COMMISSION OF THE EUROPEAN COMMUNITIES

PROSPECTIVE BENEFITS FROM THE CREATION OF AN EUROPEAN METEOROLOGICAL COMPUTING CENTRE (ECMW)

4 - JUNE 1972

European Cooperation and Coordination
in the Field of Scientific and Technical Research
EUROCOP - COST

research and development

PROSPECTIVE BENEFITS FROM THE CREATION OF AN EUROPEAN METEOROLOGICAL COMPUTING CENTRE (ECMW)

Report by the Study Group on Benefit Analysis

No. 4 - JUNE 1972

EUR 4850 d, f, e

The "Research and Development" Collection comprises the publications of the European Communities relating to the organization and programming of scientific and technological research. It is run jointly by the departments of the Commission which deal with research and development problems.

Presentation to the reader

.-.-.-.-.-

The present study originated in 1971 as part of the efforts towards co-operation in the scientific and technical field (COST), among first of all 15, and later 19 European countries*.

By the end of 1969 the six Member States of the European Community had invited a number of other European countries to prepare several projects with a practical bias in various fields. One subject for discussion was the creation of a European Centre for Medium-Range Weather Forecasts which should be capable of producing routine forecasts covering periods of between four and ten days by the latter half of the seventies. This project would also make a major contribution to the aims of the World Meteorological Organization. The proposal met with great interest in all of the countries approached.

A working party responsible for compiling a project study and mainly comprising the heads of the national meteorological services was formed in 1970, following a resolution passed by the ministers concerned. This project study was submitted in the autumn of 1971; annexed to it was a survey of the probable economic and social advantages of the planned European Centre for Medium-Range Weather Forecasts which had been prepared by a special study group under the chairmanship of Mr. R. Schneider, the Director of the Swiss Meteorological Service.

After the Ministers had confirmed their fundamental readiness to participate in the European Centre for Medium-Range Weather Forecasts in Brussels on 22-23 November 1971, it seemed appropriate to air the results of the in many ways independent benefit analysis among a wider public.

The main emphasis of the survey was placed on those activities of the Centre which show the greatest immediate promise, i.e., routine weather forecasts covering 4-10 days. It is supposed that medium-range forecasts of this type would be possible around 1977.

---

* UK, Ireland, Denmark, Norway, Sweden, Switzerland, Austria, Spain and Portugal, later Finland and Yugoslavia and towards the end of the work Greece and Turkey, together with the six countries of the European Community.

Since the existing literature contains little in the way of figures on the advantages of medium-range forecasts and it was not possible to reach a solution via patterns for decision-making within the time available, the Study Group decided upon a method combining polls with forecasts of the economic growth of the sectors.

A total of 156 polls were conducted in 15 countries, the sectors covered being restricted to the following: agriculture, construction, the production and distribution of electricity and gas, transport, food distribution, water supply and protection against natural disasters. The most important questions concerned the type of meteorological information required, the uses to which this would be put, the anticipated level of the potential net benefit and the extent to which the weather forecasts would be used. Estimated values for the anticipated gross benefit to the sectors examined were then deduced for all of the countries involved. For this purpose the production in 1980 was calculated and the proportion sensitive to the weather determined. The mean rate of benefit as established via the poll was then applied and finally a reduction was performed, since the forecasts were in general only taken into consideration partly.

The agricultural sector is greatly interested in the 4-10 day forecasts. The construction industry, electricity utilities (hydro-electric power), gas producers and shipping companies would also pay great attention to forecasts of this type. Finally, interest is also displayed by the inland waterways and the food industry. On the other hand, medium-range meteorological information is only expected to be of moderate benefit to rail, road, and air traffic. Its potentially great importance for water supplies and the social advantages to be gained from protection against natural disasters could only be partially determined numerically.

The summary of the various quantifiable but incomplete results yields an economic value of the 4-10 day forecasts of 400-500 million u.a. for all of the countries concerned together for 1980. A utilization factor of only 50% of the forecasts was assumed for the two most important industrial sectors: agriculture and the construction industry. If this benefit is related to the outlay on the Centre, which is broken down in the project study, the outcome is a benefit-cost coefficient of over 25. This once again reflects, among other things, the great advantages to be gained if the resources of various European countries are pooled for the purpose of joint action.

The other services offered by the Centre to the participating countries, such as certain types of research work, the operation of a data bank or special computing facilities, must be taken into account when estimating the overall benefit to be gained from the projected Centre and provide the justification for its construction.

PREFACE

For some years the public administrations, the Commission of the European Communities and other international institutions have been increasingly endeavouring to base decisions concerning major projects on systematic and as far as possible quantitative analyses of the estimated benefits and costs (cost - benefit analyses, planning, programming and budgeting, rationalization of budget decisions, etc.). The theoretical literature on this subject is growing rapidly, but published concrete case studies preparatory to an actual decision are still a comparative rarity in Europe. One reason may be that analyses made to meet practical deadlines often fail to attain that degree of methodic perfection which is desirable in a document with a fairly wide circulation. Much valuable information and experience and many useful suggestions may thus be lost to the generality.

The present issue of "Research and Development" brings to the notice of the public a document designed to assess the economic and social benefit of a project for international cooperation in the public service field - the creation of a European Medium-Range Weather Forecasting Centre. This study forms part of a comprehensive report on the functions, equipment, estimated benefit and cost of the proposed centre. Although the actual cost-benefit comparison is not discussed below, we shall make no secret of the result, which was that there would be a cost-benefit ratio of "over 25:1". This demonstrates the great advantage of pooling the resources available for services - medium-term weather forecasts - which would benefit practically all European countries.

European Cooperation
in the field of
Scientific and Technical Research

Study Group on
Benefit Analysis

Prospective benefits from the creation of an European Meteorological Computing Centre(ECMW)

Contents

A. Introduction

I. Institutional framework

The present study was carried out in 1971, a fresh effort at scientific and technical cooperation (COST) by at first 15 and later 19 countries.[1)]

At the end of 1969 the six Member States of the Community invited various other European countries to take part in joint discussions and in the implementation of a number of projects with a predominantly practical orientation in seven fields.

The fields included meteorology - where contemporary technology with its high-performance data-processing units, satellites and automatic weather stations is opening up completely new horizons. The main topic here was the establishment of a European Medium-Range Weather Forecasting Centre (ECMW) to be capable in the later seventies of making routine 4 - 10 day forecasts. This project would also constitute an important contribution to the attainment of the aims of the World Meteorological Organization.

The ECMW project aroused great interest in nearly every country.

The institutional framework for a joint scruntiny of this and the other projects ("COST") was therefore created in Brussels during 1970 under the terms of a resolution of the responsible Ministers. It was as follows:

- a coordinating organ with wide powers - the "Committee of Senior Officials for Scientific and Technical Research";
- an " ECMW Working Party ", composed chiefly of directors of the national meteorological offices under the chairmanship of Mr E. Süßenberger (President of the German Meteorological Office), with corresponding expert groups for the other fields;

---

1) Initially the Community countries plus the United Kingdom, Irland, Denmark, Norway, Sweden, Switzerland, Austria, Spain and Portugal. They were later joined by Finland and Yugoslavia, and towards the end of the work by Greece and Turkey.

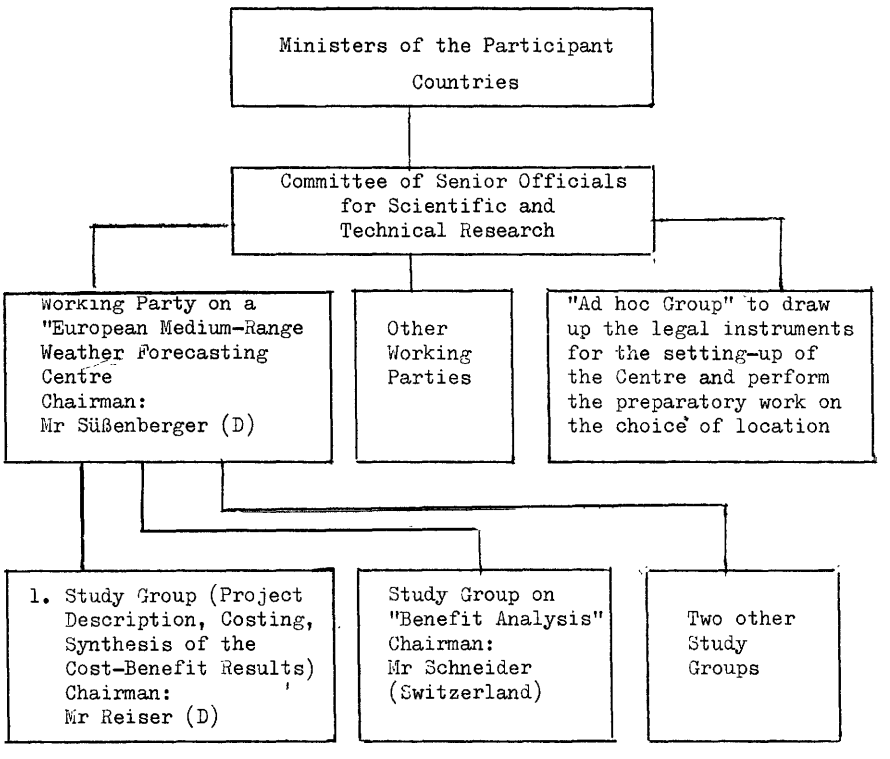
the ECMW Working Party in turn set up various specialized Study Groups, especially the "First Study Group" which did a great deal of the coordination (Chairman and Rapporteur: Mr. H. Reiser, West Germany), and was responsible for the project description, the costing, and the synthesis of the cost-benefit data, and also the "Benefit Analysis" Study Group under chairmanship of Mr. R. Schneider[1] (Director of the Swiss Meterological Office), which was responsible for estimating the economic and social benefit of the proposed centre (Rapporteur: Mr. G. Hipp, EEC Commission).

The present report was written in the first half of 1971, within this institutional framework, and was submitted to the Committee of Senior Officials on 26 August as an annex to a comprehensive project study. In the accompanying note the Group expressed the desire that the benefit analysis should be made more widely available by publication. When, at a conference in Brussels on 22 and 23 November 1971, the Ministers of 16 European countries stated their readiness in principle to participate in the project for a "European Medium-Range Weather Forecasting Centre" (the contract texts are in course of preparation and the information required to provide a basis for the choice of the location is being collected), there was no further obstacle to publication of the benefit analysis.

---

[1] List of members: Annex 3

Organization of European Cooperation in the field of scientific and technical research, and integration of the present benefit analysis into the relevant plan.



II) Summary

In accordance with its terms of reference of 15 February 1971, the Study Group on Benefit Analysis has examined the economic and social interest of the proposed European Centre for medium-range weather forecast (ECMW). The main accent in its report is on that aspect of ECMW's activities which offers the most direct and important benefits, i.e., operational four-to-ten-day forecasts.

If it is assumed that such forecasts will be available by 1977, a considerable degree of practical application may thus be expected for about 1980, provided that ECMW and the countries actively foster utilization of its products.

Since existing literature on benefits of medium-range forecasting offers only scarce statistical information and since an approach using decision models was not feasible within the time limits given, the group adopted a method combining interviews with forecasts of sectors economic growth.

156 interviews were held in 15 countries for a limited number of sectors : agriculture, construction, electricity and gas production and distribution, transport, food merchandizing, water supply, protection against natural disasters. The most important questions concerned the kind of weather information wanted, main use made of this information, possible net benefit expected (in % of sector's output) and the degree to which four-to-ten-day forecasts would probably be applied. Estimates of total benefits expected for the sectors considered and all COST countries together were then derived in a five-step procedure : estimation of output in 1980, calculation of present value at two alternative discount rates (5 and 8% per year) ,derivation of the proportion of weather-sensitive production in certain cases, application of the average benefit percentage obtained by interviews (= "possible benefits"), and reduction of the result to a lower figure, the "expected benefit" by considering that most probably, only partial use will be made of forecasts.

Interviews showed very strong interest for four-to-ten-day forecasts in agriculture, considerable interest in construction, hydroelectricity and gas production, ship routeing, icebreaking (Sandinavia), and, to a certain extent, in inland waterway tranportation and food distribution. Benefits to be expected in rail, road and airtransport, seem rather modest. Results for water-supply and social value of protection against natural disasters could, though possibly important, only partially be quantified.

Discounted 1970 value of total benefits amount to about 200 million u.a. per year at 8% interest rate (not-discounted value for 1980: 400-500 million u.a.). To this figure must be added expected value for non-food merchandizing, interest from a series of other business activities which the time available did not permit of analysing.

Other ECMW services : Research centred on medium and, to a certain extent, short-range forecasting, data-information bank function, offer of spare computer capacity to participating countries and training will contribute to the efficiency of medium-range and short-range forecasting and possibly, even to climatology. For the major countries, such services will be a valuable addition to possibilities on the national level, the smaller countries, for their part, may be enabled to keep abreast of the rapid progress in numerical weather forecasting.

The benefit figures derived are, no doubt, only tentative estimates but the mere money value obtained is so considerable that no more than a partial realization of the benefits expected would largely justify the creation of ECMW.

III) General assumptions

The proposed European Centre for medium-range weather forecast (ECMW) will have several tasks : routine medium-range (four to ten days) forecasting, research on medium-range forecasting, special services to national centres, data bank functions and training.

The Benefit Analysis Study Group decided to concentrate its work on that aspect of ECMW's activities which will have the most immediate and important economic and social consequences, namely, medium-range weather forecasting. As regards the other ECMW services, the Group felt that the end-result could not be specified in a way which would enable quantitative estimates of economic value to be compiled.

Analyses are carried out for forecasts appropriate to a centre equipped with a 50 MIPS[1] computer as proposed for the operational phase.

One (not very serious) difficulty had to be settled by adopting a simplified hypothesis at the very outset: it is highly probable that ECMW will not publish forecasts directly, but transmit charts to National Centres, where they will be processed for further regional detail and for communication to the public. The group decided to assign the entire value of the final weather forecast to the creation of ECMW. When benefits are compared with costs, the latter ought therefore to take account of some additional man-hours and machine time which will be necessary in the various participating countries.

B Benefits of medium-range (four to ten days) forecasts

The group endeavoured to estimate economic and social benefits as far as possible in monetary terms (u.a.)[2]. A relatively brief description of the methodological problems and of the procedure will be followed by a more detailed presentation of sector-by-sector analyses and their results.

I. Methodological problems and procedure

1) Problems

Three groups of problems had to be analysed and settled:

- the choice of the period to be considered
- the large number of countries and sectors to be studied and
- the method of sector analysis to be adopted.

---

1) MIPS= million instructions per second

2) u.a.= unity of account = 1 $

a) Reference period

The benefits to be evaluated will develop only gradually and in any case not until several years after the first substantial investments in ECMW have been made. In order to obtain a correct impression of the project's value therefore, it is necessary to determine a period in which benefits can be assumed to have attained a considerable level.

According to the project implementation plan, ECMW will furnish operational medium-range forecasts about five years after the implementing decision, i.e., about 1977 in the best possible case. Some time will elapse before users really apply these forecasts, but the group hopes that substantial application-promoting activity by ECMW and the National Services will ensure that this initiation period will not be very long. Thus 1980 may be a useful reference year.

Before 1980, the curve representing annual benefits would rise from a very low level in 1977 to the value to be dererminded for 1980. The subsequent pattern will depend on further propagation of ECMW's services by continuing information of the public and by the imitation effect.

In a benefit/cost comparison three types of analyses may then be made:

- comparison of current expenditure in 1980 with expected benefits during the same year
- comparison of benefit and cost values in 1980 at present worth evaluated by discounting
- comparison of all benefit and cost values up to 1980 at present worth.

The Working Party decided on a presentation of the second type, because this appeared the simplest and most practical one.

In the short time available the necessary estimates of economic growth up to 1980 could be obtained or worked out in detail for all countries only in the two most important sectors to be studied - agriculture and building - together with hydroelectric power production (these sectors accounting ultimately for about 90% of the ascertained total benefit). Nor do the production estimates for 1980 make any claim to a high degree of accuracy; they aim only to indicate orders of magnitude. (The main uncertainty in any event concerns production less than the other factors.)

The production estimates for 1980 were then adjusted to their present value. The Group decided to employ two interest-rate variants - 5% and 8% - in order to obtain a picture of the influence of this factor on the final result. The Working Party on a European Medium Range Weather Forecasting Centre having been instructed to present its cost estimates in terms of 1970 prices, it appeared advisable to relate the present value also to the year 1970.

For the other sectors only a rough estimate was made as to whether their annal growth up to 1980 would be nearer 5% or 8%, and on this basis the latest known

actual production values were adjusted to approximate "present values" for 1970.

In order that at least a broad comparison of the first type can be made, the summary includes in addition to the present values an estimate of the approximate - unadjusted - total benefit in 1980.

A comparison of the present value of the total benefit and the total costs up to 1980 would require in particular more precise estimates of the trend of the benefit curve between 1977 and 1980. But since the advantages of the project are likely to make themselves felt only towards 1980, this procedure would not give a correct picture of the longer-term cost-benefit ratio.

b) Number of countries and sectors

Analyses had to be carried out for 17 countries and - since an overall approach seemed impossible - a considerable number of sectors. In order to reduce work to something it could tackle within the time available, the group divided countries concerned into three categories corresponding roughly to three different types of climate (Oceanic, Continental and Alpine/Mediterranean) and then applied a relatively simply sector selection procedure, used by White:[1)2)] for each of these zones, thirteen sectors in a first list of business activities (compiled by R.R. Rapp and R. Huschke, who adapted it from a classification system developed by the US Weather Bureau)[3)], were ranked according to two different (or rather three) criteria :

- weather influence (including, as far as possible, the sector's ability to react to bad weather news).[4)]
- economic importance, judged by its contribution to the National Product.

An eliminating procedure based on the combined ranking position (and taking account of the relative homogeneity of the sectors concerned) produced the following list of business activities to be analyzed: agriculture(excluding forestry and fishing), construction, land and water transport, energy production and distribution and, possibly, water supply for the southern zone. When work was already in progress, favourable circumstances permitted the inclusion of food distribution.

This list was then enlarged by the inclusion of an area of predominately public interest, namely, protection against natural disasters, especially against floods.

c) Method of sector analysis to be adopted

Medium-range weather forecasts are an aid to operations planning. An intellectually satisfying way of measuring ECMW benefits would therefore use decision models applied in practice or, if such models are not available, have them developed. Theoretical weather decision models have already been proposed by several authors, e.g.,

---

1) R.M. White. Weather and the construction industry. WMO/WWW Planning Report No.27 : The economic benefits of National Meteorological Services. Geneva 1968, p.31.
2) The procedure is described with more detail in annex 1.
3) R.R. Rapp and R.E. Huschke:Weather Information: its uses, actual and potential. The RAND Corporation, RM-4063- USWB-May 1964.
4) A sector highly dependent on the weather but unable to do anything about it with a forecast of dangerous weather is of no interest for the purposes of this study.

Nelson and Winter and Thompson[1]. Unfortunately, even the simplest of all possible decision processes would involve :

- climatological probability
- probability of ECMW's forecast
- costs if no action is taken (in good and adverse weather conditions)
- costs if action is taken (in good and adverse weather conditions)

In practice, calculation of the two last-named items would require consideration of many factors, and the time available simply ruled out such an approach.[2]

The group accordingly had to have recourse to a more modest procedure :

- use of published information[3]. Unfortunately, data on the economic benefit (expressed in terms of u.a. value) of medium-range forecasts seemed to be virtually non - existent ;
- use of J.A. Van de Kraats' as yet in 1911 unpublished results concerning the benefit of five-day weather forecasts for agriculture and contruction in the Netherlands
- interviews with selected firms and institutions. This "questionnaire operation", which has proved to be the main source of information, will be briefly described in the following section.

---

1) Nelson, R.R., and S.G. Winter, Jr.; Weather Information and Economic Decisions : A Preliminary report. The RAND Corporation, RM-2620-NASA, August 1960 (quoted from Maunder).

J.C. Thompson : Potential Economic Benefits from improvements in Weather Information. In : WMO-WWW Planning Report No 27. The Economic Benefits of National Meteorological Services. Geneva 1968, p. 41.

2) For some further remarks on this point, see Conclusion

3) Rapp and Huschke's already quoted Memorandum, Maunder's "The Value of the Weather" (W.J. Maunder, The Value of the Weather. London 1970) and WMO/WWW Planning Report no 27 on Economic Benefits of National Meteorological Services were valuable sources of information concerning the weather sensitivity of the various sectors.

2. The "Questionnaire operation"

a) Questions asked

The group's questionnaire was broadly structured as follows[1]:
First, a definition of ECMW's forecasts had to be given. According to additional information obtained from the First Study Group, ECMW's forecasts for the sixth day might be similar in character to present forecasts for two days ahead. On this basis, two examples of ECMW forecasts were constructed. The first part of the questionnaire enquires into the benefits yielded by such forecasts. It submits a list of weather parameters, with a request to mark items according to their importance. Interviewees are then asked to indicate the kind of use made of such information, and the money value they would attribute to it (in absolute terms and in percentage of production or turnover). In weather risk situation users should have the opportunity to compare costs of protection with losses caused by adverse weather. (See IV). A final question concerns the probable degree to which forecasts would be used.

A second part tries to fathom what interest there is in still better forecasts which would meet users' requirements entirely. Originally, this section was intended to furnish a point of reference which together with results of the first part might permit interpolations in the event of the First Study Group finding itself obliged to change its ideas concerning relative forecast quality for the sixth day. In fact, it has proved valuable as a check on replies to Section One, since if there were no substantial differences between the two replies, there was reason to believe that the person interviewed had somewhat overestimated ECMW's performance in that section[2].

The third and last part of the questionnaire enquires whether the interviewee envisages any means of reducing, or even of eliminating completely, the influence of the weather in the foreseeable future.

---

1) The complete questionnaire is reproduced in Annex 2.

2) Actually, several interviewees corrected their replies to part 1 after replying to part 2.

b) Enquiry breakdown by countries and sectors

Proceeding on the hypothesis that it would be possible to do about 100 interviews, this number was then spread over the 17 countries and seven main sectors. Since it seemed necessary to distinguish in transport between road and rail and in water transport between sea and inland waterways, some reduction had to be made, and therefore the energy sector analysis was cut down to, essentially, hydroelectric energy production plus, if feasible, some further interviews on gas and oil.

The breakdown criteria were the economic importance of the sector to the country concerned, the benefit of having some data on countries using advanced techniques (agriculture in the Netherlands and in Denmark, construction in Sweden), the desire to cover as far as possible all climatic zones and for most important sectors to have four to five interviews per country. With a few exceptions, the interview plan was fulfilled and, in certain cases even exceeded, so that the reader may be referred to the table in Section (e).

c) Choice of interviewees

Since four-to-ten day forecasts afford advantages in planning operations, the group mainly chose interviewees who were reputed to be responsible or well-informed on operations planning in the sectors concerned. Since planning is generally more sophisticated in major enterprises, the views collected are those of men active or responsible for planning in large or other well-organized firms, members of industrial federations or research institutes or consultants to the branch concerned.

As regards agriculture and construction, the replies obtained cannot be said to be representative, according to statistical criteria, for two reasons: because the number of interviews is too small, and because average-sized firms will probably be less advanced in planning than the firms contacted. On the other hand, the mere number of interviews conducted certainly underestimates the degree of "coverage": in the construction industry, the enterprises visited were among the largest in the country, and the degree to which smaller firms are likely to apply the forecasts ought to be reflected in people's replies to the questions "Partial or practically no use of forecasts would be made by firms accounting for ....% of total production".

In railway transport and electricity production, the case is different. Production is in the hands of only one or a very few bodies, so that replies may be considered quite representative. The same holds good for results concerning protection against natural disasters.

The other sectors occupy an intermediate position.

d) Practical organization of interviews

Responsibility for the conduct of interviews was divided up as follows :

- representatives of France, the Netherlands, the UK and Switzerland in the Benefit Analysis Group themselves carried out the necessary enquiries for their own countries;
- for a limited number of countries (Belgium, Germany, Sweden and Norway, Spain and Italy) Mr. J.M. Wavre was commissioned under contract to perform the requisite work. The meteorological services of the countries concerned prepared the way for the necessary contacts and assisted Mr. Wavre during the interviews;
- all other countries (meteorological services) were asked by telex to conduct the interviews on their own.

As far as time allowed, the questionnaire was sent in advance of the interview. In several cases, the personal interview had to be replaced by written contacts plus an exchange of opinions by telephone.

e) Replies obtained

The number of questionnaire replies available at the termination of the report is shown in the table 1, broken down by countries and sectors.

In all, 132 replies were obtained, including - as a result of Swiss, Dutch and Italian initiatives - five answers from air-transport. Adding interviews for agriculture and construction in the Netherlands concerning interest of 5 days forecasts yields a total of 156.

f) Acknowledgments

This highly satisfactory result has been obtained thanks to

- the kind and active cooperation of the persons interviewed. (The question concerning the economic benefit of forecasts in terms of u.a. or in percentage of production was certainly not an easy one- especially for people aware of the multitude of factors that have to be considered in decision-making).
- the tremendous efforts of the meteorological services in all the participating countries (Several services even added extra interviews to the programme, and thus enabled account to be taken of special characteristics or opportunities in their countries).
- the remarkable efficiency with which Mr Wavre the consultant, carried through about 70 interviews in six countries within two months.
- and, last but not least,
- the rapidity with which the Committee of Senior Officials granted the funds necessary to finance Mr Wavre's mission.

Table 1. Number of questionnaire replies by country and sector at 30 July 1971 (Including Dutch results concerning interest of 5-day forecasts for agriculture and construction)

	Agriculture	Construction	Energy		Transport					Water supply	Protection against natural disasters	Other sectors: Food merchandizing	Total
			Electricity	Other	Sea Transport	Inland waterways	Railway Transp.	Road Transp.	Air Transp.				
Germany		7			1			6			1	1	16
France	9	3	1							2	1		16
Italy	1	3	2	1	6			2	1		2		18
Netherlands	8 [1]	16 [1]				4			1			1	30
Belgium		7	1	1								1	10
Luxembourg													
United Kingdom		1		1	1								3
Ireland	3												3
Denmark	5												5
Norway			2		2								4
Sweden		3	2		1		1			1 [2]	1		9
Finland					1	3							4
Austria												2	2
Switzerland		3	3				3		3		3	4	19
Spain	8		2					3		1			14
Portugal	x [3]									x [3]			
Yugoslavia	1	1	1										3
Total	35	44	14	3	12	7	4	11	5	4	8	9	156

[1] Dutch results concerning interest in 5-day forecasts

[2] included in electricity production

[3] partial information

II. Sector Analysis

1) Agriculture

a) Interest in medium-range forecasts

Of all sectors analyzed, agriculture showed the greatest and most positive interest in medium-range forecasts. In the Netherlands, for example, development of five-day prognoses was generally considered more important than improvement of the accuracy of current one-to-two day forecasts.

The dependence of agricultural production on weather conditions is both direct and indirect. "There is the obvious first-order effect in which we know that crop growth depends on weather. Second-order effects are those arising from pests and diseases, nearly all of which have strong associations with weather in their incidence, in their development, or in their spread"[1].
"Arable farming and horticulture are entirely weather-sensitive", cattle breeding much less with the important exception of hay-growing.[2]

The interviews conducted in seven countries (France, Italy, Netherlands, Ireland, Denmark, Spain, Yugoslavia) revealed particular interest in forecasts of temperature, frost, and rain (including heavy rains and thunderstorms). One correspondent also desired information on air moisture and two on morning dews.

This information would in general be used for better planning of operations in: sowing; spraying of herbicide and fungicide; harvesting of crops (hay and cereals); marketing of produce (tomatoes and meat); protection of harvested crops e.g. sugarbeet, against frost damage; irrigation; prevention of crop fires.

Results expected are more production (losses reduced), better product quality, and savings in materials and man-hours. A reduction in the amount of spraying with chemicals (due to weather forecasts) offers, furthermore, general interest from a sanitary point of view.

The economic interest of those results for the individual entrepreneur can be very considerable: sometimes medium-range forecasts may save the bulk of a farmer's harvest in arborculture (one reply from south of France) or in vine-growing (1 answer from southern France).

Answers concerning the net value (after deduction of costs due to specific measures) were furnished in two-thirds of the interviews. Results appear in the following table :

---

1) Penman, quoted by W.J. Maunder. The Value of the Weather. London 1970, p.63.

2) DRS J.A. Van de Kraats, in an unpublished communication of April 1971.

Table 2. Agriculture:

Estimated net value of four-to-ten day forecasts[1] in % of production

	Interview Country					
	Netherlands[1]	Ireland	Denmark	France	Spain	Yugoslavia
- Arable farming/ mixed farming	1 /2.5			10		10.5-15
- Cereals	1 - 2 1 - 2		1 1.5 0.1-1.5 3 4)		5[2]	
- Forage, hay	1< < 3 >1 5			20	5[2]	
- root and tuber crops (ex. beet)	3 - 4	2.5-5[5]				
- Horticulture	0.5	1-5[5]				
- Arboriculture				>6 in some cases 10/		
- Peat		2.8				
- Fruit					5[2]	
- Citrus fruit					5[3] 10-90	
- Wine				5		
- Milk products		0.2(max)				
- Whole of weather sensitive sector	1 min.					

[1] Netherlands : value of 5-day forecast.

[2] Replies by one and the same person.

[3] This estimate is independent of other figures given for Spain.

[4] "Seed growing".

[5] Replies by one and the same person.

Since replies for the Netherlands concern the interest of a five-day forecast only, the figures in the first column probably underestimate the merits of a four-to-ten day prognosis. On the other hand, the 5% value shown for citrus fruit in Spain seems high when compared with the total losses of citrus fruit due to frost (9% of production[1]). The numbers of replies being relatively low and the percentage estimates varying relatively little from one country to another, it appeared best to adopt a uniform rate for all COST member states, which was tentatively fixed at 1.5-2% of the total weather-sensitive production (arable farming and permanent crops)[2].

---

1) J. Castejon Chacon: Estudio de daños por heladas en los cultivos de agrios (unpublished document).

2) If weather sensitivity of production were considerably lower in the Mediterranean countries than in other regions, this fact would probably be reflected in smaller year-to-year fluctuations in production. In fact rates of change in total agricultural production between 1952 and 1968 show some differences from country to country, but these differences bear little relation to climatological zones. In fact, the amount of variation is about the same in France and in Spain, or (though on a higher level) in Germany, Austria and Portugal. Similar evidence was afforded by a glance at details of several important products, i.e., wheat, potatoes, grapes and wine, for 1964-1968. Taking account of the difference of the sizes of countries (agricultural land) in order to allow for inter-regional compensation of fluctuations did not substantially change this impression.

The total economic benefits to the agriculture of the seventeen countries will be derived by the following procedure. The value of actual production and economic development prospects during the '70s yield an estimated total output for 1980. This value is to be discounted to its 1970 equivalent using interest rates of 5 and 8%. Actual proportions between crop production on the one hand and total agricultural end-production on the other will then help to determine the share of weather-sensitive production, to which the 1.5-2% figure given above applies. Since not all farmers can be assumed to make full use of the forecasts envisaged, the result will have to be corrected by estimated application coefficients.

b) Production and expected growth of output

In 1968, the value of agriculture's contribution (net of forests and fishing) to the gross domestic product at factor cost[1] for the 17 COST countries amounted to about u.a.36 billion[2] (see Table 3).

The growth of agricultural production will probably be very modest during the 70s - about 2% per year on the average (in real terms), with a few countries even experiencing a decline.

---

1) Owing to the lack of comparable gross output statistics for the 17 countries, the value of production is measured, in this report, mainly by the sector's contribution to the gross domestic product at factor cost.

2) Very approximate figure, including forests for several countries. Elimination of fishing and forests is simple in the case of some countries, possible but time-consuming in the case of others and virtually impossible as regards forests in a few states.

The contribution to the gross domestic product in real terms may thus be some 30% higher than in 1968, which means about u.a. 47 billion. (For country-by-country details see Table 3)[1].

---

1) Estimates were derived as follows:

a) Extrapolation of growth rates (real terms) 1956-68

b) Comparison of results with OECD study "Agricultural projections for 1975 and 1985". For 1968, see especially p. 52.
This study works essentially with linear extrapolations, including a slow-down in the rate of increase in yield after 1975. Results are thus relatively low; the production increase would only be one-third to half of the rates derived under a) for many countries and about half for all countries together. The OECD comment on these results is that it is nevertheless on the cards that the trend in real terms will accord with an increase more pronounced than a linear increase. (To make results approximately comparable, the OECD increments for 1975-1985 were multiplied by 1.2 and thus converted from a 10-year to a 12-year basis)

c) Choice of compromise growth rates: $\frac{(a) + (b)}{2}$

TABLE 3

Agriculture [1] - Contribution to gross domestic product at factor costs

-prices 1968-

	1968	1980[4]	1956/68	1968/80
	10^6 u.a.	10^6 u.a.	average growth per year %	average growth per year %
Germany	5080	6400	2.9	1.9
France	8330[2]	10910	3.1	2.3
Italy	7070	9500	2.7	2.5
Netherlands	1540[2]	2030	3.4	2.3
Belgium	920	1070	1.7	1.3
Luxembourg	40[2]	47		1.3
United Kingdom	2480[2]	3140	2.4	2.0
Ireland	430	530	2.3	1.8
Denmark	1000	1160	1.8	1.2
Norway	330	315	(-1)[3]	-0.5
Sweden	700	680	-0.3[3]	-0.3
Finland	630	710	1.1[3]	1.0
Austria	790[2]	965	2.3	1.7
Switzerland	1000[2]	1240	2.3	1.8
Spain	3370	4300	2.4[3]	2.1
Portugal	690	795	1.4	1.2
Yougoslavia	1980	2495	2.3[3]	2.0
Total	36380	46300 (rounded)		2.0

1) Forest and fishing excluded

2) Including wine and forests

3) Partly estimates

4) Only approximative values, cf. part B, section I 1a

c) Present value of output in 1980, share of weather-sensitive production, potential and expected benefits

The proportion of weather sensitive production, i.e., the share of crop production in the total value of agricultural end-production, for the 17 countries ranges from 10% in Denmark to 65% in Spain. Table 4., column 3 figures were generally available ; only the proportions in Austria, Portugal and Yugoslavia had to be estimated. For the sake of simplicity, it was assumed that these percentage figures would still be valid in 1980. The discounted value of the weather-sensitive productions then adds up to u.a. 9-12.000 million. Applying the benefit rates of 1.5-2% derived above[1] thus gives a total potential benefit of u.a. 180-240 million (5%) or u.a. 135-180 million (8%) : such would be the economic interest of forecasts if agriculture were to make full use of them. In point of fact, this will hardly ever be the case, and certainly not during the first five years of ECMW's services.

Consequently, correction factors have to be introduced. Only five questionnaires offer suggestions on this point and the views expressed vary widely; full use of the forecast might be made by anything from 3 to 80%, partial use by anything from 0 to 40%. It is important to note, however, one person who had given a particularly low estimate (a Spanish farmer) added that, in the event of successful application by pioneers, an imitation effect would drive the % figure up to more than 90%.

Since it seems plausible that big farms would make better use of the new type of information than smaller units, it was suggested that data in form size be employed as a basis of estimation. Such data could be gathered for the Community countries, for the Scandinavian nations and for Switzerland. Farms were then classified into large (>50 ha), medium and small (< 10 ha). By assuming that these groups would make 60%, 50% and 20% use respectively of the potential benefits and applying these ratios to the three groups shares in agricultural land, average use ratios for eight countries between 45 and 55% were arrived at, the higher percentage being valid in France and Denmark.

---

1) Results of questionnaire replies refer generally to gross output (value including materials bought from other sectors etc.). Applying these percentages to sectors production in terms of contribution to gross domestic product at a factor comparable data (cf. foot-note p.18) makes estimates rather too low than too high.

The medium value of 50% coincides with the result given by an alternative, more summary method suggested by the Group in the event of there being insufficient data: if one assumes that full use is made as to one-third of production, 50% use as to another third and practically none as to the rest, this gives an average of 50%[1].

Since the factor finally applied will in any case be arbitrary to a certain extent, the Group decided to use one and the same average factor - 50% - for all countries. This rate may somewhat underestimate farming dynamics in countries with particularly well-organized agriculture, such as the Netherlands and Denmark, and it may overestimate the effects in less-developed regions. It must be remembered, however, that the 50% figure is considered valid for a certain period - about 1980 - only, the degree of application increasing in time as a result of instruction efforts, and the learning effect (imitation).

Reducing the potential benefits by the adopted 50% yields (Table 4, cols. 8 and 9) definitive total expected benefits of

u. a. 90 - 120 million (i = 5%)
or about u. a. 66 - 90 " (i = 8%)

per year (discounted to 1970 value).

---

[1] For actual short-range forecasts in Hungary, R. Czelnai, F. Dési and D. Szepesi have derive , on the basis of information on proven economies, a minimum application factor of about 22% - Cp. "On the Economical Efficiency of the Meteorological Activities" Időjaras. Kulönlenyomat. Separatum, p. 494/495.

Table 4 Agricultural production value discounted to 1970 (Contribution to gross domestic product at factor cost), share of weather sensitive (=crop) in production in total end-production, potential benefits, application factors and probable economic benefits of 4-10 day forecasts

	Production 1980[1] value 1970 million u.a. discounted at		Share of weather sensitive(=crop) prod. (approx.) in %	in million u.a.		Potential benefits, 1.5-2% of columns (4) and (5) million u.a.		Expected benefits 50% of potential benefits million u.a.	
	5%	8%		5%	8%	5%	3%	5%	8%
	1	2	3	4	5	6	7	8	9
Germany	3930	2960	30	1180	890	18-24	13-18	9-12	6.5-9
France	6700	5050	40	2680	2020	40-54	30-40	20-27	15-20
Italy	5030	4400	60	3500	2640	53-70	40-53	26-35	20-26
Netherlands	1250	940	30	375	280	5.5-7.5	4-5.5	2.8-3.8	2-2.8
Belgium	660	495	30	200	150	3-4	2-3	1.5-2	1-1.5
Luxembourg	29	22	25	7.2	5.5	0.11-0.14	0.08-0.11	0.05-0.07	0.04-0.05
United Kingdom	1930	1450	30	580	435	8.5-11.5	6.5-8.5	4-6	3-4
Ireland	325	245	20	65	50	1-1.3	0.75-1.0	0.5-0.6	0.4-0.5
Denmark	710	540	10	70	55	1-1.4	0.8-1.1	0.5-0.7	0.4-0.5
Norway	190	145	30	55	45	0.8-1.1	0.7-0.9	0.4-0.5	0.4
Sweden	420	315	30	125	95	2-2.5	1.5-1.9	1-1.2	0.7-1
Finland	440	330	20	90	65	1.5-1.8	1-1.3	0.7-0.9	0.5-0.6
Austria	590	450	25[2]	150	110	2-3	1.7-2.2	1-1.5	0.8-1.1
Switzerland	760	570	20	150	115	2-3	1.7-2.3	1-1.5	0.8-1.1
Spain	2650	1990	65	1720	1290	26-34	19-26	13-17	9.5-13
Portugal	490	370	65[2]	320	240	5-6.5	3.5-4.8	2.5-3	1.7-2.4
Yugoslavia	1530	1160	30[2]	460	350	7-9	5-7	3.5-4.5	2.5-3.5
Total(rounded off)	28400	21400	40	11730	8840	176-235	132-177	88-117 ≈85-120	66-88 ≈65-90

1) estimates

1) only approximative values, cf. part B, section I 1a.

(2) Construction

(a) Interest in medium-range forecasts

In 1966, the US Department of Commerce made a study of weather effects on construction. Operating conditions in the USA and in Europe are sufficiently similar[1] to render results interesting : in the US, a quarter to a third of residential and general building, two-thirds of repair and maintenance work and three-quarters of highway and heavy and specialized construction can be weather-sensitive (out-door work, perishable materials, etc., Table 5)

Table 5.
Distribution of total annual construction volume and the proportion considered potentially weather-sensitive (U.S.A.)

Construction category	Annual volume 10^9 u.a.	In % of annual volume[2]				
		Potentially weather-sensitive				Total sensitive
		Perishable materials	On-site wages	Equipment	Overheads & Profits	
Residential	17.2	6	9	1	12	28
General building	29.7	6	14	1	9	30
Highways	6.6	25	25	12	11	73
Heavy and specialized	12.5	15	25	20	20	80
Repair and maintenance	22.0	12	18	6.5	14.5	51
Total (rounded off)	88.0	10	16	6	13	45

Source: J.A. Russo : "The economic impact of weather on the construction industry of the United States". Bulletin American Meteorological Society, Vol.47, No. 12, Dec. 1966,p.970.

For the construction sector as a whole, sensitivity would thus be about 45%.

1) Cf. J. Wittrock. Reducing unemployment in the construction industry. OECD 1967, p. 153 ff.

2) Rounded off

In most European countries, residential and other building represents 70 - 80% and roads, bridges, dams and other public works about 20 - 30% of the total construction activity. If US results (30% sensitivity for the first and 75% for the second category) were applied, the conclusion would be that in Europe too some 40% of the total construction activity is weather sensitive.

In fact, total dependence will probably be higher through indirect effects : if weather-sensitive operations become delayed, subsequent interior work cannot be executed, conversely, if medium-range forecasts contribute to say, a 0,5% increase in the rough work performed, this will very probably bring about an increase in finishing operations too during the period considered.

The group's questionnaire campaign showed that there was particular interest among the firms contacted in temperature (frost) rain and heavy precipitation, snow and wind speed. Indications concerning the occurrence and duration of phenomena were also required. In the case of dam-building and other work in ports the state of the sea is important. Some firms attributed great value to data on visibility (no fog) and one correspondent mentioned insolation.

Before the replies as to the use and the economic value of medium-range forecasts are dealt with, it seems appropriate to call attention to some special features of the construction industry[1].

Firstly, there is the possible influence of the most relevant meteorological phenomena : potential production losses due to low temperature and heavy precipitation depends naturally on the relative incidence of these phenomena in the different countries. Comparison of average temperatures in the two coldest months (January and February) and average rainfall per year reveals that some countries are particularly favoured and other particularly handicapped. Prominent in the first category is Spain, with little precipitation and practically no frost ; the second group encompasses Finland and parts of Sweden, with its very low temperatures, Norway (to a certain extent), the Alpine countries with relatively low temperatures and high precipitation and probably also Portugal, due to its heavy rainfall in winter.

---

1) Development of the following points was greatly facilitated by J. Wittrock's excellent study on "Reducing seasonal unemployment in the construction industry", OECD, Paris 1967.

Secondly, the real influence of weather phenomena depends to a certain extent on the possibility of working under unfavourable conditions, the organization and the social system playing an important role here.

Winter operations need for example careful preliminary planning: preparing sites, having warm clothes, accommodation for manpower, protective or heating materials, etc. Scandinavian countries and, to a certain extent, the Netherlands, France and Switzerland have gone a long way towards carrying on activities during the cold season.

The influence of the social system on the application of medium range forecasts is particularly difficult to cope with. A OECD study[1] and some replies to questionnaires indicate that this influence is more favorable in some countries than in others.

Use of forecasts : questionnaire replies. Nearly all the firms contacted considered medium-range forecasts useful ; the degree of interest, however, varied widely. This may be due to the fact that there are actually several important types of time ranges for planning : the plan for execution of the whole project (which in one firm covered more than two years), something like monthly planning, and planning for the next day. The role of weekly or fortnightly plans is not quite clear. In well organized firms, such plans exist, but they seem somewhat rigid, liable to be changed only in case of major necessity. For instance, one firm said medium-range forecasts would not offer much advantage, but monthly forecasts would revolutionize the branch. Many firms in the Netherlands would rather have improved short-term forecasts than five-day forecasts. On the other hand, there were firms enthusiastic about four-to-ten-day bulletins, as such information made for much better planning. In practically every case, building consultants and research institutions saw considerable advantage in the new possibility offered.

---

1) Readers desiring additional information are referred to Wittrock's book, and in particular Ch. VII.

We shall deal fairly briefly with the replies as to the kind of use firms would make of four-to-ten-day forecasts, the main aim of the relevant questions being to serve as a base for stimating the economic value.

Most firms underlined the possibility of <u>better planning.</u> Reducing the number of stoppages of work brings advantages which are more important than the direct gain in hours worked[1]. In Belgium and in Germany, several enterprises would - if they had medium-range forecasts - lay workers off earlier in bad weather (instead of having them come to the site and sending them home again) and tell them at once when to come back.

As one firm stressed, this would call for an appropriate adjustment of the rules concerning bad-weather allowances. Since in such cases there may be a certain clash between the interests of individual firms and those of society, interpretation of some replies is not easy. In one case the Group queried the reply and was assured that it concerned a genuine gain in production.

Better planning can also mean taking precautions against bad working conditions (asking for special cement if cold is forecast, remembering that the depot will need a few days to send it, ordering pumps if a rainy period is approaching, protecting derricks, etc.), doing work at once instead of later (concrete pouring if possible, gatting materials up to the tenth floor if winds will not allow this later on), protecting work and materials against damage (by covering, insulating, heating or removing). In some cases, it can even mean changing over to another site.

The benefit percentages given by most firms are summarized in Table 6 . Since only a few replies were available on road and bridge construction (many big firms contacted were of a mixed type) and since these replies did not show significant differences compared with all the others, no distinction was made between building and other activities.

---

1) Wittrock, p. 242-243.

Generally speaking, figures are favourable, but considerably lower than in the case of agriculture. Here too replies from the Netherlands concern five-day forecasts only, and thus they may again somewhat underestimate the interest of ECMW's forecasts. (Four of the "no interest" replies are from Dutch system construction firms.) It is noteworthy that estimates vary as widely in Sweden as in Germany or most replies from Belgium.

Some literature references facilitate the formulation of a definitive proposal.

In the USA, the construction industry's actual dollar losses due to weather (including hurricane damage!) were estimated [1] at a minimum of 3,5% of production annually, rising to 11% in extreme years.[1] It is considered that about 1/3 of normal losses could be avoided by improving 24-hour forecasts and by making full use of existing services. In terms of production values this leaves only 1-2% for damage avoidable by medium-range forecasts, damage avoidable by other kinds of services and unavoidable damage[2].

---

1) On the basis of simulation models.

2) Russo, op. cit., p.971

Table 6. Construction Industry. Estimated net value of 4-10-day forecasts in % of production

Value Range	Interview Country: Belgium	Netherlands[1]	France (South)	Germany	Switzerland	Sweden	Italy	Other c.
0		000000[3]						
>0 without further specification	xx	xxxx		xxxx			xx	
0< ≤0.1	0.02			0.02				
0.1< ≤0.2	0.1-0.2		0.2			0.2		
0.2< ≤0.3								
0.3< ≤0.4			0.1-1				0.4	0.3-0.8 U.K.
0.4< ≤0.5	0.5	0.5 0.5		0.5	≤0.5 0.1-0.9			
0.5< ≤0.6		0.5-1			0.1-0.9			
0.6< ≤0.7						0.5-1		
0.7< ≤0.8	0.75	0.75						
0.8< ≤0.9	<1							
0.9< ≤1.0	1	1.0						
1.0< ≤1.5	1.4	1-1.3		1				1.1
1.5< ≤2.0						1-2	1.75[2]	(Yugosl.
2.0< ≤2.5					2-3			
2.5< ≤3.0			0.1-6					
3.0< ≤4.0		2.5-5						
4.0< ≤5.0								
5<	min 5	5						

1) Interest shown in 5-day forecasts,

2) Doors, windows.

3) 6 replies.

x = one reply with no percentage.

In the case of the United Kingdom, Mason[1] has quoted the sector's annually weather losses at about £ 100 million, or about 3.5% of production (nine working days). "These losses are caused mainly through lost or inefficient working days, idle equipment and ruined materials", which marks an upper limit as regards economic value for all kinds of meteorological assistance. During 1953-56, experience with building contracts on five sites showed that working hours lost through atmospheric conditions amounted to 0.8-1.8% of the total working hours[2].

Where France is concerned, it has been calculated that weather influence rarely causes more than 2% losses in working hours in all sectors of construction. The exceptionally cold winter in 1956 sent this figure up to 4%.[3]

In Austria, weather indemnity fund statistics show that on the average about 2% of working hours are lost on public works as a result of climatic conditions[4].

In the Netherlands, weather indemnities paid by the construction industry's aid fund during the years 1958 to 165 show a loss of 1,000,000 to 7,700,000, on the average about 3,200,000 working days due to frost. On the basis of the total labour force in 1960 - about 210,000 - and an average of 250 working days per year, this means that between two and fifteen on the average approximately 6% of the total working days were lost[5] through frost alone. From 1966 to 1969, losses in working hours due to frost, rain and reduced daylight evolved as follows: 1966: - 11%; 1967 and 1968 : - 7% ; 1969 : -8%.[6]

Information just provided is sunnarized in the following table.

---

1) B.J. Mason, The Economic Value of Meteorological Services in the United - Kingdom. WMO.WWW Report No. 27: The Economic Benefits of National Meteorological Services, p. 2k.

2) Wittrock, p. 242.

3) Ibid., p. 178.

4) Ibid. p.97.

5) Ibid. p. 219

6) Information furnished by the Dutch delegation

Table 7: Construction. Weather losses in % according to various sources (Literatur)

		USA	UK	France	Netherlands (frost losses)	Austria
		I	II			
Total losses						
- normal year	3,5	3.5	0.8-1.8	2	6	2
- extreme year	11			4	15	

In view of the fact that many entrepreneurs regard improvement of short-range forecasts as still more important than five-day forecasts, the group is inclined to think that perhaps two-thirds of the potential loss reduction in the construction industry ought to be attributed to better application and further sophistication of short-range forecasting. This leaves us with the following benefit potentials for medium-range forecasts and other kinds of assistance in a normal year :
UK 0.4 - 1.2 ; France 0.7 ; Netherlands 2 ; Austria 0.7.

Owing to the wide margins in many of the replies, it is not easy to calculate an average for questionnaire reply percentages. Taking account of the 0-values, assigning the arithmetic mean to all replies of the 0.1 - 1 or 1 - 2 type and neglecting "more-than-0-but-I-cannot-tell-how-much" replies, yields a mean of about 0.9 %.

Since some of the questionnaire replies concern those construction phases which are particularly weather-sensitive i.e. rough work and civil engineering, the group thought that 0.7 - 0.9 might be too high for the total construction sector and thus adopted a 0.5 % (approx.) for all countries except Spain and Portugal, which are arbitrarily alotted 0.1 and 0.3 respectivily. This was because of the modest incidence of bad weather phenomena in the first named country and, to a lesser degree, the second.

b) Production and expected growth of output

In 1968, construction's contribution to the gross domestic product at factor cost in all the participating countries amounted to about u.a. 45 billion, (i.e., approcimately 8 %). Estimates of future growth were based on OECD-s GDP forecasts for

1980 [1] and an extrapolation of the sector's share in the GDP during the last 10-13 years. Results are summarized in Table 8. The real growth achieved by construction (at constant prices and exchange rates) may average about 5.5% during the '70s, so that the total contribution to the GDP may reach in 1980 about 86 billion u.a.

c) Present value of 1980 output, potential and expected benefits

Discounted at 5 and 8% interest rates, the value of 1980 production amounts to u.a. 53 and u.a. 40 billion respectively at present worth, i.e., roughly the actual production in 1968-69. Application of the potential benefit percentages yields total potential benefits of u.a. 190 - 250 million. (table 9)

How much of this possible benefit can be realized in practical conditions likely to be ruling in 1980?

Here too questionnaire replies differ considerably. There is, however, some consensus on relatively large-scale application of ECMW's forecasts by big firms. Unfortunately, the group was not in a position to procure in the time available comparable statistics on the construction industry's structure according to number of firms, persons employed and turnover. As regards Germany in 1970, firms employing more than 100 workers accounted for scarcely 5% of the total number of firms, but for as much as 42% of employment and 45% of the branch's turnover. In the UK, the proportions would appear to be similar, whilst in Belgium big firms employ only about 30% of the sector's total manpower. Assigning 80% application of results to firms with more than 100 workers, 50% to firms with 20-99 employees and only 20% to still smaller units gives an average application factor of nearly 60% for Germany and somewhat less than 50% for Belgium. The UK figure might be similar to Germany's.

---

1) OECD: "The Growth of Output, 1960-1980", Paris, Dec. 1970.

Table 8.

Construction industry. Contribution to gross domestic product at factor cost (1968-1969: current prices, 1980: prices and exchange rates 1968).

	1968 10^6 u.a.	1969 10^6 u.a.	1980[3] Forecast 10^6 u.a.	Average rate of growth 1968-80 %
	1	2	3	4
Germany	8,900	-	16,100	5
France	12,840[1]	12,240[1]	27,750[1]	6.6[1]
Italy	5,340	6,240	11,400	6.5
Netherlands	1,730 (1967)	-	3,600	5.8
Belgium	1,190	1,300	2,100	4.9
Luxembourg	51	-	80	3.8
United Kingdom	6,000	6,140	8,400	2.9
Ireland	160[2]	-	285	4.9
Denmark	1,110	1,320	1,900	4.6
Norway	635	700	1,050	4.3
Sweden	2.000[2]	2,190[2]	3,100	3.7
Finland	645	750	1,240	5.6
Austria	1,045	-	1,900	5.1
Switzerland	1,550[2]	-	2,450	3.9
Spain	1,230	1,400	2,800	7.1
Portugal	182	200	525	9.2
Yugoslavia	630 (1967)	-	1,700	7.9
Total (rounded off)	45 200		86,400	5.5

[1] at market prices.

[2] estimates.

[3] only approximative values, cf. part B, Section I 1a.

Table 9. Construction. Production (contribution to GDP at factor cost) discounted to 1970 value, potential benefits, application factors and probable economic benefits of four- to-ten-day forecasts.

	Production 1980,[1] discounted to 1970 value in 10^6 u.a. at		Potential benefits % of production value	Potential benefits in u.a.10^6 Discounted at		Expected benefit =50% of potential benefit in u.a. discounted at	
	5%	8%		5%	8%	5%	8%
	1	2	3	4	5	6	7
Germany	9,890	7,450	0.5	49	37	24.5	18.5
France	17,040	12,850	"	85	64	42.5	32
Italy	7,000	5,280	"	35	26	17.5	13
Netherlands	2,210	1,670	"	11	[illegible]	5.5	4
Belgium	1,290	970	"	6.5	5	3.2	2.5
Luxembourg	49	37	"	0.24	0.19	0.12	0.09
United Kingdom	5,160	3,890	"	26	19.5	13	10
Ireland	175	132	"	0.9	0.7	0.4	0.3
Denmark	1,170	880	"	6	4.5	3	2
Norway	645	485	"	3	2.5	1.5	1
Sweden	1,900	1,435	"	9.5	7	4.5	3.5
Finland	760	575	"	4	3	2	1.5
Austria	1,170	880	"	6	4.5	3	2
Switzerland	1,500	1,130	"	7.5	5.5	4	3
Spain	1,720	1,300	0.2	3.5	2.5	2	1
Portugal	320	245	0.3	1	0.75	0.5	0.4
Yugoslavia	1,040	790	0.5	5	4	2.5	2
Total	53,040	40,000		260	195	130	97

[1] Only approximative values, cf. part B, sector I 1a

Since data for sufficient differentiation are not available in the majority of the countries concerned, the group decided to apply a uniform factor of 50% to all potential benefit figures.

The expected economic value of medium-range forecasts for the construction industry thus boils down to, very roughly, u.a. 100 million per year - somewhat less than 100 at an 8% discounting rate and 130 at 5%.

The group contacted three different research and consultancy services in this industry and tried to find out whether it would be possible to measure benefits also by a complementary decision model approach[1]. Discussion of this problem showed, however, that a realistic series of simulations would involve a great deal of additional time (nine months) and money.

3. Energy

Not being in the position to treat the energy sector as a whole, the group decided to focus its attention on two important activities :

- electricity, and more particularly hydroelectricity production, which at the same time accounts for a substantial proportion of water resources management.
- gas production and distribution

Some remarks on the need of forecasts for energy in general are given in section c.

a) Hydroelectricity production and distribution

(aa) Sector's interest in medium-range forecasts

Electricity producers and distributors having hydroelectric power stations are interested in medium-range weather forecasts for two reasons. Firstly, hydroelectric power generation is dependent on the amount of water available, which itself depends on storage capacity and atmospheric parameters. Secondly, consumer demand also varies with weather conditions, especially demand for heating and lighting purposes.

According to the questionnaire replies, forecasts of rain, heavy rains and snow would be very welcome, permitting better management of water reservoirs ; temperature, sunshine and wind are considered important because they influence snow-melting (more water !) and, at the same time, consumer demand. Other important elements mentioned are height of snow line and radiation energy (water economy) and luminosity (consumer's demand).

---

[1] Of the type mentioned by A. Russo in "The Economic impact of weather on the construction industry of the United States". American Meteorological Society Bulletin. Vol. 47, No 12, Dec. 1966, p. 971.

In all the countries contacted, the information would be used to obtain maximum (medium-range) water power production, which is cheaper than steam-generator electricity, or imports. "If substantial rain can be expected, it is better to draw heavily on water resources in the reservoir instead of stocking more and more water and then having to open the sluices in order to avoid inundations" (Spanish answer confirmed by interviews in Sweden and Italy).

"The EDF's major requirements in meteorological information cannot be satisfied merely by the collection and dissemination of primary observation data; it must also have forecasts, the compilation of which will call for a huge amount of basic and aplied research..... Meteorological forecasts affecting energy production concern hydroelectric power above all". (France)

Norwegian producers would be in a better position to make use of plants with only small reservoirs ; they would let Sweden know that cheap hydroelectricity would be available and would pass the same information to the paper industry, which would then buy electricity rather than fuel oil for its steam boilers (oil being, at normal proces, cheaper). Medium-rage forecasts would also help to reduce the number of consumption restrictions which sometimes are still necessary today.

Comparison of replies concerning the economic benefit of the forecasts probably provided and the benefit of forecasts which would fully meet the customers' requirements proves worthwhile when the "utility percentages" have to be chosen.

Table 10. Hydroelectric power generation. Estimated net value of 4-10-day forecasts in % of hydroelectric production

	Forecasts as proposed	Forecasts that would entirely meet customers requirements
Yugoslavia	0.2	same figure
Switzerland	(see page 36) 2 cases: interesting, but no figure	
Sweden	1) 0.05 - 0.15 2) 0.15	"still more" more than 10%
Norway	1) 0.03 -0.1(?) 2) 0.015-0.085 = 10% of value if forecast were given with all the desired precision	same figure 0.15 - 0.85
Spain	1) less than 1[1] (value of a very precise 24 h forecast and fairly good forecasts for seven consecutive days: 1%)	same figure
	2) - 0.5 -2	same figure
Italy	0.02 - 0.2	same figure

Once we realise that the rather high (but judiciously arrived at) estimates for Spain have been made for very precise estimates and when we take account of the fact that one Swedish reply makes a substantial difference in relative usefulness between the two types of forecasts compared, it seems reasonable to adopt a percentage of about 0.1.

[1] In % of total production (including thermal power)

It is interesting to note that an interview in Belgium concerning the utility of medium-range forecasts for thermal power production and distribution showed that such forecasts might help in better dispatching, and in weekly planning of maintenance operations. Benefits in this case were estimated at 0.02–0.1% of production value. Since hydroelectricpower stations accumulate profits from better water resources management and distribution effects, the lower Belgian figure seems quite plausible.

ab) Production - actual and growth prospects

In 1969, the corrected hydroelectricity production of the COST countries totalled about 330 TWh[1] (compared with roughly 200 TWh ten years earlier). Its share in total electricity generation varies widely - from 90 - 100% in Norway, Switzerland and Portugal, 40 - 50% in Italy, France and Spain, to less than 10% in Germany, in the U.K. and practically zero in Belgium, Netherlands and Denmark.

Since many countries have already developed what from an economic standpoint is the most worthwhile part of their water resources potential, the future growth of hydroelectric production will be slower than in the past. Estimates extrapolating plans known up to 1974 total about 450 TWh for 1980[2].

ac) Potential and expected benefits of medium-range weather forecasts. On the basis of probable production in 1980, the economic value of four-to-ten day forecasts will be derived as follows:

- calculation of additional production rendered possible by forecasts - in TWh
- estimation of the corresponding figures in u.a. terms
- application of a benefit realization coefficient to allow for only partial use of the information.

---

1) 1 TWh = 10^9 kwh

2) Very provisional figures kindly furnished by EEC and OECD departments concerned with electricity. These data must not be considered as official estimates.

Table 11.

Hydroelic power generation: Production, potential and expected benefits of 4-10-day weather forecasts.

	Production at average hydraulicity conditions 1969 TWh	1980[1] forecast TWh	Potential benefits $\frac{0.1}{100}$ x COL (2) x 0.8 cents/KWh 1000 u.a.	in 1000 u.a. discounted to 1970 value 5%	8%	Expected benefits in 1000 u.a. ≈ 90% of potential benefit discounted at 1970 value rounded off 5%	8%
	1	2	3	4	5	6	7
Germany	16.5	21	168	103	78	95	70
France	52.9	64	512	314	237	280	210
Italy	44.6	55	440	270	204	240	180
Netherlands	-	-		-			
Belgium	0.24	1	8	5	3.7	4.5	3.5
Luxembourg	0.94	1.1	9	5.5	4.2	5	4
United Kingdom	5.2	5.2	42	26	19	23	17
Ireland	0.71	0.7	6	3.5	2.7	3	2.5
Denmark	0	0	0	0	0	0	0
Norway	58.8	95.4	763	468	353	420	320
Sweden	51.1	66.5	532	327	246	295	220
Finland	10.1	13.4	107	66	50	60	45
Austria	19.7	27.3	218	134	100	120	90
Switzerland	29.0	34.0	272	167	126	150	115
Spain	30.2	39.1	313	192	145	170	130
Portugal	6.2	12.4	99	61	46	55	40
Yugoslavia	11.8[1]	16	128	79	59	70	55
Total (rounded off)	338	452	3620	2220	1675	1990 ≈2000	1500

[1] only approximative values, cf. part B, Section I 1a

[2] times 1968 production.

Additional production due to medium-range forecasts is obtained by multiplying expected production in 1980 with the 0.1% we expect power station managers to gain. For the COST countries as a whole, this amounts to about 0.5 TWh.

In order to obtain the corresponding u.a. equivalent, hypotheses have to be made concerning the price which power stations can obtain for the additional quantities offered. Here the group decided to apply in the case of all countries the relatively cheap tariff figure for the main water power producers (Norway, Sweden), i.e. about 0.8 cents/KWh. (By way of comparison, the average price in the Community countries in 1968 was 1.7 cents for high voltage and 3.8 cents for low voltage in the public distribution system. These are, however, average prices in which the proportion accounted for by thermal power generation is by far the greatest). The result is about u.a. 3.5 million for 1980.

Since costs involved in additional production are negligible, this figure can be considered as a net potential profit. Discounted to the 1970 value, it comes down to u.a. 1.6-2.2 million. Since elctricity production and distribution is managed by one or relatively few very well-organized companies in all the countries concerned, application coefficients given in the questionnaires are all 100% or very near that figure. As regards Switzerland, the operation system of electricity power organization is somewhat different from those in other countries. Replies to questionnaires indicate the necessity of preliminary studies, before quantitative estimates can be expected. Since it seems too optimistic to assume that there is full benefit realization everywhere, the group applied a 90% rate to all countries.

Expected benefits to the sector concerned may thus attain about u.a. 1.5-2 million per year for the whole area considered (1970 value).

(b) Gas production and distribution

At the time the report had bo be written, ony three replies to questionnaires concerning gas were available. All three indicated interest in information on temperature, rain and wind speed, these parameters influencing final demand. One reply stressed importance of snow and fog.

One of the answers stemmed from a country which has given up production and buys all gas from a neighbouring country. It thus sees practically no interest in four-to-ten day forecasts which seem too far ahead for day to day management and not far enough ahead for other planning. The replies from the other two

countries consider medium-range forecasts as valuable because "they permit the prediction of gas send-out and the planning of special maintenance operations" and because they would allow more economic use of storage and distribution plant and optimisation of the purchase of natural gas. According to one reply[1], this might mean an economy of about 350,000 u.a. in present conditions (hundred percent application, gas industry being unified).

The figure given may at the same time be representative for 1980 benefit at 1970 value : if gas production and consumption continues to grow by about 5% per year as it did during the period 1958-1969, an actual-value factor of 5% will bring the 1980 forecast to about the present value of production. At 8% discount, the figure is reduced to approximately 250,000 u.a. per year.

Supposing that similar economies would be possible in other countries, an extrapolation of growth rates of gas production 1958-1969 until 1980, combined with the ratio economies/production in the country for which this value is available,[1] would give, for all COST countries together, expected benefits (100% application) of 2 million u.a. ($\pm$ 0.3 according to the dicount factor applied) per year at 1970 value.

c) Some remarks on the need of forecasts for energy in general

The group was of the opinion that the overall benefits in the different energy production fields (atomic energy included) will be much more substantial if four-to-ten-day forecasts are used. This is due to the fact that each meteorological situation, corresponds to a specific distribution of temperatures, insolation, winds and precipitations. There are many possible ways and combinations for supplying the amount of energy needed, some of them being more economic than others.

Such planning is not possible at the present time, but several countries are conducting research in this field to develop mathematical models where meteorological information is one of the main parameters

---

1) Only one country gave a value.

2) Average gas prices, e.g. in most member countries of EEC and in U.K. do not differ very much.

4. Transport

In the field of transport, medium-range forecasts hold out a promise of considerable benefits to ship-routeing, ice-breaking in the Baltic Sea, inland waterway transport and even pleasure boating on lakes, but fewer advantages for air, road and rail transport.

(a) Ship-routeing and ice-breaking

"Natural conditions such as wind, seaway, ocean current, cloud and icebergs still have a marked influence, in this technical age, on the profitability of deep-sea voyages. The weather as a blanket concept affects the travelling time, fuel consumption, and safety of passengers, crew, vessel and cargo.

For these reasons, a number of marine meteorology and hydrographic services in the world are concerned to develop methods for determining optimum ocean routes. By this is meant routes involving the shortest travelling time which can be worked out having regard to the aforementioned natural conditions which are to be expected throughout the passage. Here it is not at all a matter of determining the shortest route in absolute terms but of choosing the shortest among all those routes which offer a certain degree of safety, profitability, etc..

In the USA, a method of determing optimum routes was developed at the end of the 50s which made use in particular of the relationship between the vessel speed and the seaway (height and direction of forward movement of waves). This method suffers in practice at the present time from the fact that it presupposes the existence of six-to-eight-day seaway forecast charts, which are as yet not yet available to us. Other techniques in addition to the US method outlined above are necessary[1]."

Questionnaire replies from Norway, the United Kingdom, Italy and Germany revealed interest among shippers in most atmospheric parameters. It was added, however, tha ECMW's forecasts ought to furnish more information on the state of the sea - height and direction of waves and swells, wind speed and direction. The forecasts would be used to secure savings in travelling time, or to avoid damage by choosing a faster or safer route, the arrival time could also be communicated earlier or with more precision to those responsible for unloading at the port of destination, a possibility which also represents money value, since dockage is very costly. Finally, weather forecasts would even be used for better planning of maintenance work on board. According to two sources of information, one hour's travelling time saved with an average-sized ship represents economies of u.a. 100-140.

[1] H. Kruhl, Deutscher Wetterdienst, Seewetteramt, in a paper entitled "Transatlantische Routenempfehlungen", dated 17 October 1968.

The German ship-routeing service in Hamburg[1] stated that econonomies due to routeing of nearly 400 transatlantic trips in 1970 are estimated at about u.a. 0.4-0-5 million.

If ECMW could furnish six-to-eight-day forecasts charts of "the North Atlantic surface pressure field and upper-air pressure field and seaway forecasting charts for the North Atlantic area", with the precision of present 24-hour forecasts, this would increase the average time saved from the present eight hour to at least 15 hours. Since ECMW's forecast for the sixth day is in fact supposed to be less precise, i.e., corresponding to present forecasts for the second day, the Group thought the gain might only be about half as great : the economic benefit accruing to German ship-routeing would thus be, in present conditions, about u.a. 0.2 million per year. This figure only represents time saved. In reality, there will be further economies due to damage avoided[2].

During recent years, weather routeing services have been set-up in several other European countries, the U.K., the Netherlands, Norway; the activities of the German Seewetteramt Hamburg, in this field are rapidly expanding - 250 routeings in 1968, 392 in 1970. In these conditions, it seems safe to assume that even if an 8% discount is applied, the 1970 equivalent of ECMW's services to German ship-routeing is at least worth u.a. 0.5 million net, (on the assumption that the necessary funds for the expansion of the ship-routeing service itself will be granted).

Supposing that in 1980, other European countries will have weather-routeing boards achieving about the same rate of activity (compared with the total number of vessels existing) and enjoying the same success as in Germany, this may well permit total economies of about u.a. 5-6 million/year for all the COST countries combined.

Icebreaking. During winter, Finland and Sweden have to use ice-breakers in order to maintain shipping in the Gulfs of Bothnia and Finland.

---

1) If an 8h saving currently affords savings of u.a. 0.4 -0.5 million additional 4h means additional economies of 0.2 million u.a.

2) According to Allen as quoted by Maunder (p.118), special studies have shown that the threat of severe damage from the weather has been reduced by 46% for vessels using recommended routes.

Two government departments responsible for ice-breaking operations were keenly interested in ECMW. "The planning of icebreaker operations is normally made about four days in advance, and the same length of the planning period is approximately valid for the closing and opening of the harbours and the restrictions on the sea traffic due to severe ice conditions, therefore improved 4-10 day forecasts would be most important[1)].

Information on temperature, wind (which drives ice), fog (visibility) and snow and on waves, ice and ice formation on ships would be particularly beneficial. It would be used for the strategic positioning of the ice-breakers, for better working on ships, and to cut down number of idle days on board and in port and reduce damage.

---

1) Abstract by Mr D.Söderman, Finland.

Table 12: Transport. Estimated benefits of 4-10 day forecasts for ship-routeing and ice-breaking

	Merchant fleet on 1 July 1969 1000 gross registered tons	Estimated expected benefits resulting from	
		better ship-routeing in 1980 discounted to 1970 value (8%) u.a. 10^6/year	better planning of ice-breaking discounted to 1970 value (at 5%) u.a. 10^6/year
Germany	7,027	0.5	
France	5,962	0.4	
Italy	7,038	0.5	
Netherlands	5,255	0.4	
Belgium	1,052	0.1	
Luxembourg	-	-	
United Kingdom	23,844	1.5	
Ireland	164	0	
Denmark	3,490	0.2	
Norway	19,679	1.5	
Sweden	5,029	0.4	1.5-2
Finland	1,330	0.1	1
Austria	-	-	
Switzerland	193	0	
Spain	3,199	0.2	
Portugal	825	0.05	
Yugoslavia	1,428	0.1	
	85,515	6	2-3

Sources : Col. OSCE: Statistiques de base de la Communauté 1970, p. 72
and UN Statistical Yearbook 1969, p.396.

Estimates of the economic benefits of four-to-ten-day forecasts were furnished for Finland. According to the specialist interviewed, such forecasts would reduce by at least 10% the obnoxious effects of bad weather and difficult ice conditions on the bulk of Finnish exports and imports. Very detailed studies made over a period of several years indicated that the extent of such bad effects amounts to about 30 million Finnmarks for the whole country, so that the benefits accruing from medium-range forecasts would reach 3,000,000 Finnmarks or about u.a. 0.7 million per year (10% of the 30 million Finnmarks in question).

According to the same specialist, ECMW's services would furthermore permit a reduction of direct ice damage to ships by at least 50%, thus giving an additional benefit of 1,000,000 Finnmarks or about u.a. 0.25 million. The total economic value of four-to-ten-day forecasts would thus attain about u.a. 1,000,000 per year for ice-breaking in Finland alone. The group considered this figure as being also representative of benefits in 1980 discounted to 1970 equivalent at a 5% interest rate [1) 2)].

Since no direct information was available for Sweden, an attempt was made to transfer the Finnish result. Taking account of two factors, namely that the volume of Swedish shipping is three to four times as large as that of Finland's, and that in normal winters only a certain amount - albeit substantial - of activity in Swedish ports is hampered by ice, it seemed acceptable to rate Sweden's possible benefits at one and a half to twice that value for Finland, i.e.u.a. 1,5-2 million per year. The group is aware that this may be the most summary estimate of all the figures given in the report.

---

1) Expected growth of national product will be about 4.5% year

2) In table 13, benefits are discounted at 8%, which gives a total of about 0,8 million u.a. per year.

b) Inland waterway transport

Questionnaire replies were obtained for

- Rhine shipping (four replies from the Netherlands)
- wood-rafting and pleasure boating in Finland.

Rhine shippers are interested in four-to-ten-day forecasts of water height at different places, and of all kinds of precipitation for their influence on water height - especially rain in Switzerland and Germany. Ice and fog forecasts would also be appreciated. The main use would be in planning the loaded draught (height of water, precipitation) and in preliminary safety measures (fog). Ice forecasts are in general, more interesting for other inland waterways : when ice is possible, shippers may decide to choose another route, not to approach certain harbours or refuse cargo altogether. Carrying companies might, in the case of ice forecasts, decide to employ rail or road transport instead.

Benefits were estimated at "0.5% on the average", at nearly one per cent" and even at "2%" of turnover or value of production. On the basis of information on the turnover and share in the market of the firms interviewed, application of the most cautious benefit percentage (0.5) and a result application factor of 0.9 yields, for the Netherlands alone, economies in Rhine shipping of nearly u.a. 2,000,000 per year.

Wood-rafting in Finland seems to profit mostly from short-range forecasting, but a marginal interest in four-to-ten-day forecasts was expressed.

A large pleasure-boating society (great lake) in the same country looks forward very much to ECMW's services, which would enable it to plan tours better, step up advertising or adjust the subject-matter of its publicity. The expected rise in number of passengers carried may mean a net increase of revenue of about 10%. Forecast application probably being high (perhaps about 80%), the total benefit for the entire Finnish pleasure boating (passenger tours) sector would approcimate to u.a. 0,05 million per year.

c).

Other forms of transport

c 1)

For railway transport, enquiries in Switzerland and Sweden showed moderate interest in medium-range forecasts. Knowledge of future temperatures (especially below freezing point or above 30°C), heavy rains, wind, fog, and freezing of the sea and danger of avalanches would make it possible to adjust building operations, mobilize manpower and equipment to clear away snow or fallen trees, arrange alternative coach services, assist planning of marshalling (which has to be done in fog-free stations) and make preparations for putting on extra services along the coast- (when the frozen sea makes shipping impossible - case of Sweden). In one case, ECMW's services were said to afford savings amounting to 0.16% of the turnover. Since the group had the impression that the suppliers of this information expected forecasts to be more precise than promised and since the information takes account of repercussions on building activities (which are dealt with elsewhere), it was not possible to work out a benefit-value estimate for the whole of the sector[1].

c 2)

In road transport, atmospheric conditions can influence the safety of persons and material transported, the quality of goods being carried, and the time required to reach the point of destination. In addition, they may cause a deterioration of material during rest periods. Some of the possible measures are left to private initiative, some are a task of public services (road maintenance, snow clearing, salting, etc.).

No special enquiry was mad into possible repercussions of forecasts on safety of road users. Official statistics attribute only a slight proportion of trafic accidents to weather influence (6% in Germany, 10% in Switzerland if road conditions are included)[2]. Indeed, as long as some people do not heed existing weather conditions, it seems premature to speculate about beneficial effects of four-to-ten-day forecasts. It may be said, however, that individuals could sometimes make use of medium-range forecasts to keep off the road in bad weather conditions (holiday planning).

---

1) A firm transporting fruit and vegetables by rail (sometimes the journey takes 4-5 days) thought that 4-10-day weather forecasts might help avoid losses due to extreme temperatures (one wagon-load of tomatoes completely spoilt means u.a. 8-9000 lost. For this firm economic benefits could average 0.1-0.3% of the turnover. But here again, the interest of medium-rang forecasts is bound up with benefits from short-range forecasts.

2) The Group is conscious of the problematical nature of these statistics.

Concerning other points, the rather disparate replies to questionnaires may be simmarized briefly as follows. Though the representative of a transporters federation saw many possible applications for medium-range forecasts- protecting the goods, choosing the right type of truck, the right outfit and a good driver in case of snow forecasts, driving without a trailer - measures which might permit savings of time and avoid damage to trucks and goods transported, several firms contacted were rather sceptical : "Truck drivers stick to the way they know, and if the weather gets too bad, they just stop and wait until conditions get better." This may just be one way to achieve a high degree of safety.

The attitude of a major body responsible for public passenger transport was positive :four-to-ten-day forecasts might be of value for better maintenance planning (frost protection measures at the beginning of winter). Another passenger car service firm, however, showed little interest, saying it would need forecasts with much more regional detail.

Local authorities responsible for street maintenance could be helped by ECMW to achieve some economies in road-clearing, namely by alerting extra crews when heavy snowfalls are expected, and in salting (cost, damage to cars and concrete),

The replies received did not enable the Group to make any statistical estimate of the benefits to the sector concerned.

Contacts with bodies responsible have shown that these bodies are mainly interested in short-range forecasting.

c 3)
Air transport . The interviews that took place with representatives of three airlines did not indicate much interest in 4-10 day forecasts. Aircraft operations and planning depend much more on short-term forecasts . Airport maintenance authorities would require greater precision in 4-10-day forecasts for snow clearance than appears attainable from ECMW products in the foreseeable future.

5. Water supply

The benefit offered by four-to-ten-day forecasts to management of water resources used in hydroelectric power generation has already been mentioned in section 3, "Energy".

Another important aspect is water supply for irrigation in the southern

countries[1]. Contacts with two responsible bodies in Mediterranean France and information from Portugal showed that four-to-ten-day forecasts of temperature and all kinds of precipitation would be much appreciated for planning of operations. A money value estimate for such information could not, however, be obtained.

The problem of urban water supply has scarcely been dealt with. According to an interview held in Spain, medium-range forecasts could be used to inform the consumers of possible water restrictions well in advance.

6. Protection against natural disasters

Most of the information so far given here concerned business sectors. However ECMW forecasts might be of considerable social value in another sector: in protection against natural disasters.

Under this head, some information was collected on

- atmospheric phenomena of particular violence or danger, though not necessarily of catastrophic dimensions : conditions inducing forest fires, avalanches
- natural disasters : inunadations, floods.

a) Forest fires, avalanches

Replies concerning warnings of avalanches leave the impression that four-to-ten-day forecasts will not be precise enough to offer advantages for such operations. The case of forest-fire protection is somewhat more interesting (interviews in Sweden and Switzerland).

In COST countries, forest fires cause annual losses of the order of several million u.a. Meteorological influence is direct - lightning (about one-third of total surface burnt in Sweden) but negligible in Community countries - and indirect - according to information from Sweden, the danger of fire(from all other sources) seems to be inversely proportional to the air humidity, the spread of fires being fostered by strong winds. Services responsible for fire vigilance are thus interested in forecasts of thunderstorms, rain, air moisture and wind. Four-to-ten-day forecasts would afford better information to the public and better planning of surveillance in Sweden and France. "Airborne patrolling covers regularly some 77% of Swedish forests. Costs km^2 are roughly S.Kr. 5[2]. Medium-range forecasts might afford 10% economies in patrolling, which means about u.a. 1,000/year(Sweden).

---

[1] COST countries have about 6,000,000 ha irrigated arable land and land under permanent crop, Italy, Spain and Portugal account for about 90% of this figure.

[2] Statens Brandinspektion. Meddelandum. 1970 : 8, p.2

(b) Floods, inundations

In 1953, a stormsurge "flooded 540 sq km of highly populated land and drowned 1800 people"[1] in the Netherlands ; it caused about 300 deaths and £ 30 million worth of damage in the UK[2].

In 1962, a similar event left hundreds of dead in Hamburg (but one dead only in Schleswig Holstein[3]. A list of major inundations in Italy during the period 1953-1968 enumerates 12 cases[4].

Floods such as those in 1953 owe their catastrophic effects to the fact that they occur extremely seldom, i.e., once in a hundred or several hundred years. River inundations, on the other hand, are relatively frequent, especially in the Mediterranean Zone.

The group thinks that ECMW's four-to-ten day forecasts may, when integrated into existing flood forecasting systems, prove a valuable aid in the organization of civil defence in the event of flooding danger and thus contribute to the reduction of losses.

---

1) P.J. Wemersfelder. Fighting Floods and stormsurges in the Netherlands. In : Committee on the Challenges of Modern Society- Disaster Assistance (Flood mitigation), No.2, p. 39-7.

2) G. Cole. London and East Coast Tidal Flood Warning System. Ibid., p. 41-1.

3) Questionnaire information.

4) Histoire et types d'alluvions en Italie pour la période 1951-1968, Ibid., p. 32-1

7. Other sectors and activities

a) Food merchandising

At a fairly advanced stage in this study, a conference of European food distributors in Switzerland enabled some information on this branch to be collected. Many, though not all, of the firms contacted believed that ECMW's forecast could be of economic value. Percentages advanced were about 0,1 - 0,2% of tunover, the average application factors given being approximately 50%.

Extrapolation of results based mainly on Austria and Switzerland to all the seventeen countries (gross value added being considered as the sector's products), yields expected benefits of about 8-16 million u.a. at 5% and about 6-12 million at 8% discount rate.

b) Further sectors

A complete study would have to consider many other sectors : fishing (particularly in the case of Norway, Denmark, Spain and Portugal), coal and oil for heating, several manufacturing industries (e.g. textiles) to a certain extent construction materials, non food merchandising interests e.g., in using four-to-ten-day forecasts for the right timing of advertising campaigns ; tourism and associated services (car garages, etc.), organizers of open-air events like important football matches, horse races and ski competitions[1], municipal bodies responsible for water supply and pollution control. Last but not least, all households could profit from a better knowledge of future weather.

Indeed, research on interactions between the atmosphere and the biosphere may, in the course of the coming 10-20 years, disclose many further possible benefits from four-to-ten-day weather forecasts, since "the effects of weather variations are perhaps the least understood of all the factors which influence our economy[2]".

---

1) Interest confirmed by an interview with organizers in a Swiss ski resort.

2) Maunder, op.cit.,p.146

III Additional benefits from forecasts meeting user requirements entirely

The benefits so far examined here concerned forecasts of a type where information given for the sixth day would roughly correspond to the characteristics of the actual forecasts for the second day.

In order to dertermine what economic benefit might be expected from still better forecasts, the questionnaire asked the parties concerned to give a value estimate for a sixth-day forecast that would meet requirements entirely. Some of the interviewees were not in a position to answer. Many said it would not make a great deal of difference. In agriculture, however, higher benefit ratios were indicated in about a quarter of the replies. Time did not permit to go into this matter in depth.

IV Probability in weather forecasts

Most interviewees wanted probabilities included in the forecasts. Some questionnaire replies have shown however, that the significance of a probability factor was not always fully understood.

In weather risk situations, users should have the chance to balance the costs of potential protection against the losses caused by adverse weather. The optimum decision can only be made if weather forecasts incorporate a probability factor.

By way of illustration, the following example shall be considered : Losses caused by rain, snow or temperature excesses, etc. amount to 10,000 u.a. On the other hand, protection costs may be 1,000 u.a. for one occasion. The right decision for this case would be to employ protection if the risk probability exceeds 10%. To employ protection if the risk probability falls below 10% would be wasteful, not to employ protection if the risk probability exceeds 10% would be careless.

V Frequency of forecasts

The group wanted to know whether users need four-to-ten-day forecasts issued every day, or whether three to four new bulletins per week would be sufficient. The replies may be summarized by saying that if forecasts were given on Friday, Monday and Wednesday, most customers would be satisfied.

VI Trends towards more weather independance ?

Theoretical possibilities of reducing weather influence exist in many sectors : use of glasshouses in agriculture heating railway points or streets in transport systems, building railway tunnels against avalanches, pushing instead of rafting in Finland ; in Sweden, the question was even raised whether it would not be economic to replace winter coast shipping, which needs ice-breakers, by railway transport. In most cases, however, these possibilities involve too much expense. Practical consequences may be expected from the development of more highly resistant plants in agriculture, the gradual shift to nuclear energy in electricity production, and better adaptation to winter work conditions in construction (though there was still some scepticism concerning this point - despite impressive performance in Sweden). On the other hand, ship-routeing may become still more important for the bigger and faster ships which are to be built.[1] To sum up, the Group does not think that the weather-dependence of the operations analysed will be much lower in 1980 than at present.

VII Necessity of forecast application

Expected benefits have been based on a 50% forecast application hypothesis for the two most important sectors considered. This rate may seem high to some, low to others ; questionnaire replies varied widely and were not in fact a very great help in this problem.

In any case, the group wishes to stress that to increase the benefit from application of these forecasts to the European Economy by about 1980, ECMW and the National Meteorological Services would have to make a substantial effort not only to provide efficient medium-range forecasts for users but also to see that the results are applied. This may be done, for example, by permanent contacts with training facilities, research stations and producers federations in the branches concerned, as well as by direct advice to selected firms, which might then initiate an imitation process in the neighbourhood or region, not to mention governmental bodies.

[1] In bad weather conditions, ships have to slow down to about 15 knots. The relative time loss is greater for fast vessels.

C. Benefits to be expected from other ECMW services

Apart from medium-range forecasting, ECMW would carry out research in medium-range forecasts, it would offer special services to National Meteorological Institutes in the form of spare computer capacity (about 1/3), and it would perform data bank functions and develop training activities.

A detailed description of these other tasks, together with the most important information on benefits expected, was given by the First Study Group in its report, dated 5 May 1971 (Doc. COST/65/71). All these other services would contribute directly (research, free computer capacity) or indirectly (training, data bank) to the economic benefits from medium- and short-range forecasts. Certain information services may also be very valuable for climatology. For planning, viz. estimating risks and coming to decisions, climatological probabilities are often very useful. Such information consists of frequency distribution of single quantities, combined distributions of two or more quantities (e.g., temperature and wind, or temperature, humidity and sunshine, etc.) the probability of uninterrupted runs (duration in time) of different length above or below critical values, etc. Suitable information of that kind is sparse, because most countries lack the resources (computer, personnel, finance) to extract this information from the basic data.

Since problems are the same everywhere, with central organization and enough computer-capacity a set of routine programmes could fulfil all countries' requirements much more cheaply and much faster than the national services could. This would also be an appropriate way of using spare computer capacities in the operation of the centre. The economic importance of such information with respect to construction, and especially to the heating and ventilating industry, is significant.

Better medium-range forecasts must necessarily entail better short-range forecasts, and the special services offered will allow national institutes to treat computer problems beyond their resources, such as research into the dynamics of small-scale systems.

For the smaller countries, training and temporary association with ECMW research staff may be the only way of keeping actively abreast of progress in numerical weather forecasting. For larger nations, these other activities will in any case facilitate subsequent application and interpretation of ECMW's output.

For all member countries, "other activities" mean savings in time and resources.

D. Conclusion

The preceding analysis has shown that the creation of ECMW gives promise of very substantial economic and social benefits. Assuming only 50% application of ECMW forecasts in the most important sectors (agriculture and construction), the economic value of 4-10-day forecasts in the quantitatively investigated sectors[1] adds up to about 400 to 450 million u.a. in 1980, for all the COST countries combined. This corresponds to a present value (1970) of about 200 million u.a. per year at 8% discount rate, or about 260 million at a rate of 5%/year.

Table 13: Synthesis. Benefits to be expected from four-to-ten-day weather forecasts in 1980, discounted to 1970 value with an interest rate of 8% - in u.a. million

	Agriculture	Construction	Energy: Hydro-electr. production	Energy: Gas product. & distribution	Transport: Ship-routeing	Transport: Ice-breaking	Transport: Inland waterways	Other sectors: Food distribution	Total quantified
Germany	6.5-9	18.5	0.07		0.5				
France	15-20	32	0.2		0.4				
Italy	20-26	13	0.2		0.5				
Netherlands	2-2.8	4			0.4		1.5		
Belgium	1-1.5	2.5	0		0.1				
Luxembourg	0.04-0.05	0.1	0		-				
United Kingdom	3-4	10	0		(1.5)				
Ireland	0.4-0.5	0.3	0		0				
Denmark	0.4-0.5	2	0		0.2				
Norway	0.4	1	0.3	≈2	1.5			9±3	
Sweden	0.7-1	3.5	0.2		0.4	1-1.5			
Finland	0.5-0.6	1.5	0.05		0.1	0.8	(0.05)		
Austria	0.6-1.1	2	0.1		-				
Switzerland	0.6-1.1	3	0.1		0				
Spain	9.5-13	1	0.1		0.2				
Portugal	1.7-2.4	0.4	0.04		0.05				
Yugoslavia	2.5-3.5	2	0.06		0.1				
Tot. (rounded off)	65-90	100	1.5	≈2	6	2	≈1.5	9± 3	≈ 200

1) The group thinks that simple adding up is permissible for the sectors considered.

Additional benefits would accrue in other business sectors such as fishing and non-food merchandizing,tourism, and in public services such as water supply and - last but not least - protection against natural disasters. To these effects must be added the less immediate repercussions of ECMW's other activities - research, data bank functions, special services to National Meteorological Centres, and training.

Annex I

Sector selection procedure
(Business sectors)

Sectors were finally chosen by a procedure used by White[1)] and adapted to the necessity of dealing with 17 countries. The operation comprised several steps.

1. Compilation of an initial list of business sectors

The group used a list of 13 sectors which R.R. Rapp and R.E. Huschke "adapted from a classification system developed by the US Weather Bureau" (3, p.54). These sectors were:

Agriculture	Construction
Forestry	Recreation industry
	Merchandizing
Commercial fishing	Land transport
Power and fuel supply	Air transport
Water supply	Water transport
Manufacturing	Communications

2. Classification of countries into three climatological zones

Countries were classified as follows

North-western zone (predominantly oceanic climate)	Central zone (European transitional, continental and alpine climate)	Southern zone (largely mediterranean climate)
United Kingdom, Ireland, France Belgium, Netherlands, Denmark, Norway	Germany, Luxembourg, Sweden, Finland, Austria, Switzerland, Yugoslavia	Italy Spain Portugal

The group is conscious of the very considerable simplifications which this classification implies.

1) R.M. White: Weather and the Construction industry. In WMO-WWW Planning Report No. 27, p 31/32

3. Ranking of sectors according to relative weather influence

For each of the three zones, sectors were ranked according to assumed weather influence , taking account of sectors capacity for adaptation.(If there is no way of taking precautions against bad weather, four-to-ten day forecasts are of no use).

Because of the difficulties inherent in this procedure, the results of the initial ranking were then condensed into three categories, namely sectors ranking high (first four to five) intermediate (the following five to seven) and low (the rest).

Table 1: Weather-influence ranking of sectors

Weather influence and precaution-taking capacity	North-Western Zone	Centrale Zone	Southern Zone
High	Fishing Agriculture, water transport, recreation	Construction, land transport, energy production and distribution	Land transport agriculture, water supply energy, fishing
Intermediate	Construction, water supply, merchandizing, land transport, energy production and distribution, air transport	Recreation, agriculture, manufacturing, fishing, water supply, merchandizing, air transportation	Construction, merchandizing, manufacturing, forestry, communications
Low	Manufacturing, forestry, communications	Forestry communications	Water transport, air transport (recreation?)

4. Ranking of sectors according to their economic importance

a) Statistical problems, economic importance of sectors

The economic importance of the different sectors has been measured by its contribution to the gross domestic product. This value is not only the sole production characteristic disposable and comparable for nearly all the countries , it has also the advantage not to depend on the sectors degree of concentration.

OECD tables concerning contributions of different sectors to GDP (time series until 1969) were a valuable source of information, unfortunately published tables contain only eight business sectors : agriculture, forestry and fishing are lumped together, as also are electricity, gas and water, and all kinds of transport and communications are comprised in a single figure. However, copies of the original questionnaires used by OECD, enabled some more details to be gathered for Denmark, Norway, Finland, Spain and Portugal (forestry, fishing, air, land and water transport). For Switzerland, the Swiss delegation furnished a series of data missing from OECD tables. It was practically impossible to find figures corresponding to the term "recreation" in its broad sense. Value added for restaurants and hotels embraces part of this concept, while tourist spending (derived from other sources) reflects another important aspect, the trouble being that in European statistics there is no sector encompassing all production for recreation purposes.

b) Ranking lists

Ranking lists of the different sectors corresponding to their economic importance and based on partial information are shown in the following tables, grouped by climatological zones (Tables 2a, 2b and 2c).

Table 2a: Ranking of sectors according to economic importance:

North-Western Zone

	UK	France	Belgium	Netherlands	Denmark	Norway
	value added basis 1968)	gross value added at factor cost 1965 [1]			contribution to gross domestic product at factor cost 1968	
Manufacturing	1	1	1	1	1	1
Merchandizing	2	2	2	2	2	2
Construction	3	3	3	4	3	4
Agriculture	6	4	4	3	4	5
Energy production and distribution	5	5	5	5	7[2]	6[2]
Recreation : restaurants and hotels	-	(7)	(7)	(9)	-	-
Land transport)		6	6	6	6	7
Communications)	7	8	8	8	8	9
Water transport) (4)		9	5	7	5	3
Forestry))		-	11	-	9	10
Air transport))		10	9	10	6	8
Water supply)(9)	8	11	10	11	-	-
Fishing)		12	13	12	8	11

1) input-output tables, supplemented in the case of forestry by national accounting data for 1969.

2) Electricity, gas and water

Table 2b : Ranking of sectors according to economic importance:

Central Zone

	Germany	Finland	Yugoslavia
Basis:	Contribution to gross.nat. product at factor cost		value of total production
	1967	1969	1966
Manufacturing	1	1	1
Merchandizing	2	2	4
Construction	3	3	3
Agriculture	4	4	2
Energy production and distribution	6[1]	7[2]	6
(Recreation-restaurants, hotels)	(0)	(0)	(0)
Water transport	8	8	)
Land transport)	)	)	)
Air transport)	5	6	5
Communications	7	9	)
Forestry	9	5	0
Water supply	0	0	0
Fishing	10	10	0

1) Electricity, gas and water supply.

2) Included in "energy".

Table 2c: Ranking of sectors according to economic importance

Southern Zone

	Italy	Spain	Portugal
Basis:	Gross value added 1965 basis at factor cost	Contribution to gross domestic product at factor cost	
Manufacturing	1	1	1
Merchandizing	3	3	3
Construction	4	4	4
Agriculture	2	2	2
Energy production and distribution	8	6[1)]	5[1)]
(Recreation-hotels, restaurants)	(6)	(0)	(0)
Land transport	5	7	7
Communications	7	10	11
Water transport	9	11	9
Forestry	-	8	6
Air transport	11	5	8
Water supply	12	0[2)]	
Fishing	10	9	10

1) Electricity, gas and water

2) comprised in energy production and water

5. Elimination sectors ranking low in economic importance or weather sensitivity

This process reduced the number of sectors to the following list: Manufacturing, merchandizing, agriculture, construction, energy, (recreation), land and water transport, and possibly water supply, in the Southern Zone (although the first mentioned items are the most important, this enumeration does not imply any ranking order).

Since manufacturing and merchandizing would first have to be broken down for further analysis, and since no valid statistics exist for recreation, it was decided to concentrate efforts on the following business activities :

- agriculture (excluding, forestry and fishing)
- construction
- land and water transport
- energy (production and distribution), and possibly
- water supply, in the Southern Zone.

When work was already in progress, particularly favourable circumstances - a meeting of European food distributors in Switzerland - made it possible to obtain some results for food merchandizing.

Annex 2

European Cooperation

in the field of

Scientific and Technical Research

ECMW Study Group

on Benefit Analysis

Secretariate

QUESTIONNAIRE

A. Please complete Annexes Ia and Ib as fully as possible.

B. Assuming that there will be 4-10 day weather forecasts, and that the characteristics[1] of these forecasts correspond to those of the following text:

(a) Bright in the morning. Cloudy later with moderate rain in afternoon. Wind light SE at first, becoming strong SW'ly. Maximun temperature 10° C, minimum 5°C.

(b) Fresh easterly winds. Cloudy near east coast, with a little light rain ; sunny periods elsewhere. Maximum temperature 6°C in east ; 10°C in central and western areas. Slight frost inland at night.

1. Would you be interested in these forecasts ?
(Yes - No)

1.1 If not, please give reason :

1.2 Would you like to receive forecasts incorporating a probability factor (e.g., 60% risk of rain, fog, ice, etc.)?

---

[1] Quality of present two-day forecasts in the majority of countries, since beyond the sixth day the accuracy would diminish but would still be better than that of climatological information.

2. What kind of information would be particularly useful to you ?

Forecasts of

	Very important	Useful	Not useful
Temperature			
Frost, glazed frost			
Ice			
Rain			
Thunderstorm			
Hail			
Heavy precipitation			
Snow			
Fog			
Cloud			
Sunshine			
Wind (speed[1], gusts)			
State of the sea			
Others.....			

1) Indicate speed.

3. How would you use this information ?

3.1 Aims
(e.g.: - farmers : avoidance of losses due to rain during harvest ;

- building contractors : avoidance of damage due to frost ;

- road haulage firms : safe transportation of perishable goods, etc).

3.2 Specific measures taken

(e.g. : - farmers : changing of harvest schedule ;

- building contractors : rescheduling of concreting, etc.;
- road haulage firms : changing of equipment, routes or schedule).

4. The measures listed under 3.2 will result in :

- avoidance of production losses, losses of working hours, wastage of equipment, etc. ;
- increased output, and possibly other beneficial effects.

4.1 Please indicate these results as precisely as possible :

4.2 Please try to estimate the monetary value of these effects, if possible as a % of the total value of your production (turnover)[1)]

4.2.1 - gross value, not counting the cost of the specific measures listed under 3.2 :

.....

.... % of value of production

---

1) This will enable us to compare your information with that from other sources and to draw conclusions which would be of use to your branch of activity.

4.2.2 - net value, after deduction of cost of specific measures :

.....

.....% of value of production

(If an exact estimate proves difficult, even a combination of lower and upper limits would be valuable, e.g., "not less than 1% and not more than 5%"or "not less than 0.1 % and not more than 0.9 %.

5. Assuming that the 4-10 day forecasts were issued only every other day, would this affect your reply to the question under 4.2.2 ? If so, in what way and why ?

4.2.2/b. Net value, after deduction of specific measures taken (see 3.2) :

.....

.....% of value of production

6. Others firms in your branch may or may not make use of the 4-10 day forecasts to be provided. If you had to give an estimate, how would you fill out the following table ?

6.1	Fullest possible use of forecasts would be made by firms accounting for	.....%	of total production of your branch
6.2	Partial use (50%) would be made by	.....%	"
6.3	Practically no use would be made by	.....%	"
	All firms	100%	"

C. Assuming that the 6-day forecast can be improved so as to meet your requirements entirely:

- Can you define the limits of your requirements ? (See Para. B2). (Examples : maximum temperature to $\pm$ 2°C, wind gusts greater than 50 knots)

- Can you reply again to the question under 4.2.2. ?

  4.2.2/c. Net value, after deduction of cost of specific measures taken (See 3.2.) :

  .....

  ..... % of value of production

  and also to the following table :

6.1/c Fullest possible use of forecasts would be made by firms accounting for	.....%	of total production of your branch
6.2/c Partial use (50%) would be made by	.....%	"
6.3/c Practically no use would be made by	.....%	"
All firms	100%	

D. Do you envisage any means of reducing, or even of eliminating completely, the influence of the weather in the foreseeable future ? (Examples : by covering a construction project with a plastic tent or an inflatable hood; by using more resistant seeds or plants, etc.)

Annex Ia to Annex 2

(This Annex will only be submitted to the person directly responsible for the questionnaire. Its contents will not be rendered public or divulged to third parties without your written permission).

Place and date :

Person interviewed :

Duty :

Address :

Name of interviewer :

Complete address :

Telephone :

Annex Ib to Annex 2

(This Annex will be treated in absolute confidence. However, it is essential that it be completed and you are asked to reply as fully and as accurately as possible.)

Country : Date :

Field of activity (e.g., agriculture) :

Nature of activity (e.g. stock breeding, wine-growing):

Form of Company :

Gross turnover :

Number of employees :

Importance in the country considered, giving details of criterion adopted (turnover as percentage of national figure for the branch; etc.) :

Annex 3

Study Group on Benefit Analysis
list of members

Messrs	R. Schneider (Chairman)	- Switzerland
	Assistant : P. Valko	
	R.A. Buchanan	- UK
	R. Lombardo	- France
	J.A. Van de Kraats	- Netherlands
	G. Hipp (Secretary and rapporteur)	- Commission of EC
	H. Benzler (Secretary)	- Commission of EC

Consultant : Mr. J.M. Wavre

SALES OFFICES

All reports published by the Commission of the European Communities are on sale at the offices listed below. When ordering, specify clearly the EUR number and the title of the report, which are shown on the internal title page.

OFFICE FOR OFFICIAL PUBLICATIONS OF THE EUROPEAN COMMUNITIES

P.O. Box 1003 - Luxembourg 1 (Compte chèque postal N° 191-90)

BELGIQUE — BELGIË
MONITEUR BELGE
Rue de Louvain, 40-42 - B-1000 Bruxelles
BELGISCH STAATSBLAD
Leuvenseweg 40-42 - B-1000 Brussel

DEUTSCHLAND
VERLAG BUNDESANZEIGER
Postfach 108 006 - D-5 Köln 1

FRANCE
SERVICE DE VENTE EN FRANCE
DES PUBLICATIONS DES
COMMUNAUTÉS EUROPÉENNES
rue Desaix, 26 - F-75 Paris 15e

ITALIA
LIBRERIA DELLO STATO
Piazza G. Verdi, 10 - I-00198 Roma

LUXEMBOURG
OFFICE DES
PUBLICATIONS OFFICIELLES DES
COMMUNAUTÉS EUROPÉENNES
Case Postale 1003 - Luxembourg 1

NEDERLAND
STAATSDRUKKERIJ
en UITGEVERIJBEDRIJF
Christoffel Plantijnstraat - Den Haag

UNITED KINGDOM
H. M. STATIONERY OFFICE
P.O. Box 569 - London S.E.1

Published by the Directorate general for Dissemination of Knowledge
Centre for Information and Documentation — CID
Luxembourg

Price : B.Fr. 100.—