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NATIONAL ENERGY POLICY AND CLIMATE CHANGE PREVENTION

The role of new energy technologies

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1. INTRODUCTION

Energy policies of some industrialized nations have been strongly influenced by environmental objectives concerning emission reduction of greenhouse gases, in particular CO_2. Although in the short term efficiency improvement remains the major option for response strategies, initiatives concerning new energy supply technologies and an increased awareness of the eventual necessity of changes in lifestyle are needed to make drastic reductions in emissions possible in terms of technical feasibility and social acceptance. Such new technologies must address the specific problems associated with the major components of supply: cleanliness in case of fossil fuels, safety in case of nuclear power and costs in case of renewable energy. Moreover, the introduction of new energy technologies and the adoption of life style changes may be strongly interdependent.

On the basis of these assumptions the Netherlands Energy Research Foundation (ECN) has initiated an innovative experimental research programme termed ENGINE (ENergy Generation In the Natural Environment) for major technological options within each component of supply, while the Netherlands Agency for Energy and the Environment (NOVEM) has started a complementary programme SYRENE (SYstem integration of Renewable ENergy and End Use) dealing with the systems aspects of sustainable energy development. The objectives of this paper are twofold: first to explain the rationale behind both programmes in the framework of Dutch energy and environmental policies, and secondly, to present the characteristics of the two programmes in terms of establishing a sustainable energy future.

2. ENERGY POLICY AND CLIMATE CHANGE IN THE NETHERLANDS

2.1 Government objectives for CO_2 emission reductions

The Brundtland report has resulted in an intensive and on-going debate on how to implement sustainable development in policy decisions. Although sustainable energy development is certainly not a sufficient condition for sustainable development, it is clearly one of the most crucial policy domains. From an early stage on it has therefore received priority among policy makers, in particular with respect to climate change issues. In the Dutch National Environmental Policy Plan Plus of June 1990 goals where set to reduce CO_2-emissions [1]. By 1994-1995 total emissions are to be stabilized at their 1989-1990 level of 182 Mton annually. By the year 2000 a reduction of 3%-5% must be achieved, which implies an annual CO_2 emission level between 173-177 Mton (see figure 1).

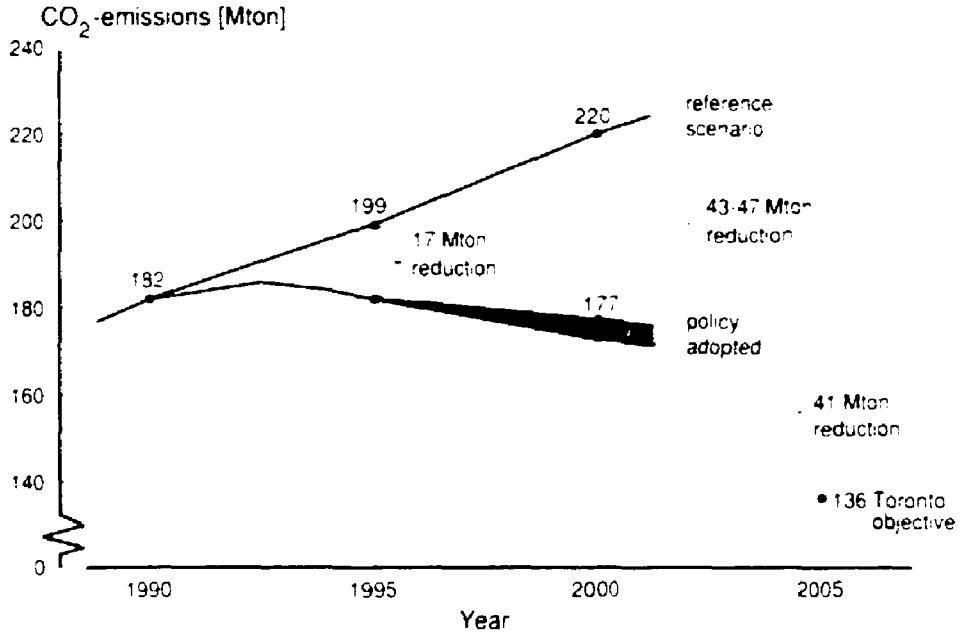

Figure 1. CO_2-emission reduction objectives 1990-2005 in the Netherlands

The policy document also proposes measures, which are considered at present sufficient to reach approximately the higher target of 177 Mton and conform to a no-regret approach. Additional measures will be proposed in the next policy plan, if present measures appear to be insufficient or if international developments in the area of climate change action make the lower limit more appropriate. Without a change in policy CO_2-emissions would have grown with about 2% annually to a level of 220 Mton. In terms of this potential future level the reduction thus amounts to 43 Mton. Changing the fuel mix from coal to gas and renewables accounts for roughly 34% of this amount. Energy saving (excluding energy saving in transport) takes care of 41%. The remaining 25% are shared by transport and waste management (resp. 16% and 9%). The elaborate measures for energy saving and renewables were detailed in a separate policy document [2].

The National Environmental Policy Plan Plus also announced a government policy paper fully devoted to the climate change issue. This document was published in September 1991 [3]. In addition to the CO_2-objectives discussed, it also presented targets and measures for other greenhouse gases. Moreover, it contained an analysis of the available options on a national level to reach the objective of the Toronto declaration of 1988 according to which a 20% global reduction of CO_2-emissions by 2005 should be an initial

goal for the long-term. However, it was clearly stated that this study only reflected the fact that the government is seriously considering more drastic targets, but that definite decisions require much more detailed analysis of technical feasibility and social and economic impacts and can only be addressed effectively in an international framework.

Table 1. Additional CO_2-reduction required for Toronto objective

Technology-oriented package

	Energy	Dwellings	Industry	Transport	Other sectors	Waste	Total
Volume measures	-	-	0.0	0.0	0.0	0.0	0.0
Carbon management	-	-	-	-	-	12.1	12.1
Additional savings	0.3	6.8	3.8	2.7	4.4	0.8	18.8
Renewables	0.6	0.1	0.0	0.3	0.1	0.4	1.5
Fuel substitution	1.7	0.2	0.0	0.4	0.0	-	2.3
CO_2-removal	4.7	-	1.8	-	0.0	-	6.5
Total	7.3	7.1	5.6	3.4	4.5	13.3	41.2

Volume-oriented package

	Energy	Dwellings	Industry	Transport	Other sectors	Waste	Total
Volume measures	-	-	2.5	0.5	3.2	6.2	12.4
Carbon management	-	-	-	-	-	6.0	6.0
Additional savings	0.3	6.6	2.8	2.8	1.7	0.1	14.3
Renewables	0.5	0.1	0.0	0.2	0.1	0.2	1.1
Fuel substitution	3.3	0.0	0.0	0.2	0.0	-	3.5
CO_2-removal	3.4	-	0.6	-	0.0	-	4.0
Total	7.5	6.7	5.9	3.7	5.0	12.5	41.3

2.2 Analysis of the Toronto objective

The analysis of the Toronto objective in the climate change policy document includes two types of measures: volume reductions and technical options. Volume reductions concern actions which limit the level of activities that are responsible for CO_2-emissions such as energy-intensive industry or greenhouse cultivation. Technical options concern energy savings, fuel mix, CO_2-removal and recycling. To reach the Toronto objective for the Netherlands requires a reduction of 41 Mton additional to the targets already adopted.

Two option packages were considered in the calculations: a volume-oriented package, in which besides technical options also volume reduction is included, and a technology-oriented package, in which only technical options are included. Six target groups were distinguished: the energy sector, dwellings, industry, transport, other sectors and waste management. Table 1 describes for each package of measures the reductions deemed feasible per option and per target group. More details can be found in a report by the Netherlands Energy Research Foundation, which was responsible for this analysis [4].

It was concluded that the objective is technically attainable, but that the required measures go far beyond a no-regret approach. For example, the additional investments in energy saving reach a level of three times those necessary for the no-regret approach already adopted. The measures also entail a substantial scrapping of capital goods in advance of

their economic life-time. Moreover, serious and costly implementation problems are expected, since the policy instruments to realize the targets are not in place. Finally, some options necessitate international action. For instance, displacing the Dutch aluminum industry and greenhouse cultivation only makes sense, when this will not cause an equivalent CO_2-emission elsewhere. Similarly, recycling of plastics must be guaranteed internationally, since a major part of the Dutch production is exported.

2.3 Role of energy research and development

It appears that drastic measures in the period up to the year 2005 involve substantial economic and social strain. Given the large scientific uncertainties in matters of climate change and the absolute necessity for coordinated international action, it is unlikely that energy policies beyond a no-regret approach will be put in place in the next couple of years. In these circumstances an increased emphasis on energy research and development is called for. The next round of measures to reach the Toronto objective already presupposes significant progress in the field of research and development, for instance with respect to CO_2-removal, heat pumps, fuel cells and renewables. Moreover, if the risks of climate change are proven to be real and serious in the coming decade, the Toronto objective will only present a first step in limiting those risks and much more dramatic measures may be needed. These will necessitate a total restructuring of present national energy systems.

It is not yet the time to worry about the path towards such restructured energy systems. But the elements of the blueprint and its general design should be available. This observation forms the rationale behind the ENGINE-programme of the Netherlands Energy Research Foundation and the SYRENE-programme of Netherlands Organization for Energy and Environment. In general terms ENGINE is supposed to contribute to the development of the major potential elements of such a system, while SYRENE looks at the integral design.

3. OBJECTIVES AND APPROACHES OF ENGINE- AND SYRENE-PROGRAMMES

3.1 The ENGINE programme

The main objective of the ENGINE (ENergy Generation In the Natural Environment) programme is to develop new energy technologies, which may play a fundamental role in developing a sustainable energy future. None of the three components of today's energy system (fossil fuels, renewable and nuclear) are excluded from such a system. The actual contribution will be the result of a dynamic process, in which the relative success of research and development efforts, future market conditions, the progress of climate change policy and the evolution of social acceptance play an unpredictable role. With respect to fossil fuels research will concentrate on high-efficiency technologies such as fuel cells, CO_2-removal at power plants and hydrogen technology. With respect to renewables the major emphasis is placed on photovoltaic cells, in particular focusing on reducing costs. In the nuclear field safety and waste management are crucial and research is concentrated on third-generation designs and radio-active waste reduction. The case of H_2-CO_2 technology is presented in more detail in section 4, while the substance of the nuclear and renewable research components is described below.

If nuclear energy is going to play a role in future energy systems, improvements in reactor design to maximize safety features and minimize waste problems are necessary. The ENGINE programme includes a number of nuclear research activities adressing these goals. The approach is based on the assumption that sustainability in terms of efficient resource use implies increased attention for innovative breeder concepts such as the PRISM/IFR design and thermal reactors with mixed U/Pu fuels and high conversion factors. Fundamental reactor-physical research is required to allow evaluation of the inherent safety characteristics of these reactors. In addition to considerations of fuel efficiency and inherent safety, concerns about waste management have put a high premium on development of low-activating construction materials and transmutation of actinides. Finally, if successful, these new developments of the nuclear fuel cycle will have important consequences for proliferation aspects. These proliferation aspects are also part of the nuclear component of the ENGINE-programme.

The renewable component of the ENGINE-programme is primarily concerned with photovoltaic systems, although some activities in the area of biomass are also considered. The photovoltaic activities concentrate on polycrystalline silver cells. The objective is to lower system costs by improving cell efficiencies and fabrication processes. A laboratory with advanced measurement and processing facilities has been set up. Topics currently studied include simulation modelling of cell behavour, ultra-thin cell fabrication, hydrogen passification , innovative cell connections and integration with the electrical grid.

The ENGINE programme also includes the social aspects of sustainable energy development. This social component focusses on three major issues: the influence of life styles on the level and composition of energy demand in the long-term, product life cycle assessments for new energy technologies and risk management strategies.

3.2 The SYRENE programme

The main objective of the SYRENE (SYstem Integration of REnewable Energy and End-Use Technology in the NEtherlands) programme is to improve the programming of long-term energy research activities by conducting system studies and giving advice about long-term

energy technology policy. The programme is also aimed at strengthening the ties between a number of long-term energy research activities of the Netherlands Organisation for Energy and Environment.

The starting point is a sustainable energy supply for the 21st century which pollutes as little as possible (greenhouse effect included) and makes as little use as possible of non renewable resources. A total-system approach has been selected, i.e. technologies are evaluated from energy source through transportation, to conversion, distribution, and end use and waste disposol.

By examining options within the context of a complete national energy system for some year far in the future and by drawing conclusions on the basis of this examination about which changes must be made in the current situation in order to achieve realization of those systems ("backcasting" instead of forecasting), inconsistencies in and potential combinations of technology and the necessary infrastructure can be determined as a basis for making choices about research and development.

With the aid of a relatively simple model, scenarios for this sort of innovative energy systems are drawn up. A material and energy analysis is made of several of these scenarios in order to ascertain the consequences that potential options have for the environment, energy supply and energy demand and resources (all components of the energy system). The next step is answering the questions of how the energy system options can be implemented in the long run and what the implicit consequences are for the infrastructure. With the aid of these analyses, gaps in knowledge can be detected on the technological level, which provide input for setting priorities when programming research activities.

In the Netherlands, this type of system research has been supported by planners from the energy sector, research institutes and the government. It is also very important to examine the approach and results in the light of activities in this area abroad. To get an idea of the possibilities of and interests in international cooperation NOVEM, together with the OECD and IEA, organized an international conference in December 1991 called "Energy technology policy for sustainable development: a comparison of long-term approaches". The need for a system approach, in which the integration between energy technologies and markets is studied, was generally recognized. The response to this conference was so promising that a follow-up to this conference is being prepared.

4. THE CASE OF H_2 - CO_2 TECHNOLOGY

The fossil fuel part of the ENGINE programme is focused on the use of fossil fuels for the production of energy without substantial emission of CO_2. Of course, the use of fossil fuels imposes other environmental problems due to emissions of gaseous contaminants and solid waste, but the reduction of this type of pollution has been, and still is, the goal of many research and abatement programmes.

Energy production from fossil fuels almost inevitably leads to the production of CO_2. The only exception is the route via the 'carbon black' method, in which case H_2 is liberated from fossil fuels and all the carbon is left in its non-oxidized state. It will be clear that massive use of this technique will greatly enhance the exhaustion of our fossil fuel reserves. The only alternative is to prevent CO_2 from being released into the atmosphere, and the subsequent fixation in a suitable sink. Possible sinks to be mentioned in this context are re-use in the chemical industry and food industry, conversion to biomass, and storage in empty gas or oil fields, aquifers, salt domes and oceans.

Re-use will not absorb more than a few percent of the present CO_2-production of an industrialized nation. The fixation in biomass cannot be considered to be a solution since the biomass produced will subsequently have to be stored or used, thereby releasing all or most of the fixed fossil fuel derived CO_2. The energy gained by the use of the biomass obtained in this fixation process originated from insolation of the CO_2-fixation plant. It is very likely that this solar energy can be converted at less cost by existing techniques.

Presently the only remaining methods seem to be underground storage and burial in oceans. These solutions are investigated in several experimental studies conducted at various places. Because the expertise required for the experimental studies is already available at other Dutch institutes, ECN limits its activities in this area to systems studies.

The fossil fuel part of ENGINE focuses at the development of techniques to convert fossil fuels into secondary energy carriers, without CO_2-emissions. Typically, the secondary energy carriers are electricity and H_2. The rationale of the research is that in the future, the use of fossil fuels by small and middle-sized users should, and in this way could, be avoided, whereas for the large users, techniques for the isolation of CO_2 should, and in this way could, be developed. Typically, electricity production is an example of large scale use of fossil fuels In systems analyses studies carried out at ECN, the merits and costs of existing and future options of CO_2 separation are compared. Options range from the less attractive but presently available technique of CO_2 scrubbing from flue gas, to more attractive systems like H_2/CO_2 separation in shifted coal gas and the use of coal gasification in combination with fuel cells. The use of fuel cells is attractive since there is an automatic separation of the fuel and oxidant flows. As a result, the produced CO_2 is not diluted by the major constituent of the oxidant flow, N_2. In the experimental part of the work, techniques for the separation of H_2 and CO_2 are studied. The method under development at ECN aims at the selective permeation of H_2 trough a ceramic membrane. Possible advantages over CO_2-scrubbing techniques are that the separation can be done at a higher temperature and that the remaining CO_2 is kept at high pressure, thereby reducing the amount of energy that is needed to compress the CO_2 to levels at which underground storage takes place.

In case of less centralized energy use, CO_2 isolation seems less attractive, if not virtually impossible. In those cases, there is need for a secondary energy carrier that holds no carbon. Typically, this could be electricity and/or hydrogen. The use of electricity is not part of the research, since it causes no further pollution. However, the use of H_2 for heat production still results in NO_x emissions due to the high combustion temperature. Here ECN aims at producing low-NO_x hydrogen burners using the existing expertise on ceramic foam burners.

Another major sector of energy consumption is that of (road) transportation. Although electric vehicles and H_2-fuelled cars theoretically offer a solution here, the problems of energy storage are tremendous. In case of the use of H_2 in internal combustion engines, the high combustion temperature causes an environmental problem through NO_x production. On this area, ECN is active in the application of the solid polymer fuel cell (SPFC). This type of cell is typically suited for mobile applications. In order to avoid infrastructural, safety and storage problems, methanol can be used instead of H_2. The methanol is converted to H_2 and CO_2 in an on-board reformer. Initially, this methanol is fossil fuel derived and there is no complete solution for the CO_2 problem. However, due to the better efficiency, a fuel cell powered car will emit less CO_2 than cars equipped with IC engines. If on the long term solutions are found for the problem of H_2-storage, there is no further need for methanol. Another option is the production of methanol from biomass.

5. CONCLUSIONS

Climate change prevention has become an accepted goal of Dutch energy policy. In fact, it has stimulated the design and implementation of a detailed plan to strengthen energy conservation efforts and accelerate the introduction of renewable energy technology. To reach targets in excess of the adopted 3-5% CO_2-reduction target by 2000 much more dramatic measures than presently in force are necessary. These measures will increasingly depend on the introduction of new energy supply technologies. Given the major uncertainties surrounding problems of climate change any strategy for climate change prevention should therefore reinforce research and development activities for sustainable energy systems. The ENGINE-programme of the Netherlands Energy Research Foundation and the SYRENE-programma of the Netherlands Organisation for Energy and Environment incorporate such activities.

6. ABSTRACT

Climate change prevention has become one of the major concerns of environmental policy in the Netherlands. The Dutch government has set definite targets for CO_2 emissions in the coming decade. These targets and the measures necessary to reach them are described in the paper. In addition, the technical feasibility of reaching the Toronto objective of a 20% reduction in CO-2 emissions by the year 2005 in the Netherlands is discussed. It appears, that energy conservation options are most crucial for the short term, but that eventually new supply technologies are needed to obtain drastic reductions in the long term. The increased need for research and development efforts has led to two innovative research programmes on sustainable energy development in the Netherlands. The ENGINE-programme is implemented by the Netherlands Energy Research Foundation (ECN) and addresses the specific problems associated with the three major components of supply: cleanliness in the case of fossil fuels, safety in the case of nuclear energy and costs in the case of renewable sources. The complementary SYRENE-programme is implemented by the Netherlands Organization for Energy and Environment (NOVEM) and addresses the systems aspects of sustainable energy development. The objectives and approaches of these two programmes are briefly presented.

L'ensemble des mesures destinées à prévenir les changements climatologiques est devenu l'un des impératifs de la politique de l'environnement aux Pays-Bas. Le gouvernement néerlandais a défini des objectifs précis limitant les émissions de CO_2 dans la prochaine décennie. Ces objectifs et les mesures nécessaires à leur réalisation sont décrits dans ce rapport, où sont discutés également les possibilités techniques pour atteindre l'objectif de Toronto, notamment la réduction de 20% en émissions de CO_2 dans l'année 2005 aux Pays-Bas. La Netherlands Energy Research Foundation a implementé le programme 'ENGINE', s'attaquant aux problèmes spécifiques associés aux trois critères les plus importants: la propreté dans le cas des energies fossiles, la sécurité dans le cas de l'énergie nucléaire et le coût dans la cas des énergies renouvelables. La Netherlands Organization for Energy and Environment a implementé un programme complémentaire 'SYRENE' concernant les aspets de système de developpement énergétique soutenable. Les objectifs et les méthodes d'attaque des deux programmes sont brièvement présentés.
La necessité croissante d'efforts de recherche et de developpement a abouti à deux programmes innovatives de recherche sur le developpement énergétique soutenable.

La prevención de cambios climáticos se ha convertido en una de las mayores preocupaciones de politica de medio ambiente en los Paises Bajos. El gobierno holandés ha fijado objetivos definidos a alcanzar en el próximo decenio respecto a las emisiones de CO_2. Dichos objetivos y las medidas necesarias para alcanzarlos se describen en este articulo. Además, se discute si es técnicamente factible alcanzar en los Países Bajos el objetivo de Toronto de reducir, para el año 2005, las emisiones de CO_2 en un 20%. Parece ser que las medidas de conservación de energia son cruciales a corto plazo, pero que posiblemente, para obtener reducciones drásticas a largo plazo, tendrán que desarrollarse nuevas tecnologias de abastecimiento. La creciente necesidad de esfuerzos de investigación y desarrollo ha abocado en dos innovativos programas de investigación en el campo del desarrollo de energia sostenible en Los Paises Bajos. El programa 'ENGINE' es llevado a cabo por la Netherlands Energy Research Foundation (ECN) y se dirige a los problemas asociados con tres de los principales componentes del abastecimiento: limpieza en el caso de combustibles fósiles, seguridad en el caso de la energia nuclear y costes en el caso de los recursos renovables. El programa complementario 'SYRENE', que se ocupa de los aspectos de sistema de desarrollo energetica sostenible, es llevado a cabo por la Netherlands Organisation for Energy and Environment (NOVEM). Los objetivos y puntos de partida de ambos programas se resumen aqui.

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