders (99%) are in treatment with a physician, most often a general neurologist (60%).

Almost half the responders (48%) that completed the questionnaire about interferons and Copaxone® was unable to state whether the medicine helped decrease MS symptoms. They noted that they do not know how the disease course would have run if they had not been taking the medicine.

Of the interferons and Copaxone®, Avonex® is the medicine that is used most often (34%). Satisfaction with use and satisfaction despite side-effects is mostly positive (mean scores 3,4-3,8 out of 5) for all medicines in this category. Administration of Rebif® and Avonex® is experienced as bothersome by most users. Responders using Avonex® experience the most limitations due to side-effects, both when they start taking the medication and at this moment.

For Betaferon®, Rebif® and Copaxone®, the most frequently reported side-effect at the moment of filling out the questionnaire is injection site reaction. The most frequently reported side-effect for Avonex® is headaches.

88% of responders that completed the prednisolone questionnaire use a prednisolone course during an exacerbation. For 60% of the responders, this course lasts 5 days. 87% of responders noted a decrease in symptoms due to prednisolone use. Most responders are satisfied with the use of prednisolone (mean score 3,6). During the use of prednisolone 88% of responders experienced side-effects, such as bad taste, insomnia and fatigue. About 78% of responders still suffer from side-effects after finishing the course. The most frequently reported side-effect at this stage is fatigue (48%). 70% of responders is satisfied about the use of prednisolone, despite the side-effects (mean score 3,8).

The choice for a medical treatment depends on the type of MS and the limitations experienced from MS symptoms. Every user has to weigh the limitations of MS, the burden of medicine use (e.g. injections and infusions) and the side-effects of the medicines.

Science Shop Pharmacy, University of Utrecht (supervisor: C.J.A. Lievers, Division of Pharmacoepidemiology & Pharmacotherapy; N.A. Winters, Science Shop for Medicines)

10.4 Autism and medicines

The Dutch Association for Autism and the Ombudsman Foundation requested a survey on the experience of their members with medicines. This was done in two surveys, subsequently, for regular medication and alternative medication. Alternative medication is e.g. homeopathics, minerals, vitamins, magnesium, melatonin, omega 3- en 6-fatty acids and fytotherapeutica, like valerian.

There were 159 respondents. Regular medicines were quite often used outside their registered application. Seroxat was the most satisfactory regular medication. Use of Dipiperon, Dixarit and Orap was often discontinued because of lack of effect. Risperdal, Ritalin, Seroxat and Depakine were mostly discontinued because of side-effects. Seresta use was mostly stopped because symptoms had become less. Of the alternative methods, melatonin was most satisfactory for patients. (Science Shop pharmacy, Utrecht)

10.5 Information brochure Addison's disease and AGS

Especially for young people, a brochure on Addison's disease and Adreno-genital syndrome (AGS). These are diseases in which the adrenal gland makes too little or no hormones. The brochure gives information on this and on the required medication (on behalf of the Dutch Association of Addison and Cushing Patients).
(Science Shop pharmacy, Utrecht)

10.6 The prescription of the first anti-epileptic in recently diagnosed epilepsy

On request of the Dutch epilepsy association. A research into the prescription by GPs. Are the guidelines for GPs from the Dutch Neurology Association up to date? Are patients well enough informed on the long-term consequences? Literature survey, law survey, interviews with six experts. Not all new medicines are taken up in the guidelines. The fits consult leaves too little time to involve the patient in the decision, although the law does require patient's involvement. The guidelines thus need to be updated.
(Science Shop pharmacy, Utrecht)

10.7 Missing a pill: Go on or catch up?

Pharmacists often find it hard to say whether a missed dosage should be compensated or not. Students have done research on a number of different medicines, for e.g. epilepsy, diabetes, asthma, cholesterol, pain, and more. Six articles were published (Science Shop Pharmacy, Groningen)

10.8 Side-effects of gadolinium

A review for the Association 'Victims of Contrast Fluids' (Science Shop Pharmacy, Groningen)

11. Project Examples – Electronical and Electrical Engineering and Mechanical Construction, Architecture and Building

11.1 Simple voting system



A voting system for high school events was made (Science Shop Technical University Eindhoven).

11.2 Auction clock



An auction clock to be used for training / demonstration purposes lacked software and a number of parts. It was repaired and programmed by students. (Science Shop technical University Eindhoven).

11.3 Speaking clock

A clock will tell the time when a button is pushed – for a person with bad eye-sight. (Science Shop Technical University Eindhoven).

11.4 Sound box Nature Museum

A sound box with bird-sounds was made for a Natural history Museum (Science Shop Technical University Eindhoven).

11.5 Architecture 1



Students made a design for the enlargement of a community building, so the stage and the storage room would become useful.

11.6 Architecture 2

Students in architecture designed the new cantina building for an association operating a children's playground.

11.7 Bus and Transport Terminal

The Coopérative des Anciens Chauffeurs de l'état (Codace) in Kigali, the capital of Rwanda, asked advice for the design of a coach station combined with a distribution centre for goods. Six different options were designed, which gives a good impression of the possibilities to choose from.



11.8 School and flows of pupils

The St. Joris school's building is too small, leading to bottlenecks in class rooms and corridors. Construction engineering students came up with a range of possible solutions, which were show-cased at the school.

12. Project Examples: Applied Physics

12.1 The effects on health from high-tension wires

Ongoing literature update on website to inform citizens on the state-of-the-art of scientific knowledge on this issue (Science Shop for Physics, Groningen)

12.2 Health effects of large radio transmitter

Critical discussion of literature on potential health effects from a big radio transmitter mast in Jirnsum, on behalf of resident groups. Includes explanation of relevant statistics and scientific reasoning (need for mechanistic explanation of health effects). (Science Shop for Physics, Groningen)

12.3 Sound of windturbines (1)

Software was developed which allowed residents to calculate the noise of wind turbines themselves (CD-Rom, Science Shop for Physics, Groningen).

12.4 Sound of windturbines (2)

Research was done on behalf of resident organisations in The Netherlands. Noise from windturbines was present especially during the nights, contrary to the outcome of the reports underlying the licensing procedures. The increasing height of the turbines caused them to have their wings in higher atmospheric layers (>100m) which have relatively high wind speeds at night. So, even when on ground level there is no wind, the turbines still operate. Because there is less wind at ground level, noises are not masked. Citizens suffer from noise with 'whopping' peaks, when sound waves from individual turbines in the park amplify each other. Research proved and calculated the complaints of residents, and paid attention to microphone effects in measuring the noise. (PhD thesis, Science Shop for Physics, Groningen).

SUMMARY

This study was started after complaints of residents that the sound of a wind farm was louder and more annoying than predicted, especially when there was little wind in the evening or at night. The explanation appeared to be the occurrence of another wind profile than that used to predict the noise impact (the wind profile describes how the wind velocity increases with height). There are probably several reasons why this was not found earlier: 1) because wind turbines become taller, there is a growing discrepancy between prediction and practice; 2) measurements are usually done in daytime when the wind profile resembles more closely the commonly used standard profile; 3) based on the sound that occurs in daytime, it is hard to imagine the sound can be so different at night; 4) "there are always people complaining", so complaints are not always a reason for a thorough investigation; 5) at least some wind energy proponents prefer to downplay the disadvantages rather than solve them.

According to Dutch legislation and international guidelines the sound production of a wind farm can only be checked by measurements when the wind farm operator cooperates. The consequence is an implicit partiality in favour of the operator detrimental to independent verification. Because of the level of detail of instructions measurements and assessments are hampered and there is no margin for the very expertise of an investigator. For a lay person understanding the jargon was already utterly impossible and he cannot but hire an expensive expert to argue his case. From this study one can conclude that through the use of a restricted model of reality, viz. a forever neutral atmosphere, experts have lost sight (temporarily) of the true reality in which a neutral atmosphere is not very prevalent. It is precisely the occurrence of complaints that may indicate such errors.

The sound of modern wind turbines is generated mainly by the flow of the wind along the blades. In this process a turbulent boundary layer develops at the rear side of the blade where trailing edge sound of relatively high frequencies originates and which is radiated into the environment. This turbulent boundary layer becomes thicker and produces more sound when the wind flows in at a greater angle. The inflowing wind is turbulent itself. The blade cuts through these turbulent movements and as a result again sound is generated: in-flow turbulence sound. Here lower frequencies dominate. Finally a blade also radiates sound when the forces on the blade change because of a local variation in wind velocity. This happens every time the blade passes the tower because there the wind is slowed down by the tower. On the one hand this causes more trailing edge sound due to the change in inflow angle, on the other hand more infrasound is generated because of the sudden sideways movement at the rate of the blade passing frequency.

For all these sounds loudness increases when the speed increases. Because the tip has the highest speed the sound of a wind turbine mainly comes from the blade tips. Moreover, for human hearing the trailing edge sound is most important because it is in an area of frequencies that we can hear well.

It is often assumed that there is a fixed relation between the wind velocity at hub height and at a reference height of 10 meter. This is the relation valid in a neutral or 'standard' atmosphere. No other relations are given in legislation or international guidelines for wind turbine sound that are valid in other conditions of the atmosphere, viz. the stable and unstable conditions. The atmosphere is *unstable* when in daytime the air near the ground is relatively warm from contact with the surface heated by solar insolation. In that case vertical air movements originate and the wind profile is not equal to the profile in a neutral atmosphere, though it does not differ strongly. A *stable* atmosphere however has a markedly different wind profile. The atmosphere is stable when the air close to the ground is relatively cold due to contact with the ground surface when this cools down at night by radiating heat. A stable atmosphere occurs especially in nights with a partial or no cloud cover and the wind is not too strong (close to the ground). In a stable atmosphere the turbulence has decreased substantially and as a result layers of air are less strongly coupled. The lower layer of air is thus less taken along with the wind that at higher altitudes keeps on blowing, giving rise to greater differences between wind velocities at different heights.

The present study was performed mainly near the Rhede wind farm close to the Dutch – German border. The farm consists of 17 1.8 MW turbines of 98 m hub height and three 35 m blades. The level of the incoming sound has been measured at a number of locations. The sound could be measured up to a distance of 2 km. It proved that, contrary to predictions, already at a weak wind (at 10 m height) the turbines could rotate at almost top speed and consequentially produce much sound. It appeared that a wind profile proper to stable conditions could explain the measured sound levels excellently. At the same wind velocity at a reference height of 10 meter, wind turbines in a stable atmosphere generate more sound than in a neutral atmosphere, while at the same time the wind velocity near the ground is so low that the natural ambient sound due to rustling vegetation is weaker. As a result the contrast between wind turbine sound and natural ambient sound is more pronounced in stable conditions than it is in neutral conditions. When the wind profile after sunset changes while the atmosphere becomes more stable, the difference in wind velocity over the rotor increases. This causes a change in the level of the trailing edge sound. At the low tip this is reinforced because the inflow angle already was less favourable due to the wind being slowed down by the presence of the mast. The differences in wind speed lead to variations in the sound radiated by the blade tips that reach their highest values when a tip passes the mast. For a modern, tall wind turbine the calculated variation is approximately 5 dB at night, whereas it is approximately 2 dB in daytime. This is perceived as a more pronounced fluctuation of the sound.

A more stable atmospheric boundary layer moreover implies that there is less atmospheric turbulence, so wind turbines in a farm will experience a more equal and constant wind. As a result, in a stable atmosphere wind turbines can, more than in daytime, run almost at the same speed and then diverge again. With several turbines the fluctuations in sound can reinforce one another when they reach the ear of an observer simultaneously. With two turbines (at the same distance) this leads to an increase in level of 3 dB, with three turbines to an increase of 5 dB. In measurements this reasoned upon effect indeed occurred. With a single 45 m high wind turbine at a distance of 280 m at night variations of 6 dB were found. Near the wind farm the variations were usually 5 dB, but they could rise to approximately 9 dB, as expected when the fluctuations of several turbines coincide.

From other research and from descriptions of residents one can establish that the sound of a wind turbine or wind farm becomes more annoying because of 'swishing', 'sloshing', 'clapping', 'beating' or 'thumping'. All descriptions mention a periodic variation on top of a constant noisy sound. This corresponds to the calculated and measured modulation of trailing edge sound. From psycho-acoustic research it has been shown earlier that human sensitivity to sound fluctuations is high at frequencies that occur in the night time sound of modern wind turbines. If this fluctuating sound is sufficiently loud in a bedroom it can cause sleep disturbance. In the temperate climate zone a stable atmosphere is to be expected between sunset and sunrise over land if there is a -partly- clear sky (because clouds hinder the radiation of heat) and the wind is not too strong (because a strong wind promotes vertical heat exchange). From an analysis of measurements of the KNMI at Cabauw, in the central part of the Netherlands, up to an altitude of 200 m, it appears that there is a diurnal and seasonal pattern in the wind profile that correlates with the diurnal and seasonal variation in the heat exchange between the earth's surface and the atmosphere. The fact that at sunset the wind often lies down is a consequence of the increasing atmospheric stability, and this decrease in wind velocity close to the ground is accompanied by an increase at higher altitudes. This has significant consequences for the energy production of a wind turbines, where the rotor height plays an important part. If one starts from the measured wind velocities at Cabauw at 10 m height and a forever neutral atmosphere, the annually averaged electrical power generated by a 80 m high, 2 MW (reference) wind turbine would amount to almost 500 kW. However, based on the real, measured wind speed at 80 m height the annual power in reality amounts to 600 kW. So, because of atmospheric stability there is, relative to a neutral atmosphere, a significantly higher yield at night time hours, that even amply compensates for the lower yield in daytime hours. The higher wind velocity at night on the rotor also causes a higher level of generated sound. If again one starts from the measured wind velocities at Cabauw at 10 m height and an atmosphere assumed to be

neutral, the average sound power level generated by the reference wind turbine is 102 dB(A). In reality, however, it is 2 dB higher. This is also an average over an entire year; in separate nights the difference can be substantially higher, e.g. when a turbine rotates at (almost) top speed at a time it was expected to not produce at all because of the low 10 m wind velocity.

The degree of atmospheric stability at Cabauw is hardly different from what was observed at the Rhede wind farm. At other locations in countries in the temperate zone stability occurs to a similar extent. The consequences of atmospheric stability as described here, will thus occur at many wind farms that exist or are to be built in the temperate zone. However, above large bodies of water stability is rather a seasonal than a diurnal phenomenon, and in mountainous terrain the consequences of stability on the wind profile can be strengthened as well as weakened due to changes induced by height variations in the area. The sound of a wind turbine or wind farm can thus become more annoying after sunset for two reasons: it becomes louder and the sound exhibits stronger fluctuations. At a given rotor diameter a blade can only be made less noisy with a different design or by slowing down the speed. A decrease in speed however reduces the generated electrical power and must therefore be applied only when necessary. To achieve this a control can be applied that lowers the speed when a noise limit is exceeded, increasing the speed again when the limit allows. This control could work on the generator and/or the pitch angle of the blades. By changing the pitch angle while the blades rotate, the wind can flow in at an optimal angle at any position on the rotor, by which the energetic efficiency will increase on the one hand and the fluctuation strength of the sound will decrease on the other hand, even rendering the fluctuations inaudible. The total sound power will then decrease even relative to a neutral atmosphere, because the in-flow turbulence sound level will be lower due to the relative absence of atmospheric turbulence. Tilting the rotor to change the pitch angle during rotation does not appear to be a fruitful strategy: the tilt must be so great that the disadvantages will dominate.

The fluctuations near a wind farm can be stronger due to interference from the fluctuations of several turbines. This can be prevented by desynchronizing the turbines, as it happens in daytime by large scale atmospheric turbulence, by adding small and uncorrelated variations in the load of the rotors or the pitch angle of the blades of the individual turbines. Controlling the sound production thus requires a new strategy for managing wind turbines: in daytime there is often more margin available for sound production than at night and this margin can be used in daytime in exchange for more restrictions at night.

Finally another, very different problem was addressed: the influence of wind on a microphone in or without a wind screen. When there is sufficient wind the microphone signal contains a low frequency, rumbling sound disturbing the measurement of ambient sound. This rumble is not sound from the environment, but is generated by pressure fluctuations caused by turbulent wind velocity variations. With a pressure sensitive microphone these pressure variations are not distinguishable from acoustical pressure variations. It appears that a wind screen is effective only by damping contributions of small turbulent eddies. A wind screen has no effect when eddies are bigger than the wind screen. The strength of atmospheric turbulence does not only depend on the (average) wind velocity, but also on the local roughness of the earth surface and the stability of the atmosphere. These last two factors cause friction and thermal turbulence, respectively. The turbulence strength is well known for an unobstructed wind flow over flat land. Turbulence is weaker in a stable and stronger in an unstable atmosphere. The 'sound' pressure level based on atmospheric turbulence appears to agree well with measured and published levels of wind induced pressure levels. Thus the influence of wind on a sound measurement in wind can be calculated. In reverse this calculation model yields a new method to measure the strength of atmospheric turbulence.

To conclude, it can be stated that with respect to wind turbine sound an important phenomenon has been overlooked: the change in wind after sunset. This phenomenon will be more important for modern, tall wind turbines and in view of the many wind farms that are planned. If this problem is not recognized and solved it will hamper the expansion of wind energy. <http://dissertations.ub.rug.nl/faculties/science/2006/g.p.van.den.berg/>