Commissie Genetische Modificatie

Chair: Prof. B.C.J. Zoeteman

To the State Secretary for Housing, Spatial Planning and the Environment
Mr P.L.B.A. van Geel
P.O. Box 30945
2500 GX The Hague

Your reference	Your letter dated	Our reference	Date
		CGM/050408-04	8 April 2005

Subject
Report Farm Scale Evaluations

Dear Mr Van Geel,

I hereby present you with the report '*Farm Scale Evaluations evaluated*: *What can policy expect from science with respect to publicly-controversial technological innovations?*'

Summary
Science is often used by the government to generate public support for its policies. However, the use of 'normal' science is not always effective. An example of this is the introduction of genetically modified (GM) crops. In the United Kingdom, the government has failed in its efforts to generate public support for its policy on GM agriculture by use of scientific research, including the *Farm Scale Evaluations* (FSE). Certain subjects are too complex and too contested by public debate for such an approach, and therefore an alternative is required. The methods of normal science may be complemented with those of 'post-normal' science.
In this report the possibilities for using 'post-normal' science in the policy cycle are analysed. A number of recommendations are made for both the policy preparation and decision-making phases in the policy cycle with respect to increasing the support for decisions about innovations, such as: (1) involving as many interested parties and experts as possible (extended peer review), (2) not limiting the discussions to specific questions but including the underlying wider issues as well, and (3) formulating shared ambitions. The final deliberation is a learning process that requires the input of various parties plus the ambition to make joint progress, if a societally robust judgement is to be reached. Ultimately the government will have to take a decision in a transparent manner and ensure the enforcement of this.
There are no standard solutions for the use of science in developing and enforcing policy. The government should realise that certain subjects, including technological innovations, may become so contested by public debate, as a result of media coverage and politicising, that the policy instruments normally used are no longer suitable. In its future societal based reports, COGEM will inform the government in advance as to whether it intends to follow the method of 'normal' or 'post-normal' science.

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In future COGEM will employ the new approach of ‘post-normal’ science for publicly debated, controversial subjects. Therefore in your request for advice, please state the type of advice you expect from the Commission.

This report is being sent to you within the framework of COGEM’s statutory duty to inform you about important ethical and societal aspects associated with genetic modification.

Yours sincerely,

Prof. B.C.J. Zoeteman
Chair COGEM

Farm Scale Evaluations evaluated

What can policy expect from science with respect to publicly-controversial technological innovations?

COGEM report CGM/050408-04

Netherlands Commission on Genetic Modification (COGEM)
COGEM's task is to advise the government about the risks of genetically modified organisms (GMOs) and to inform the government about ethical and societal issues associated with genetic modification (Environmental Management Act, Section 2.3)

Contents

Summary

Science is often employed by the government to generate credibility and public support for its policies. However this approach is not always effective, as sometimes the subjects are too complex and too contested by public debate. A case in point is the introduction of genetically modified (GM) crops in agriculture. In the United Kingdom the government has tried to use various scientific studies, including the Farm Scale Evaluations (FSE), to gain support for its policy on GM agriculture. Yet this strategy was unsuccessful. Based on these experiences, the British government's advisory body on genetic modification, the Advisory Committee on Releases to the Environment (ACRE), is formulating recommendations for the government.

This report analyses the possibilities for using science in the policy cycle. It expands on a previous report by COGEM about the integral ethical-societal assessment framework (1). Use is made of the British discussion about the FSE study, as this clearly illustrates the nature of the problem. Experiences with Dutch initiatives in this area, such as the 'Food and Genes' debate, are also drawn upon.

The learning effect of the FSE study appears to have been more extensive than was intended with the setting up of the field experiments. The FSE study and the discussions and debates associated with this can also be viewed as a social experiment. Policy makers may draw lessons from this about the application of science in acquiring support for policy on controversial subjects, such as GM agriculture.

Scientific knowledge may be employed in different ways to support government policy on technological innovations. For relatively neutral questions where the knowledge used requires the opinion of experts, as it concerns the latest insights, specialists are consulted. The technical-scientific advice issued by COGEM falls under this category.

However there are also questions, such as the introduction of gene technology in agriculture, which are so contested by debate, that even the experts cannot provide sufficient certainty in a satisfactory manner. For the development of policies for complex societal problems, which might give rise to much public disquiet, the newly-emerging methods of post-normal science would appear to work better. In post-normal science, not only scientific experts but also other experts, stakeholders and people affected by the policy play a role in the forming of an opinion. By involving all of these parties in an open debate, post-normal science should deliver results which are scientifically and societally robust and therefore cannot easily be dismissed.

Finally there are questions to which science cannot provide any indications or in which the debate has become so contested that science will not fulfil any function. For these cases only political decision making and political responsibility remain.

From the FSE study and several Dutch examples, lessons may be drawn concerning the nature of debates about innovations in the policy-preparing phase of the policy cycle, such as:

- As many stakeholders and experts as possible should be involved in the debate (extended peer review);
- These debates should not be limited to specific questions, for example should GM crops be permitted and what are its potential risks, but should also discuss the underlying wider issues;
- Founded on these wider issues, certain shared ambitions should be formulated in the debate subsequently to be operationalised as objectives;
- These ambitions may eventually be used to evaluate certain practices concerning the technology;
- These ambitions may, moreover, direct the development of new technologies.

The debate about the wider issues in the policy phase of decision making fits within the framework of post-normal science. Such a debate must have a mutually shared objective, if it is to produce worthwhile outcomes. In other words it must carefully weigh up the costs and benefits to society against the dangers and risks. The final balance is a learning process that requires the input of various parties along with the ambition to make joint progress, if a societally robust judgement is to be reached. Ultimately the government will need to take a decision in a transparent manner and ensure the enforcement of this.

There are no standard solutions for the application of science in developing and enforcing policy. Therefore in each phase in the policy cycle, the best style of interaction will have to be discovered.

In COGEM's opinion constructive and open debates will only take place if a number of conditions are satisfied, for example:

- All parties concerned should be heard in the debate;
- The underlying objectives should be considered;
- A methodology should be available which enables the participants in the debate to reach unambiguous agreements. This should not favour arguments in one direction only;

- The participants in the debate should have the ambition to make joint progress and to learn from each other;
- The participants in the debate should aim at shared views and compromises.

These guidelines are no guarantee for success. The methods of post-normal science are still very much under development. An initiative in this direction is, for example, the project 'Biotechnologie als Open Beleidsproces' [Biotechnology as Open Policy Process] from the Dutch Ministry of Health, Welfare and Sports. For the learning process it is important that the different parties involved exchange information and experiences.

The government should realise that as a result of media coverage and politicising certain subjects, including technological innovations, may become so contested by public debate, that the conventional policy instruments are no longer suitable. This may eventually result in societal innovation being obstructed. COGEM urges the government to be aware of such potential developments and to anticipate these, applying the growing insights from post-normal science for making decisions about innovations.

Concerning its position COGEM proposes, as a result of the above analysis, that when the government submits a request, it indicates wherever possible the type of advice it expects from COGEM: the employment of normal or post-normal science. COGEM moreover asks that in its requests for advice the government gives due consideration to the fact that complex problems require the post-normal approach described above. Whenever the employment of post-normal science is indicated, COGEM will inform the government of this approach in advance. It will include identifying and listing the wider issues involved and the utilization of extended peer review.

1 Introduction

The government frequently bases its policy on scientific results. Science provides credibility and contributes to the general public's support for the line of policy chosen. However in some cases the contribution of science to the policy does not have the desired effect. Sometimes the subjects are extremely complex[1] and are so contested by public debate that the application of science fails to generate confidence. A case in point is the use of science for developing policy on major technological innovations, such as the introduction of genetically modified crops (GM crops) into agricultural practice.

Developing policy on GM agriculture is anything but a simple task. This innovation involves various perspectives and interests that may be mutually conflicting and are sometimes so interrelated that it is almost impossible to gain a clear and transparent picture of the issue. For example, one of these perspectives is the increase in agricultural productivity obtained by using modern molecular biology techniques for breeding, which might reduce the environmental burden. Yet the potential transfer of the genetic information introduced into the crop to other nearby crops or organisms in the ecosystems surrounding the cultivated area is another viewpoint that merits attention. The first perspective focuses on the business interests of the producers who wish to use GM crops to improve their productivity. The second perspective concerns the potential risks for the environment. In addition to this, the conflicting business interests of traditional and organic cultivation may come into play.

A completely different aspect that must be considered in forming the policy is the growers' and consumers' freedom of choice. Respect for the growers' freedom of choice implies that they are not forced into one specific form of cultivation and that coexistence is guaranteed. The consumers' freedom means the right to choose or not to choose foods produced with the help of genetically modified organisms. This may concern primary products (GM crops) or products made from GM crops which also contain the new genetic information (cells or tissues are part of the product). It may also concern products made from GM crops that do not contain the new genetic information (oil pressed from a GM crop). Products made from non-GM crops with the help of genetically modified microorganisms are not labelled as such. Guaranteeing the consumers' freedom of choice implies that not only the cultivation, but also the entire production chain is reviewed and monitored.

Policy making with respect to the cultivation of GM crops in agricultural practice therefore means taking decisions about a complex societal question

[1] In this monitoring report the term 'complex' not only indicates the intricacy of something but also that no unequivocal structure can be applied to it.

under uncertain circumstances. And that is particularly difficult. For the ecological effects, the precautionary principle is the guiding principle adopted in Dutch and European policy practice. The precautionary principle implies, for example, carrying out scientific research into the consequences of introducing GM crops in agricultural practice, as this may contribute to reducing the uncertainty about certain risks.

When taking decisions and implementing measures, the Dutch government first of all tries to identify which negative consequences are associated with a certain activity and how great the risk of detrimental effects occurring is. The government partly bases this risk policy on the scientific evidence for these consequences and the probability of these (2). The technical and scientific advisory reports published by COGEM, which frequently contain case-by-case risk analyses in relation to genetically modified organisms (GMOs), are examples of how science contributes to the foundation of knowledge necessary for formulating and enforcing policy. There are however different approaches for involving science in policy and decision making within the policy cycle. In the policy-determining phase all parties use science to support their own standpoints. In the policy-making and policy-enforcing phases this involvement mainly concerns the relationship between a democratically-elected government and science. What are the responsibilities of both parties and which limitations apply? The next section examines these issues in greater detail.

2 Scientific knowledge in policy practice

Science is often used to support policy. Yet scientific information does not always contribute to the generation of public support. Sometimes, despite the scientific quality of a certain study, there is no increase in the consensus which can serve as a basis for the policy. However, this does not mean that scientific research may not play a role in the public and political debate in these cases. Scientific research alone is not sufficient. If the results of scientific research are to be useable for policy development, implementation and enforcement then the knowledge acquired will not only need to be robust from a scientific viewpoint, but also from a societal viewpoint. In other words this knowledge cannot be easily dismissed. This societal robustness may be achieved via a process in which a dialogue with the involved parties plays an important role[2].

Scientific answers to societal questions

Science never simply delivers 'knowledge for the policy'. To reach results, scientists first of all need to subject societal problems to something of a transformation. The policy problems must first of all be related to subject disciplines, theoretically unravelled and then poured into a methodological mould, before they may be researched at all. Good science cannot be performed without precisely formulated questions, adequate methods and measurable results. Therefore wherever possible, the questions posed from the policy context are translated into a research question that scientists can use. For the introduction of GM crops into agricultural practice this leads, for example, to the following requirements. Researchers need certain carefully selected experimental fields; they have to reach agreement about what can be compared with what and at what level; certain types of seed must be chosen, agreements must be reached about how the cultivation will take place and how and when weeds will be controlled; an operational definition of biodiversity should be available together with a reference point or baseline against which the cultivation of the GM crop may be compared; agreements should be reached about which results are relevant and how these will be gathered, and so forth.

This transformation gives rise to few problems in the case of simple factual questions: Then there is a large degree of overlap between the policy problem and the scientific problem. Yet there are also questions, such as the impact of

[2] In this monitoring report the terms discussion, debate and dialogue are used as follows. In a discussion, the objective is to convey one's own vision. In a debate the objective is to convince the other parties by means of arguments and rhetoric. In a dialogue, mutual respect and the willingness to listen to and learn from each other are assumed. The purpose of a dialogue is to increase mutual understanding and more ideally to reach a consensus (including if necessary consensus about agreeing to disagree).

GM agriculture, which cannot easily be transformed into a solvable scientific problem. Here both structure and nature of the problem are contested.

These discussions often occur on the boundary between science and policy. Although knowledge of facts, theories and methods are important, these cannot determine whether the result of a scientific experiment will indeed provide the best possible answer for a certain policy question. Not only is the data open to different interpretations, for example with respect to reliability, validity and generalisation by the scientists, but the results are also evaluated from political viewpoints and expectations, irrespective of whether the researchers concerned appreciate that or not.

In 2003, COGEM indicated that scientific research (for example risk analysis) is subject to certain normative assumptions. Furthermore agreements about both facts and values are temporary in nature. Each agreement is only a stage in the cyclical process of ethical, public, or scientific opinion forming; it is not an end phase. The policy followed should relate to this (1).

Wherever possible, policy makers like to reduce problems into simple factual questions. Then the rational model of normal science does not have to be discarded and the traditional roles can be assumed: The policy maker requests, the scientist gives an answer and the citizen passively listens. A major advantage of this model is that criticism from public interest groups about the research design and results, can be labelled as ‘political gripes’.

However policy makers who reduce complex problems into simple questions easily fall into a trap from which it is difficult to escape, particularly if the environment is at stake. Several years ago the chair of the Advisory Council for Research on Spatial Planning, Nature and the Environment described this trap as follows: ‘The danger of this type of complex problem in which the environment and nature play a role is that the problem is framed as a choice between different potential solutions, whereas for many the use and necessity are still a matter of discussion. The policy maker, and frequently even more so the politician, is already thinking in terms of solutions. In his eyes the problem is a structured problem. In other words, the politician or policy maker assumes that there is a consensus about the values at stake and that it is up to science to indicate which solution is the most efficient. Science is therefore viewed as the problem solver. (...) As other parties have a different vision on the policy problem, they not only object to the manner in which the problem is presented, but also try to undermine the results of scientific research which fit into this perception of the problem. An entrenched battle ensues with piles of reports being used as ammunition by one side or the other. Whether they like it or not scientists are called upon to defend the various standpoints.’ (3). In other words too rational an approach may unintentionally result in an escalation of conflicts. A more detailed analysis of the application of science in the policy context is

useful for establishing realistic expectations among policy makers and for avoiding such traps.

Normal and post-normal science

The technical-scientific risk analysis by experts is the normal manner in which science is used during the development of policy on the use of gene technology in Dutch cultivation practice. However there are also other ways in which science may make a contribution to the development of policy in this area. To illustrate this, a classification of the ways in which scientific knowledge is used in the policy context is outlined. This is based on the work of two authors who have written about the use of science and political decision making since the start of the 1990s, Funtowicz and Ravetz (4, 5, 6).

In their analysis of how science is used to solve policy questions, Funtowicz and Ravetz make a distinction between normal and post-normal science. Normal science is defined as the science in which problems are solved according to a prevailing and undisputed paradigm. This provides standard strategies for solving problems. Its theoretical framework and assumptions are generally accepted. The scientific community guarantees the quality of this type of science by means of peer reviews. An example sometimes used to illustrate this type of science is the solving of a puzzle. The edges have been completed and now the individual pieces have to be put in place.

Problems that society considers to be ‘normal’ questions and which may purely be solved using routine technical expertise are classified as applied science by Funtowicz and Ravetz. This type of application occurs frequently and elicits few controversies. If the subjects are slightly more controversial and if the knowledge used requires the opinion of experts, for example because it involves the latest insights, then according to Funtowicz and Ravetz this is still normal science. This type of application can be characterised as the consultation of professional experts. Their advice forms a solid basis for policy. This type of application also occurs frequently. For example, the technical-scientific advisory reports provided by COGEM belong to this category.

However, Funtowicz and Ravetz observe that this type of normality does not always apply, especially if there are complex issues on the agenda, such as environmental, health or sustainability issues. These subjects are so contested by debate, that policy development in such areas may no longer just be based on scientific facts. There is a greater degree of uncertainty, not only from a technical or scientific viewpoint but also morally, and there are several perspectives which claim to be valid. Science, and with this the scientific expert, is accorded a different role in the solving of this type of problem. A new attitude

is required for using science in policy development and decision making. Funtowicz and Ravetz term this post-normal science [3].

The post-normality may emerge from a considerable scientific uncertainty. Then there is no single paradigm which gives undisputed guidance for solving the problems. Yet scientific research might also be accorded a different significance as a result of the socially-charged nature of the issue. In the case of conflicting interests, people are less easily satisfied by the contribution of science and the scientific results and the study design underlying this are then more carefully scrutinised. Therefore the policy context also determines the normality or post-normality of the science. In the case of post-normal science the quality of the solutions put forward is not only guaranteed by the scientific experts. These are questions in which the advice of scientific experts is still important, but does not have any special authority. Therefore, in the eyes of Funtowicz and Ravetz, the role of science in the policy cycle is not discarded for such questions. Yet there are also other experts, stakeholders, and people affected by the policy, who must be heard if support for the policy is to be generated. Therefore, according to Funtowicz and Ravetz, a broader quality assessment should take place, an extended peer review. COGEM's reports belong to this category.

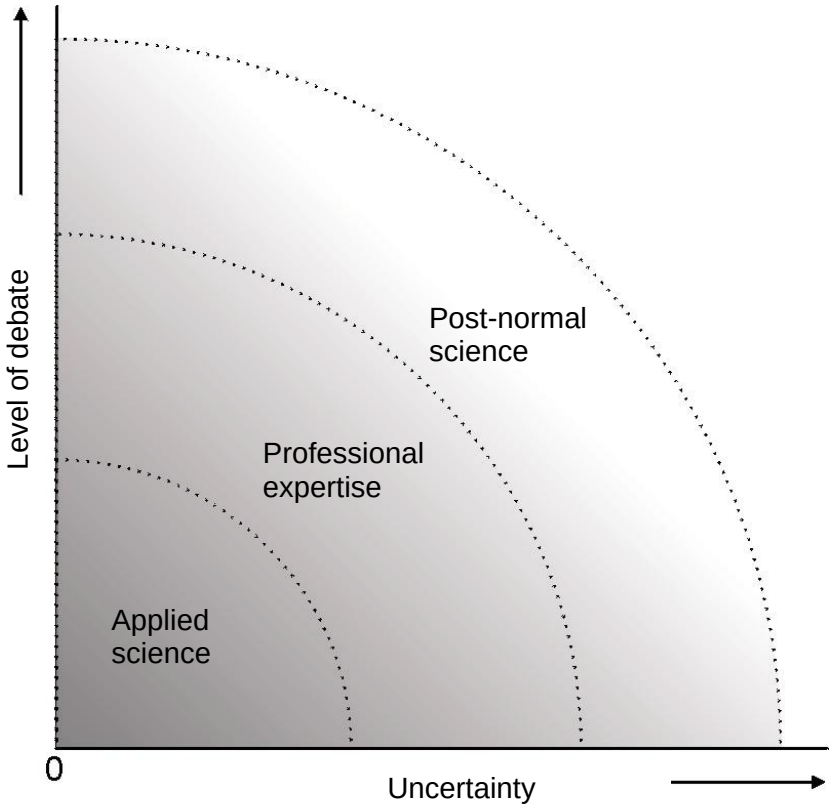
Finally there are questions for which science cannot provide any indications or where the debate has become so contested that science may no longer fulfil any function. In these cases, only political decision making and political responsibility remain.

Funtowicz and Ravetz indicate that in situations where there is confidence in the government and science, normal science is sufficient for answering policy questions. It provides support for the policy preparation, decision making and enforcement, and there is then sufficient robustness from a scientific and societal point of view.

In complex situations, where there is a broad range of standpoints and styles of reasoning, the methods of post-normal science are more appropriate. Science may still contribute to the policy, but the scientific results should then be subjected to an extended peer review. Funtowicz and Ravetz do not sufficiently elaborate on the extended peer review methodology for use in the policy cycle, especially with reference to the decision-making phase. In particular they fail to consider the fact that groups with different styles of reasoning participate in such a process. And although they describe the process with the term *review*, which concerns an assessment of the quality, they forget the fact that in such processes a shared idea about quality is often lacking (7). If the extended peer review is to be more than just a widening of the circle of experts, and if it is to lead to robust results, then it should be clear that efforts must be undertaken to

formulate mutually shared objectives. There must be the willingness to draw up an agenda and to follow this and there must be agreement about the criteria for success. A further elaboration of the extended peer review methodology is therefore desirable.

The figure below illustrates the relationship between the different types of knowledge and the intensity of the public debate.



Source: After Silvio O. Funtowicz and Jerome R. Ravetz, The Emergence of Post-Normal Science, in: René von Schomberg, ed. (1993). *Science, Politics and Morality. Scientific Uncertainty and Decision Making*. Dordrecht: Kluwer Academic Publishers, p. 100.

Gene technology in the light of normal and post-normal science

The application of scientific knowledge to support government policy on gene technology is a question which will be better understood with the help of the previously described ideas of Funtowicz and Ravetz. Applications of gene technology concern a relatively recent technology. Insight into the implications of these new developments, in terms of both risk and society, requires more than just routine expertise. It demands professionals who have the expertise necessary to form a good judgement and therefore policy makers call upon such scientific experts to assess gene technology innovations. The potential detrimental effects of the innovations are weighed up against the effects of the conventional agricultural practice. For a considerable number of questions it is useful to adopt a case-by-case approach in the risk analysis of specific cases to

fill up gaps in knowledge within the prevailing paradigm. Then it is sufficient to base the policy on the scientific advice of the professional experts. The problem-solving strategies of normal science are successful here.

Yet sometimes, and this is the case for the assessment of GM agriculture, the issue is so hotly debated, that even the experts are not able to provide sufficient certainty in a satisfactory manner. A wide spectrum of stakeholders are involved in the possible introduction of GM crops into agricultural practice: growers, consumers, the public, scientists, industry, non-governmental organisations (NGOs), politicians, and so forth. They often have conflicting interests and assume previously adopted standpoints. They also use different definitions of the problem. To protect public health and the welfare of humans and animals, the policy mainly concentrates on potential risks for food safety and the environment. Yet there are also other visions concerning the positive or negative value of GM agriculture. In 2003, COGEM pointed out that economic, ethical and societal questions play a role in the discussions about this (8).

In the debate about GM agriculture, all of the parties involved make use of scientific data to support their own viewpoint. With this the data are often transported, without a second thought, from the model context of the paradigm-based normal science within which they were developed, to the more complex societal arena. During this transport from the one context to the other, the conditions within which the outcomes are applicable are often forgotten about. Accordingly the results of the study are often interpreted within mutually opposing frameworks. Furthermore the underlying assumptions of the scientific conclusions are continually questioned in debates. In such situations science loses its societal robustness.

The introduction of GM agriculture is a controversial subject, fraught with mistrust and uncertainty and eliciting comprehensive ethical and social questions. This leads to a situation in which there is not only a lack of consensus but also a lack of trust. The discussion partners then adhere to their previously adopted standpoints even more strongly and they no longer provide arguments but instead exhibit strategic behaviour. As a consequence the different parties do not come closer together, no confidence is built up and there is no basis for finding a policy. Other strategies are manifestly needed to resolve the controversies and to find support for policy which will lead to transparent decision making and enforceable decisions. It becomes evident that in complex questions, as the introduction of GM agriculture, the transition from normal science to post-normal science needs to be made.

The Farm Scale Evaluations (FSE) is a particularly clear example of science failing to provide sufficient basis for government policy to solve a controversial problem.

The *Farm Scale Evaluations*

The British government wanted to support its future policy for GM agriculture with various scientific studies. After a pilot project in 1999, a start was made in 2000 on a large-scale three-year study into the effect of cultivating genetically modified, herbicide tolerant (GMHT) crops on the biodiversity in and around the fields, the FSE study. In this study the biodiversity in and around the fields where GMHT crops were grown was compared with the fields where equivalent, non-genetically modified crops were cultivated. The FSE study forms one of the most wide-ranging field experiments with GM crops in Europe. The results of another large-scale field experiment into the effects of GMHT crops in the United Kingdom, the BRIGHT project, have also recently been published (9)[3].

On 16 October 2003 the first results of the FSE study were published by the Royal Society (10). These concerned the effects of maize, beet and summer rape cultivation on the biodiversity in and around the fields and the results about outcrossing in maize. The results about outcrossing in oilseed rape and about the effects of winter oilseed rape cultivation on the biodiversity in and around the fields were published on 21 March 2005 (11).

The first research report was front-page news at home and abroad and evoked widespread discussion. Although the newspaper articles were based on the same press releases supplied by the British Department for Environment, Food and Rural Affairs (DEFRA) on behalf of the researchers, (12), the wide differences in the interpretation of these is striking. That was also the case for the results of the FSE study published by the Royal Society in scientific circles. There the differences and contradictions were also considerable. Proponents of the introduction of genetically modified crops took the FSE study to confirm their viewpoint, but the opponents did exactly the same. Comments about the experimental design and the results obtained also arose from within scientific circles. COGEM published a technical-scientific report, shortly after the publications in the Philosophical Transactions (13).

From its inception up until after the publication of the results, the FSE study has led to considerable public and political debate. The objective of the FSE study was, as stated, to provide a better foundation for the development of policy and policy making with respect to whether or not the commercial cultivation of certain GMHT crops should be permitted (14). The FSE study focussed on comparing the effects of growing GHMT and conventional crops. Therefore not only the crop but also the actual cultivation practice, including the herbicide use associated with this, was examined. The study compared the effects of different cultivation systems. The GMHT crops used were developed enough to be launched on to the market; all

[3] The BRIGHT project, acronym for Botanical and rotational implications of genetically modified herbicide tolerance in winter oilseed rape and sugar beet, was carried out and about the same time as the FSE study, and in certain aspects is comparable with it. However the outcomes are different. In the FSE study little reference is made to the BRIGHT project and the converse is also true.

European licensing authorities and their scientific experts were convinced about the safety of these GMHT crops. However a lot of questions still remained with respect to the impact of the herbicide usage in the cultivation of the GMHT crops on the abundance and diversity of farmland wildlife. The objective of the FSE study was to provide a scientifically-grounded answer to this. In addition the study served to provide data on which containment measures would have to be adopted should the cultivation be permitted.

Right from the start opponents of gene technology, such as Greenpeace and Friends of the Earth, opposed the FSE study. Greenpeace criticised the limited design of the FSE study, as a result of which aspects such as outcrossing, contamination of the global food chain, gene transfer and health effects were not considered (15). Friends of the Earth was of the opinion that the FSE study could not detect the differences between GM crops and non-GM crops with respect to their effect on the biodiversity in and around the fields and certainly not the ecologically relevant differences. A responsible extrapolation of the findings would therefore be impossible. Doubts were expressed about the representativeness in geographical terms and a number of parameters such as the yield should have been included in the study but were not. Furthermore comparisons were not made with more sustainable, for example organic, cultivation systems (16).

The Agricultural Biotechnology Council (ABC), a forum for debate and information about genetic modification in Great Britain whose members include the large biotech companies BASF, Bayer CropScience, Dow AgroSciences, DuPont, Monsanto and Syngenta, also immediately entered the discussion about the FSE study following the publication of the results in October 2003. The results were not considered to be the effect of GMHT crops but rather the indirect consequence of the weed control. The ABC emphasised that these GMHT crops had already been assessed for their safety for humans and the environment. It further declared that agriculture in all its aspects formed the greatest global threat for biodiversity, even though there are forms that are more harmful and/or sustainable and forms that are less harmful and/or sustainable (17).

Criticisms about the design of the FSE study did not only come from non-governmental organisations (NGOs). The Agriculture and Environment Biotechnology Commission (AEBC), an independent temporary advisory commission set up by the British government in 2000 to advise on developments within biotechnology and the implications of these for agriculture and the environment, had also expressed criticism in 2001 in its report entitled *Crops on Trial* (18). AEBC's remit was not only to advise the government about scientific aspects, but also about the ethical and social implications of biotechnological developments and about the degree to which these were acceptable to the general public (19). AEBC drew attention to the incorrect understanding of the FSE study among the general public and called for a broad public debate in which the government would recognise that a wide range of visions about genetic modification exist. Furthermore, the AEBC wanted an independent scientific study into the results of the FSE study and a study into the economic aspects of cultivating GMOs. These recommendations were enacted. From the end of 2002 until the summer of 2003 a public debate about genetic modification was organised in the United Kingdom under the title 'GM Nation?' (20). An economic study was set up and an independent investigation was carried out into the current scientific knowledge in relation to GM crops and GM food. In July 2003 the Strategy Unit,

which provides the British government with analyses of policy problems and provides initiatives for strategic decisions, published an economic analysis entitled, 'Weighing up the costs and benefits of GM crops' (21). The final report of the study commissioned by the Secretary of State for Environment, Food and Rural Affairs (and carried out by a Science Review Panel) was published in January 2004 and revealed that the FSE study was of a high scientific level. Furthermore there were no scientific reasons for rejecting all GM crops and the products derived from these, but also no reasons for permitting everything. According to the Science Review Panel, each application of gene technology needed to be assessed in a case-by-case manner (22, 23).

Despite all of the British government's efforts, the debate about the FSE study among lay persons, scientists, representatives from industry, NGOs and politicians was far from silenced (24). Both the lack of agreement about the correct interpretation of results and the criticism of the study design chosen still remain. The political debate about GM crops that arose in the United Kingdom following the FSE study, was also highly influenced by it.
In March 2004, the Environmental Audit Committee (EAC) of the British Parliament published a critical report on the FSE study, based amongst other things on the questioning of witnesses. These witnesses were for example, Michael Meacher, the Minister of the Environment under whose leadership the FSE study was started and the present Minister Elliot Morley, but also included representatives from industry and from NGOs (25). A terse answer to the report issued on behalf of the British government by the Environment Department in April 2004, evoked a second critical response from the EAC in May 2004 (26, 27). For example, the EAC criticised the standard used for the comparison. They considered the standard used, the biodiversity under the present conventional cultivation, to be insufficiently ambitious, because over the past 50 years the biodiversity has already suffered considerable damage under this conventional cultivation. The EAC proposed that in a follow-up study, a less intensive form of agriculture that poses less of a threat to biodiversity, such as organic cultivation, should be taken as the standard.
This debate between the government and the members of Parliament in turn led to further reactions from other parties. For example, the ABC responded critically to the statements made by the EAC (28). Whilst the British government and the scientific experts were attempting to limit the uncertainty about the potential consequences of GM agriculture by calling upon scientific facts, other parties were using the FSE study and the other scientific investigations to increase the uncertainty. In a nutshell, the debate about GM agriculture was anything but settled. Contrary to what had been hoped for, no scientifically-based consensus about GM agriculture had arisen that could serve as a basis for the government policy.

If the strategies of normal science are unable to solve certain problems, the question then arises as to how such problems should be solved. Is the debate between the different public bodies involved focussed on the risk associated with a specific modification of a specific crop, or is it more concerned about much less specific, larger underlying questions, such as the relationship between different types of agriculture and nature conservation?

In the FSE example and the associated scientific investigations, the British government attempted to follow a differentiated strategy: contribution of gene

technology experts, public debate, and economic analyses. Although the circle of experts was extended this did not lead to the desired result, as the previously described discussions clearly show.

Following the strategies of post-normal science is one way of tackling such complex issues. Use is still made of the contribution of scientific experts, but their contribution is embedded in a broader framework. Post-normal science distinguishes itself by rendering the dilemmas visible and developing methods to deal with these. However, the approach of post-normal science has still scarcely taken shape and ways of achieving societal robustness still need to be mastered.

One method involves clarifying and drawing attention to the underlying objectives and broader themes, the so-called wider issues. Making these underlying objectives explicit may render dilemmas visible and it might also make these negotiable. Using this approach it might be possible to find shared ambitions at a higher level of abstraction, which may serve as a framework for the debate. Debating within such a framework will bring potential shared ambitions to light. If agreement about these ambitions can be reached at a higher level, compromises about how these may be achieved, whether or not with the help of science and technology, might subsequently be reached.

However should these strategies also fail, a considerable amount of discord remain or no single instrument facilitate the reaching of compromises, then even the boundaries of post-normal science have been reached. In such cases politicians will have to assume their responsibility and make choices without the support of science.

3 New technology between acceptation and innovation

Innovations, applying new knowledge or new techniques on a socially-relevant scale for the first time, may have far-reaching consequences for a large number of sectors in the economy. The reason behind an innovation is often technical in nature. Yet eventually public opinion determines whether or not the innovation takes hold. Some elements of the opinion forming lie in the hands of the government, whereas others lie with other parties, such as the market, the general public and consumers. A new technical possibility that fails to gain acceptance will not reach the scale of an innovation. In the case of successful innovations, the right knowledge is present at the right moment and in the right social environment. Whether or not this situation occurred in practice can only be reconstructed in retrospect.

Major innovations set the entire 'system' of society in motion. They affect the economy, they call values into question and they necessitate the enrichment and sometimes even the reformulation of objectives. Such innovations also imply that a controlling say, participative structures and the awarding of responsibilities to the various parties must be re-established. The democratic principles of Dutch society require that discussions about such system-transforming innovations are primarily broad and transparent. It is important that the associated opportunities, values, interests and risks are considered. As many of the parties involved as possible should be heard: government, market parties, 'social midfield', the general public, and consumers. In the integral ethical-societal assessment framework presented in 2003, COGEM made proposals for the inclusion of such inventories in the policy cycle within the context of biotechnological developments. Broad inventories should be a part of the policy preparation phase (1).

The following conditions should at least be satisfied if the debate is to produce worthwhile outcomes. The participants should be willing to adhere to the agenda they have established, to follow a methodological approach, to aim to reach compromises and to learn together. Learning is understood to mean that exposing oneself to information, discussion, debate and dialogue may result in one's own opinions undergoing changes.

First of all a unequivocal agenda must be drawn up which states the main question of the debate. Although system innovations, such as the introduction of gene technology in agriculture, are always layered processes in which several interests, objectives and values come into play; those who want a debate must be prepared to establish a certain degree of structure in it. This may be done by stating a central theme, with which the debate about the wider issues may start.

During the discussion, the participants should adhere to this structure and refrain from the introduction of new types of considerations or values. This could only be justified by a joint advancing insight.

An example of an initiative for an open debate about gene technology is the 'Food and Genes' debate organised on behalf of the Dutch government (29). In the design of this debate a lot of effort was made to involve the various parties and others concerned. Furthermore a lot of attention was devoted to the agenda and the wider issues, as explained in the box below.

Exploratory public debate gene technology, 2000

In the Netherlands there have been initiatives to place the policy discussion and the research concerning biotechnology into a post-normal framework.

In June 1999 the House of Representatives adopted a motion in which the government was requested to organise a broad public debate about genetically modified organisms and food. Following this motion an exploratory study was carried out into the support for and the desires concerning the details of a broad public debate about gene technology and food production. A large number of people from interested organisations were involved in the implementation of this exploratory study. In addition to the desired objective, content and form of the debate, the study detailed the conditions that had to be satisfied if a public debate was to be worthwhile. In a series of four meetings the individuals involved from agriculture, science, public organisations and parties in the supply chain were invited to present their vision on this issue. The meetings were organised in January 2000.

The participants agreed that the public debate had to contribute to a balanced opinion being formed about gene technology and food production by politicians, the government, interested organisations and the general public. The results of a public debate had to serve as an input for the political decision making about applications of gene technology in food production. It should not be the case that participants conducted a serious debate and that the outcomes of this were subsequently ignored by politicians and the government.

The public debate should serve to clarify about what, and based on which view, the opinion is being formed. This is further detailed in the following secondary objectives:
Facts: In the debate the facts about gene technology and the food production must be openly presented. A broad approach must be chosen, with due consideration for risks, the degree of (un)certainty and the use and necessity of applications. In this a distinction must be made between what is known, what is not known and what needs to be known, and the costs of achieving a given level of knowledge must be considered in the evaluation. In addition to this the facts about gene technology and food production must be related to the facts about the use of 'traditional' methods. Finally a good overall picture must be created about what gene technology has to offer both now and in the future, so that a balanced opinion may be formed.

With this it should be noted that in a discussion about facts, it is particularly important to continually specify the methods used to establish the presented facts. The perspective from which reality is observed determines what is observed.
Degree of consensus: In the debate, the points on which the different participants reach consensus and the points where they differ in opinion must become clear.
Standards and values: The debate should provide insight into the standards and values upon which the opinions formed about gene technology and food production are based (acceptability). The exchange of credentials between the participants about the subject, should contribute to the clarity of the debate. This will allow the arguments to be placed in a unambiguous perspective.

Almost all of the parties involved draw a distinction between a debate about visions of the future of food production and the role of gene technology in this, and a discussion about the facts. There is a considerable level of agreement within the four clusters concerning the importance of a debate about visions of gene technology and production, and the elements which should be considered in this. 'Sustainable food production' is the most important theme mentioned. In addition to this the theme of 'food certainty and global food supplies' is also stated. For these themes it is important that a fair insight into the facts is established. In addition to the concrete themes listed, three subjects were stated which are related to the conditions: 'freedom of choice', 'controlling say in and access to the technology' and 'decision making'.

The 'Food and Genes' debate forms an illustration of the joint search for the wider issues. However this did not lead to a shared learning process and as a result of this a number of parties lost confidence in the organisers of the debate. Despite the carefully chosen approach, the debate failed to provide the desired basis for policy. The 'Food and Genes' debate serves to illustrate that the methodological development of post-normal science is far from simple.

Concrete lessons may be learnt from both the 'Food and Genes' debate and the FSE study with respect to placing items on the agenda. A feeling shared by most of those involved is that the debate about agricultural innovations, such as the introduction of gene technology, should not be limited to whether or not GM crops should be permitted and the potential risks of this, but should also discuss the underlying wider issues. The leaders of the FSE study are also of the opinion that one the most important lessons from the study is that the questions posed in issues such as GM agriculture, ought to be more broadly formulated. GM crops are not an objective but a means of realising certain objectives. These underlying objectives could be concerned with operational management issues in agriculture (degree of industrialisation, scale, animal welfare), concerns about the quality and safety of products, stimulating sustainable food production, the freedom of choice of consumers and growers, respect for nature, concern about biodiversity, landscape planning, the type of agriculture, and the balance between agriculture and nature conservation. Based on this certain collective ambitions should be formulated which may then be operationalised as

objectives. These may then be used to evaluate agricultural practices, but also to stimulate the development of new technologies.

A second example of a post-normal type of application of scientific research in the public debate about GM agriculture is the AgroGen project described below (30). In this project efforts were made to realise a contribution from and mutual dialogue between many parties, including science, so that an evaluation could be made of the socially desirable and less desirable agricultural innovations. The methods used for this are an illustration of how post-normal science can be shaped to result in shared ambitions, which may then possibly stimulate technological development. The AgroGen project was also never completed due to a lack of support.

After the policy preparation phase, the transition will need to be made to a new phase, that of policy making. Based on their democratic mandate, politicians will need to take decisions that will subsequently have to be enforced by government bodies. Politicians and government must also give account for their actions. A second lesson from the FSE study is related to this phase of the policy process. The decision making about the wider issues fits within the framework of what Funtowicz and Ravetz term post-normal science. Such a process must have a shared objective if it is to produce worthwhile outcomes, namely that the costs and benefits to society are weighed up as carefully as possible against the dangers and risks. However, this final deliberation is never purely a political issue nor purely an issue which may be delegated to a body of experts. The validity of the solutions reached should be demonstrated in the extended peer review recommended by Funtowicz and Ravetz. Contributions are requested from various experts, including stakeholders, in order to reach a societally-robust and enforceable decision. The final taking of such decisions is the primacy and responsibility of politicians.

AgroGen

The Dutch AgroGen project was launched in 2001. This project was intended to deliver a scientific contribution to the evaluation which society wants to make between the use, advantages, risks and moral acceptability of cultivations with and without genetically modified crops. The underlying idea of the initiators (Wageningen University and Research Centre, Consument en Biotechnologie [Consumer and Biotechnology] and Schenkelaars Biotechnology *Consultancy*) was that society could only make such a careful consideration if sufficient good research results were known about the effects of these cultivations on the sustainability of agriculture, nature and the environment.
The research would be carried out in two phases. In the first phase the research to be carried out and how this would be done was determined in close cooperation with stakeholders from Dutch

society. Issues that play a role in this are: which crops, which data are necessary, how should these data be 'generated', what type of sponsors should be approached, etc. During this phase answers to the research questions formulated were sought in the available literature.
In this phase a deliberate choice was made for two-way communication, for example, in the form of workshops. This approach was an attempt to achieve transparency, so that no doubt could arise about the purpose, content and results. Furthermore the parties involved were enabled to provide input that was used as a basis for further work. The results from the first phase were made public in a research report. The objective and method of the project were explained in a brochure.

During the design of the project consideration was given to the fact that it might not be possible to find an acceptable answer to all of the research questions. After all a significant proportion of the available research results have limited value. Firstly because the research carried out is often regarded as being too closely tied to those who have a financial interest in the research, for example the biotechnology company involved. Often the location, execution and results of such research are confidential. This makes an assessment by third parties difficult and therefore the objectivity of the research carried out is called into question. Secondly the research questions and the execution of the research have often taken place without the active input of stakeholders in the public debate, as a result of which broad support for this research is often lacking. Thirdly the research has often been carried out, or at least in part, outside of the Netherlands. Due to differences in cultivation, management and environmental circumstances, doubts are often expressed about the translatability of such research to the Dutch situation. Fourthly the research conducted in the Netherlands up until that time can be regarded as fragmented: A large number of field experiments spread throughout the country which are not related to specific crop rotations. These aspects hinder the assessment by third parties, especially where a comparison with research results from integrated or organic cultivation, for example, is desired.
Therefore further research was to have been carried out in a second phase based on concrete effect measurements under field conditions in the Netherlands. Yet when the first phase was being completed in 2002, there was insufficient support from the government and industry for such field research to be carried out.

A technique or methodology should also be available for this phase in the process, which in principle makes it possible for the participants in the debate to reach testable agreements. This methodology should therefore not contain any bias, in other words it should not have an implicit preference for certain outcomes. The methodology should not favour a certain type of conclusion. The box below describes how the cooperation 'Noardlike Fryske Walden' in the province of Friesland provides an example of how such a post-normal methodology may be developed[4].

[4] This project is partially financed by the *TransForum Agro & Groen* Foundation.

The Noardlike Fryske Walden

The 'Noardlike Fryske Walden' (NFW) is a regional cooperative, created by the merger of 6 environmental cooperatives. NFW intends to realise an integral transition to sustainable agricultural practices in the working area, which covers 50,000 hectares and 1000 farms. The starting points for this are:

1. A strongly revamped approach to the environmental problems (mineral balance) from a technical and management perspective;
2. An area-wide management of nature and landscape and an increase in the biodiversity;
3. New institutional arrangements, which concern the relationships within the area and those between the area and the various government and public organisations;
4. An embedding in, and strengthening of, the regional economy. With this special attention is given to the economic perspectives for agriculture that play a central role in the maintenance of the historically-developed spatial quality, and in which the production of green energy is a supporting factor.

NFW follows on from a cooperative venture between 60 dairy farmers from the region and a multidisciplinary research team from Wageningen University and Research Centre, and is focused on the development of solutions for sustainable dairy farming in the small-scale, wooded-bank landscape. In this cooperation an effort was made to harmonise the soil, plants and animals in a natural manner. Keywords are the improvement of the soil fertility, soil biology, manure quality and low-protein food. The approach is multidisciplinary and deliberate use is made of various sources of knowledge, including local experience, expert knowledge and scientific knowledge. Wageningen University and Research Centre evaluates the management measures and tries to translate these to the situation for farmers in the rest of the Netherlands. There is close cooperation with municipalities and the province.

NFW positions itself as an important learning experience within the framework of the transition to sustainable agriculture. It aims to translate its experiences into more general insights that may be used as building blocks for transition processes elsewhere.

What to do next?

The methods of post-normal science are still under development. Learning from examples, successful and less successful projects, and existing debates, along with attention for developments elsewhere continues to be necessary. The Dutch government has also taken initiatives in this area that could provide useful lessons, for example the 'Biotechnologie als Open Beleidsproces' [Biotechnology as Open Policy Process] project from the Ministry of Health, Welfare and Sports. It is important that the information and knowledge acquired during such projects is disseminated.

The Advisory Committee on Releases to the Environment (ACRE), the British sister organisation of COGEM, has explicitly given itself the task of translating the lessons from the FSE study into recommendations for the government, in the form of a new and hopefully useful model for both estimating the integral

environmental yields and the potential environmental damage which might arise from the introduction of new agricultural technologies. In January 2004, ACRE set up a separate workgroup which is preparing a report on the problems related to the wider issues (31).

The Agriculture and Environment Biotechnology Commission (AEBC) has also joined in the discussion. AEBC, which ceased to exist on 1 May 2005, has advised the British government over the past five years about developments within biotechnology and the implications of these for agriculture and the environment. In September 2004, AEBC sent an open letter, addressed to ACRE and the British government, about the wider issues which have been brought up as a result of the FSE study (32). In this letter AEBC makes recommendations to the ACRE workgroup and the government. These are presented below in a summarised form as an example of how the discussion may be widened.

In its letter the AEBC first of all refers to a number of assumptions in the FSE study, for example those arising from EU Directive 2001/18. This is followed by a number of related questions for the workgroup, which it could focus on:

* Can the statistical significance from the FSE study be adequately and robustly translated into ecological significance and damage? To what extent is damage not only a scientific consideration but also a value judgement? And what is that based on?
* Could this study have been carried out differently? Were the correct questions posed in the FSE study? Was the focus the only correct one?
* With due consideration to the EU Directive, may other broader standards for damage be chosen?
  - May for example entire cultivation systems be considered in the environmental risk analysis?
  - May other non-conventional cultivation systems, such as organic farming or precision farming, also function as a standard?
  - Could other indirect environmental effects such as savings on fuels or chemicals be included in the assessment in addition to the effects of biodiversity? And could the advantages be weighed up against the risks?
  - Are other assessment methods also available? And if so, what are the merits of these, who could carry these out and who could determine the criteria for these?

Finally the AEBC poses questions about how the British government could gain insight into the wider environmental effects of agriculture:

* Which systems may be used to gain an overview of the diverse environmental effects of the various conventional crops and of the different cultivation methods for the same crop?
* Which objectives should be set in the area of biodiversity and the environmental effects of all forms of agriculture? How may other, socioeconomic, aspects of sustainability be weighed up against this? Given the complexity of the issue, is it feasible to set objectives in the area of biodiversity? Might not the improvement of agricultural biodiversity in the future be better served by a pragmatic introduction of practices known to be favourable for wild animals?

* Which contribution of stakeholders is necessary if these objectives are to be societally robust? Can anything be learnt in this area, in a positive or negative sense, from the public debate about genetic modification?
* Which new structures are necessary in the government if the stated objectives are to be achieved?
* Which type of research would be necessary to provide information for policy decisions? Must all crops and/or cultivation systems in the past and present be assessed in the same manner as the FSE study?
* Should other forms of regulating GM crops and non-GM crops be considered which do not exhibit the problems of the current system or which minimise these, even if this would require a review of the EU guidelines?

The ACRE workgroup has held a number of meetings since, including an open meeting on environmental impact assessment on 22 October 2004 (33). The idea of the ACRE workgroup is to find a common theme underlying all of the wider issues brought up by the FSE study. This underlying theme is: Is it technically and practically possible to make an estimate of all of the integral effects of new agricultural technologies? In other words the short-term and longer-term impact variables are being sought, which in a wider sense are related to: biodiversity, the overall management, the use of the land, sustainability and safety. The ACRE workgroup has sought further expert advice in the following areas:

- *Life cycle assessmen*t (LCA) is a holistic analysis which is mainly used in industry (from cradle to grave) to assess the environmental burden of a particular product or process. The proposal is to conduct such an integral impact analysis to obtain the necessary knowledge about how extensive agricultural systems function. ACRE considers LCA to be a useful instrument for policy makers to reach integral assessments on the effects of new or changing agricultural production systems on people and the environment. Nevertheless choices will still have to be made about how different types of effects are to be compared and considered. Also the tools still need to be developed in certain aspects.
- *Environmental economics*. The basic idea behind the proposal to apply environmental economic knowledge in agriculture is to ensure that questions about efficiency are not posed against questions such as sustainability. Instead the question should be how profits due to improved efficiency (e.g. improved yield per hectare) may be used to benefit more sustainable development.
- *Indicator species*. The basic idea behind the employment of species-related indicators for sustainable agriculture is that it must be clear what is meant by effects on biodiversity. By using this indicator approach it is hoped that more or less undisputed conclusions in this area may be achieved.

- Research into another *exemplary regulatory regime* in which the costs and benefits to society are weighed up against the risks. The basic ideas behind this are: Before reinventing the wheel, we should first of all carefully examine other regulatory practices. How do these enter the integral effect assessment in a model? How do these other practices organise public support?

By using these four themes it is hoped that a stimulus will be given to the development of an integral model for the assessment of the environmental effects of new agricultural technologies. A potential trap for ACRE in this context is the tendency to fall back into the trusted strategies of normal science.

It is still uncertain whether the ACRE workgroup will be successful in completing its commission; COGEM will keep abreast of the results. As has already been indicated, there are also Dutch examples of post-normal methodologies being developed in practice. It is important that the information and practical knowledge acquired in these projects are disseminated by the organisations involved. Based on these elements, COGEM wishes to make a contribution to the ongoing development of a post-normal scientific approach.

In COGEM's opinion the government should be aware that as a result of media coverage and politicising certain subjects, including technological innovations, may become so contested by public debate that the conventional policy instruments are no longer suitable. This may eventually result in societal innovation being obstructed. COGEM urges the government to be aware of such potential developments and to anticipate these, by applying the growing insights from post-normal science for taking decisions about innovations.

Concerning its position COGEM proposes, as a result of the above analysis, that when the government submits a request, it indicates wherever possible the type of advice it expects from COGEM, the employment of normal or post-normal science. COGEM moreover asks that in its requests for advice the government gives due consideration to the fact that complex problems require the post-normal approach described above. Whenever the employment of post-normal science is indicated, COGEM will inform the government of this approach in advance. It will include identifying and listing the wider issues involved and the utilization of extended peer review.

4 Conclusions

The learning effect of the FSE study is more comprehensive than was intended when the field experiments were started. It not only has led to scientific results about the effect of cultivating certain GMHT crops on biodiversity. The FSE study, the other associated scientific studies and the discussions and debates that have arisen as a result of these, may also be regarded as an experiment. Lessons can be drawn from these about the use of science in acquiring support for policy concerning publicly-controversial innovations, such as GM agriculture.

Scientific knowledge may be applied in different ways to support government policy on technological innovations, including policy concerning gene technology. For relatively neutral questions requiring the expertise of specialists as it concerns the latest insights, strategies from normal science are used. Professional experts are consulted and their advice provides a firm basis for policy. The technical-scientific advice given by COGEM belongs to this category.

However there are also innovations, among these the introduction of gene technology in agriculture, which are too contested. Scientific experts alone cannot provide sufficient certitude in a satisfactory manner. In order to prevent the trap of entrenched standpoints, other forms of interaction between science and policy are needed. For the development of policies for complex societal problems that potentially give rise to much public disquiet, the newly-emerging methods of post-normal science appear to be more appropriate. In the case of post-normal science, the quality of the solutions proposed is not only guaranteed by the scientific experts. Aside from the scientific experts, other experts, stakeholders and people who will be affected by the policy play a role in the opinion forming. Thus post-normal science may yield results which are scientifically and societally robust.

Finally there are questions to which science cannot contribute any solutions or in which the debate has become so contested that science may not fulfil any function. For these cases only political decision making and political responsibility remain.

When new technologies are introduced, a tension exists between acceptation and innovation. Public opinion determines whether or not innovations take hold. This should not take place behind closed doors. It is important that the associated opportunities, values, interests and risks are considered and that as many parties as possible are heard. This requires an open debate during both the policy preparation and decision-making processes.

The FSE study and the Dutch examples first of all lead to conclusions concerning the nature of debates about publicly-controversial technological innovations, in the policy-preparing phase in the policy cycle.

- As many stakeholders and experts as possible should be involved in the debate (extended peer review);
- These debates should not be limited to specific questions, for example should GM crops be permitted and what are the potential risks of this, but should also discuss the underlying wider issues;
- Founded on these wider issues, certain shared ambitions should be formulated in the debate, subsequently to be operationalised as objectives;
- These ambitions may eventually be used to evaluate certain practices concerning the technology;
- These ambitions may, moreover, direct the development of new technologies.

The debate about the wider issues in the policy phase of decision making falls within the framework of post-normal science. Such a debate must have a mutually shared objective, if it is to produce worthwhile outcomes. In other words it must carefully weigh up the costs and benefits to society against the dangers and risks. The final balance is a learning process that requires the input of various parties, as equally the ambition to make joint progress, if a societally robust judgement is to be reached. Ultimately the government will need to take a decision in a transparent manner and ensure the enforcement of this.

In COGEM's opinion the following conditions should at least be satisfied in order to make open constructive debates possible:

- All stakeholders should be heard in the debate;
- The underlying objectives should be considered;
- There should be a unequivocal agenda which states the central question of the debate;
- The participants in the debate must be willing to introduce a certain structure to the themes;
- The participants in the debate must be prepared to adhere to this structure during the debate;
- A methodology should be available which enables the participants in the debate to reach unambiguous agreements. This should not favour arguments in one direction only;
- The participants in the debate should have the ambition of making joint progress;

- The participants in the debate should aim to reach shared views and compromises;
- The participants in the debate should be willing to learn from each other.

However these instructions do not provide any guarantee that societal robustness will be achieved. The techniques of post-normal science are still being developed. There are however instructive examples of initiatives in this area, such as the project 'Biotechnologie als Open Beleidsproces' [Biotechnology as Open Policy Process] from the Dutch Ministry of Health, Welfare and Sports that was launched in February 2002. Further practical knowledge needs to be acquired in this manner. For this learning process it is important that the various parties involved exchange their knowledge and information.

COGEM concludes that for each phase in the policy cycle there exists an optimal interaction between science and policy. This interaction is moreover dependent on the societal context of the issue concerned. This means that there are no standard solutions for the application of science in policy. For each phase of the policy cycle the best style of interaction will need to be discovered.

The government should realise that as a result of media coverage and politicising certain subjects, including technological innovations, may become so contested by public debate, that the conventional policy instruments are no longer suitable. This may eventually result in societal innovation being obstructed. COGEM urges the government to be aware of such potential developments and to anticipate these, applying the growing insights from post-normal science for making decisions about innovations.

Concerning its position COGEM proposes, as a result of the above analysis, that when the government submits a request, it indicates wherever possible the type of advice it expects from COGEM: the employment of normal or post-normal science. COGEM moreover asks that in its requests for advice the government gives due consideration to the fact that complex problems require the post-normal approach described above. Whenever the employment of post-normal science is indicated, COGEM will inform the government of this approach in advance. It will include identifying and listing the wider issues involved and the utilization of extended peer review.

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