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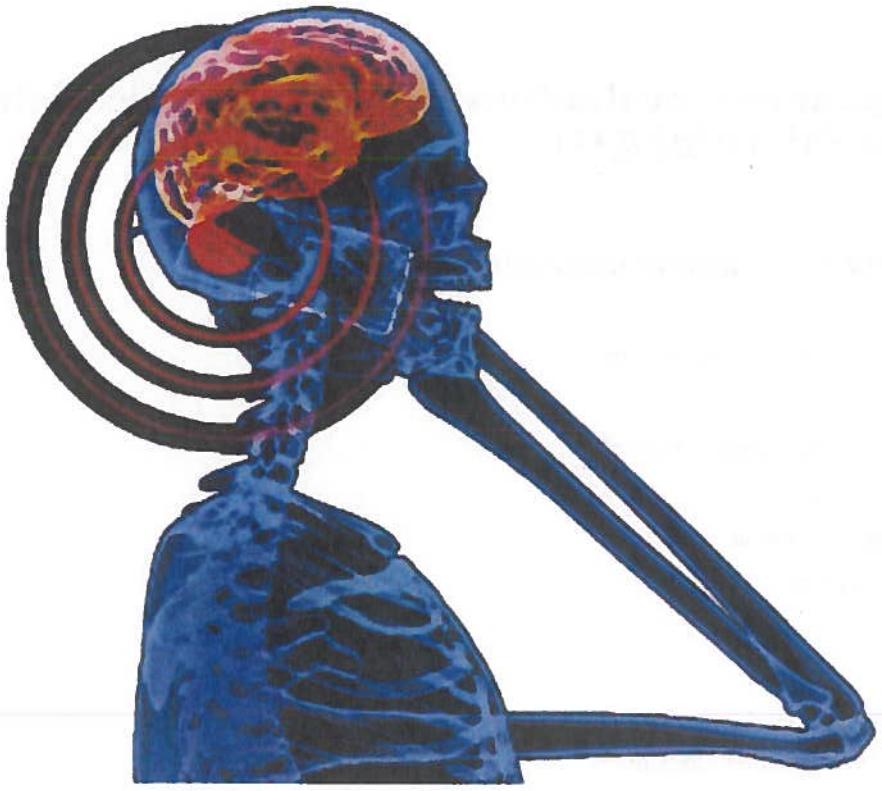
Programme evaluation Electromagnetic Fields & Health (EMF&H)

ZonMw Programme Evaluation



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Programme evaluation Electromagnetic Fields & Health (EMF&H)

ZonMw Programme Evaluation

technopolis |group|, April 2015

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Abbreviations

Abbreviation	Description
DECT	Digital Enhanced Cordless Telecommunications
EHS	Electrohypersensitivity
ELF	Extremely Low Frequency
EMF	Electromagnetic Fields
EMF&H	Electromagnetic Fields & Health
EUR	Erasmus University Rotterdam
GGD	Municipal Health Services (Gemeentelijke Gezondheidsdienst)
GSM	Global System for Mobile communications
IRAS	Institute for Risk Assessment Studies, Utrecht University
KP	Knowledge Platform
LF	Low Frequency
LTE	Long-Term Evolution
Ministry of I&M	Ministry of Infrastructure and the Environment (Ministerie van Infrastructuur en Milieu)
MRI	Magnetic Resonance Imaging
RF	Radio Frequency
RIVM	Netherlands National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu)
RUG	Groningen University
TNO	Netherlands Organisation for Applied Scientific Research (Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek)
TU/e	Eindhoven Technical University
UMTS	Universal Mobile Telecommunications System
UvA	University of Amsterdam
VUA	VU University Amsterdam
Wifi	Wireless Fidelity
WLAN	Wireless Local Area Network
WUR	Wageningen University and Research Centre
ZonMw	Netherlands Organisation for Health Research and Development

Executive summary

Over the last two decades the number of mobile phones in the Netherlands has exploded. Simultaneously, wireless Internet, electronic security gates, and so-called RFID readers have become part of everyday life. Such developments have led to concerns in society about the levels of exposure to electromagnetic fields (EMF) and their potential effects on our health.

In response to these concerns, in 2006 the Dutch government initiated a research programme on electromagnetic fields and health (EMF&H). Its purpose was to strengthen the national capacity for EMF&H research and get a better understanding of potential health impacts. The programme was administered by the Netherlands Organisation for Health Research and Development (ZonMw) and was provided with a budget of € 16.6 million for a period of eight years. In total, it funded 60 research projects in four thematic areas: biology, epidemiology, sociology and technology. As the programme is nearly finished, ZonMw has asked Technopolis Group to conduct an independent programme evaluation to assess to what extent the objectives of the programme were achieved. The evaluation methodology was based on a combination of techniques and data sources, including an online survey, stakeholder interviews, analysis of programme documents and a media analysis.

The evaluation concludes that the programme has successfully attracted many researchers with little to no prior experience in EMF&H research to the field. Around 100 scientists, including dozens of graduate and postgraduate students, have been involved in the research. The programme also has supported development of new scientific equipment and essential research methods. It has brought greater collaboration between research groups, both within the Netherlands and abroad. At least partially due to this funding, some groups are now considered leading in their field and are part of large international EMF&H research consortia. It can certainly be said that, at least in the short-term, the programme has strengthened the Dutch EMF&H research infrastructure.

The long-term sustainability of this infrastructure, however, is in doubt. The evaluation found that most researchers do not intend to continue in this field. They indicated that, at least for now, many of the questions around EMF&H have been sufficiently addressed, or at least they see no new, strong investigative leads. There is also limited funding available to support follow-up research. Therefore many researchers prefer to redirect their attention. One of the steps taken by the programme to increase permanence and anchor the developed infrastructure was to institute three special university chairs, divided over four people. This measure was only partly successful as only two of the three chairs will continue (one in epidemiology and one in technology). While the long-term contribution of the programme to an EMF&H research infrastructure is insecure, one may ask whether there is in fact a need to sustain a large, dedicated infrastructure. Much of the required expertise appears relatively generic so that, if and when needed, additional research can fairly easily be initiated.

The programme has provided several noteworthy insights into potential health impacts from EMF exposure. Some biological studies hint at a possible link between EMF exposure and impacts on the immune system that may warrant further investigation. However, the majority of biological studies found no significant indications to suggest health risks from daily EMF exposure within the recommended limits. Other valuable findings come from studies on occupational exposure, such as experienced by MRI technicians. These studies have contributed to the development of improved MRI safety protocols. Furthermore, sociological studies have provided suggestions on how governments and other parties could improve their risk communication strategies. A number of projects are either still running, or have been concluded but final results are not yet available. The quality of awarded projects was generally reasonable to good, but – notwithstanding their scientific soundness – not all projects were considered of the utmost relevance to scientific or social needs.

The programme did not intend to directly influence public concerns about EMF exposure, but rather to support research that would contribute to clarifying potential health risks. It is difficult to determine whether the programme has nevertheless had any such influence. In national print media or in online sources, there was little mention of the programme or any of the granted projects, making it unlikely that the programme has reached a wider public and made much direct impact. However, with the results of the majority of projects now available, ZonMw could seize the opportunity to reach a broader audience by preparing accessible summary reports on (aspects of) the programme, and – in collaboration with the EMF Knowledge Platform– communicating findings to the media.

Overall conclusion

In conclusion, the programme has made an important contribution to the Dutch infrastructure for EMF&H research, although the long-term sustainability of this infrastructure may prove limited. Likewise, it has contributed to some high quality and important research that has provided valuable new insights in several areas. Without the EMF&H programme, the majority of these projects would almost certainly not have been conducted.

Despite these important contributions, the total yield of the programme is somewhat modest. This is in part a logical consequence of the design of the programme: because of a lack of clear scientific leads for investigation in many areas, at the outset the programme had a fairly broad focus without a well-defined overarching research question. As a result, there was limited connection between individual projects whilst a number of projects were rather small in scale. This means that the statistical power of individual findings is quite low, making it difficult to draw any conclusive answers. Although a justifiable decision at the time, in hindsight it should therefore be concluded that this broad approach has proved a stumbling block to the full realisation of the programme objectives and the programme could have benefitted from greater thematic coherence.

Samenvatting (Nederlands)

In de laatste twee decennia heeft het aantal mobiele telefoons in Nederland een enorme vlucht genomen. Daarnaast zijn draadloos Internet (Wifi), elektronische veiligheidspoortjes en zogenoemde RFID lezers deel gaan uitmaken van ons dagelijks leven. Dit soort ontwikkelingen heeft geleid tot zorgen in de samenleving omtrent de dagelijkse blootstelling aan elektromagnetische velden (EMV) en de mogelijke effecten hiervan op onze gezondheid.

Naar aanleiding van deze zorgen heeft de Nederlandse overheid in 2006 een programma ingesteld voor het bevorderen van onderzoek naar elektromagnetische velden en gezondheid (EMV&G). Doel van dit programma was om de nationale infrastructuur voor EMV&G onderzoek te versterken en beter inzicht te krijgen in de mogelijke gezondheidseffecten. Voor het door ZonMw beheerde programma is €16,6 miljoen beschikbaar gesteld voor een periode van acht jaar. In totaal zijn hieruit 60 projecten gefinancierd in vier afzonderlijke thematische gebieden: biologie, epidemiologie, sociologie en technologie. Daar het programma inmiddels vrijwel afgerond is, heeft ZonMw het onafhankelijk adviesbureau Technopolis Group gevraagd een eindevaluatie uit te voeren om vast te stellen in hoeverre de beoogde programmadoelstellingen zijn behaald. De evaluatiemethodologie was gebaseerd op een combinatie van technieken en databronnen, waaronder een web enquête, interviews met belanghebbenden, analyse van programmadocumenten, en een mediastudie.

Het programma is er in geslaagd om een groot aantal onderzoekers met weinig tot geen eerdere ervaring in dit gebied bij het EMV&G onderzoek te betrekken. Ongeveer 100 wetenschappers, waaronder enkele tientallen studenten en promovendi, hebben meegewerkt aan de onderzoeksprojecten. Het programma heeft ook de ontwikkeling van nieuwe apparatuur en essentiële onderzoeksmethoden bevorderd. Tussen onderzoeksgroepen onderling, alsmede met groepen in het buitenland, is meer samenwerking ontstaan. Enkele van de gefinancierde groepen mogen inmiddels als vooraanstaand in het vakgebied worden beschouwd en maken onderdeel uit van grote, internationale onderzoeksconsortia. Er kan vastgesteld worden dat, op zijn minst voor de korte termijn, het programma er in is geslaagd om de Nederlandse infrastructuur voor EMV&G onderzoek te verstevigen.

Voor de langere termijn is de duurzaamheid van de onderzoeksinfrastructuur echter twijfelachtig. De meeste onderzoekers tonen geen belangstelling om hun werk binnen dit onderzoeksveld voort te zetten. Het gevoel bestaat dat veel van de onderzoeksvragen rond EMV&G voor het moment afdoende zijn beantwoord en dat er vooralsnog onvoldoende gedegen aanknopingspunten zijn voor verder onderzoek. Ook een tekort aan financieringsbronnen voor dit onderzoeksveld speelt een rol. Dit alles draagt er toe bij dat veel onderzoekers er de voorkeur aan geven hun aandacht te verleggen. Het programma heeft getracht de EMV&G onderzoeksinfrastructuur steviger te verankeren door middel van het instellen van drie speciale leerstoelen, verdeeld over vier hoogleraren. Het is slechts ten dele in deze opzet geslaagd: van de drie leerstoelen zullen er slechts twee worden voortgezet (één voor epidemiologie, en één voor technologie). Alhoewel de bijdrage aan een onderzoeksinfrastructuur voor de langere termijn onzeker is, is het de vraag of er daadwerkelijk behoefte bestaat aan een dergelijke gespecialiseerde infrastructuur. Veel van de benodigde expertise is relatief algemeen, waardoor nieuw onderzoek vrij gemakkelijk kan worden opgepakt wanneer daaraan behoefte ontstaat.

Het programma heeft een aantal belangwekkende nieuwe inzichten opgeleverd in eventuele effecten van EMV op de gezondheid. Enkele biologische studies wijzen op een mogelijke link tussen blootstelling aan EMV en effecten op het immuunsysteem, wat wellicht aanleiding kan geven tot verder onderzoek. De meerderheid van de biologische studies heeft echter geen significante aanwijzingen opgeleverd waaruit zou blijken dat, bij dagelijkse blootstelling binnen de vastgestelde limieten, EMV een risico voor de gezondheid vormen. Waardevolle bevindingen komen ook uit onderzoek naar beroepsblootstelling bij, onder meer, MRI technici. Deze studies hebben bijgedragen tot

een verbetering van de MRI veiligheidsrichtlijnen. Sociologische studies hebben aanbevelingen opgeleverd voor betere strategieën voor risicocommunicatie. Een klein aantal projecten is nog niet afgerond, terwijl voor enkele anderen de definitieve resultaten nog niet beschikbaar zijn. De kwaliteit van de uitgevoerde projecten was over het algemeen redelijk tot goed, alhoewel van enkele projecten de wetenschappelijke, dan wel maatschappelijke relevantie als gering wordt beschouwd.

Het was niet de insteek van het programma om rechtstreeks invloed uit te oefenen op de publieke zorgen rond blootstelling aan EMV, anders dan door onderzoek te ondersteunen dat beter inzicht zou moeten verschaffen in mogelijke gezondheidsrisico's. Het is niet eenvoudig vast te stellen of het programma desalniettemin een dergelijke invloed heeft gehad. In nationale media en op het Internet is er nauwelijks berichtgeving geweest over het programma of de binnen dat kader uitgevoerde projecten, waardoor het onwaarschijnlijk is dat het programma van grote directe invloed is geweest. Nu de meeste onderzoeksprojecten zijn afgerond, liggen er echter voor ZonMw kansen om een groter publiek te bereiken door middel van het opstellen van publieksvriendelijke samenvattingen van (onderdelen van) het programma. Daarnaast kan het, in samenspraak met het EMV Kennisplatform, zorg dragen voor communicatie van de programmaresultaten naar de media.

Algemene conclusie

Er kan vastgesteld worden dat het programma een belangrijke bijdrage heeft geleverd aan de versterking van de EMV&G onderzoeksinfrastructuur in Nederland, alhoewel de duurzaamheid hiervan op de langere termijn vermoedelijk beperkt zal blijken. Daarnaast heeft het programma bijgedragen aan hoogwaardig onderzoek dat op diverse gebieden waardevolle nieuwe inzichten heeft opgeleverd. Zonder het programma zouden de meeste van deze projecten zeer waarschijnlijk nooit zijn uitgevoerd.

Ondanks deze belangrijke bijdragen is het totale rendement van het programma relatief bescheiden. Dit is deels het logische gevolg van de wijze waarop invulling is gegeven aan het programma: doordat er destijds weinig duidelijke aanknopingspunten waren om richting te geven aan het onderzoek, is gekozen voor een tamelijk brede opzet zonder helder overkoepelend thema. Als gevolg hiervan was de onderlinge samenhang tussen projecten beperkt, terwijl enkele projecten relatief klein van schaal waren. Hierdoor is de statistische zeggingskracht vrij laag, waardoor er weinig zekerheid ontleend kan worden aan conclusies. Alhoewel destijds een begrijpelijke keuze, moet achteraf dan ook geconstateerd worden dat de brede programma-opzet een obstakel is gebleken voor het volledig realiseren van de programmadoelstellingen, en dat het programma baat had gehad bij meer thematische samenhang.

Introduction

Background, aim and scope

In 2006, the former Ministry of Housing, Spatial Planning and the Environment and the Ministry of Economic Affairs commissioned a research programme on electromagnetic fields and health (EMF&H). The purpose of this programme was to strengthen the national capacity for research into the health impacts of electromagnetic fields (EMF) and thus contributed to clarifying potential health impacts of EMF. The programme was administered by the Netherlands Organisation for Health Research and Development (ZonMw) and was provided with a budget of € 16.6 million for a period of eight years (2006-2014) for research into EMF and their impact on health.

As the programme is drawing to an end, ZonMw has commissioned an independent programme evaluation (hereafter referred to as 'the evaluation'), which will be followed by a short final evaluation of the remaining projects in 2019. The aim of the evaluation was to provide insight for the commissioner, programme committee, ZonMw board and researchers into the extent to which the objectives of the programme have been achieved. Specifically, the evaluation sought to answer the following questions:

1. Has the Dutch scientific infrastructure in the field of EMF been strengthened?
2. Did the granted research proposals contribute to clarifying possible effects of EMF on health?
3. What was the impact of the programme on society and on the public concern about possible health effects of EMF?

The first two evaluation questions are directly derived from the stated programme objectives, and incorporate a crosscutting objective of connecting Dutch EMF&H research to international research efforts. The third evaluation question is driven by the public concerns that spurred the programme's creation, although alleviating public concern was not an explicit programme objective.

The evaluation did not include an evaluation of the processes on a programme level, as this was part of the interim evaluation of the programme in 2012.

Methodology

For this evaluation we have used an evaluation approach based on multiple methodologies and data sources:

- Desk research was performed to get a better understanding of the nature of the funded research projects and the programme. Several sources were reviewed, among which the interim evaluation report of the EMF&H programme (2012), the EMF report of the Health Council (2006), minutes of the meetings of the Programme Committee and the Supervisory Committee, project proposals, and progress and end reports.
- A survey was developed and distributed to all grant recipients to collect data on the implemented projects and their outputs and outcomes, and supplement the data from the desk research. The results of the survey are integrated throughout the report, but can also be found collectively in Appendix A.
- Interviews were performed with key informants, including principal investigators of projects, the chairs, members of the ZonMw Programme Committee, and representatives of the Knowledge Platform EMF and EMF Focus Group to further explore issues identified during both the desk research and the survey, and to place these into context. The list of interviewees is presented in Appendix B and the interview guides in Appendix C.
- The most recent members of the Supervisory Committee were asked to provide short assessment reports of the main projects. Four such reports were received.

Additionally, two assessment reports were received from members of the Programme Committee. The instructions for the assessment reports are provided in Appendix D.

- Foreign experts were invited to provide an assessment of the quality and relevance of the project portfolio. They were assigned to one of the four thematic areas and were asked to place these into an international context:
  - Thematic area **Technology**: Prof. Norbert Leitgeb, Institute of Clinical Engineering, Graz University of Technology
  - Thematic area **Epidemiology**: Prof. Elisabeth Cardis, Centre for research in Environmental Epidemiology (CREAL)
  - Thematic area **Biology**: Prof. Jukka Juutilainen, Professor of Radiation Biology and Radiation Epidemiology, University of Eastern Finland
  - Thematic area **Sociology**: Dr. Christiane Pölzl-Viol, German Federal Office for Radiation Protection, Working Group Non-Ionizing Radiation

  As input for the external assessment, the experts received the self-assessment reports prepared by the members of the Supervisory Committee. In addition, the experts received the final evaluation reports (or, if unavailable because projects were not yet completed, the most recent progress reports) of the major projects that were funded within their designated thematic area. The reports from the members of the Programme Committee were received too late to still serve as input for the expert assessment. However, these were taken into account in the report directly.
- A media study was conducted to shed light on how outputs generated by the programme, in particular journal publications, were disseminated to the wider public through traditional and social media, and to determine how Dutch media reported on EMF&H related subjects. The first aspect was investigated by tracking citation using a new bibliographic metric known as *Altmetric*. This metric is a quantitative measure of the attention that a scholarly article has received in social media sites, newspapers, government policy documents and other online sources.[1]
- Reporting on EMF and health was analysed through a keyword search of media reports in national newspapers indexed in the LexisNexis newspaper database. The full description of the methodology for the media study is presented in Appendix E.

Structure of the report

The subsequent sections of this report are structured as follows: Chapter 1 begins with an outline of the history and objectives of the programme and an introduction of the actors directly involved with the programme. Additionally, it provides an analysis of the composition of the programme, and of the allocation of funding. The next three chapters form the core of the report, and are organised around the primary evaluation questions. Chapter 2 reviews how the programme has contributed to the development of a scientific infrastructure to support EMF&H research in the Netherlands. Chapter 3 presents an overview of the scientific results generated by projects funded in the thematic areas of the programme, and discusses the quality and relevance of the projects. Chapter 4 discusses if, and how the programme has contributed to the scientific knowledge base, as well as the public debate around potential health impacts of EMF. Finally, Chapter 5 summarises the main findings and conclusions of the evaluation, and formulates a number of recommendations.

[1] The Altmetric score is relatively new. Therefore, if an article was published before July 2011, any transient mentions of it, tweets in particular, could not be included.

1. Electromagnetic Fields & Health research programme

1.1 Background and objectives

As a result of increasing societal concern about the potential adverse health effects of mobile communication and other EMF-emitting technologies, in 2005 the State Secretary of the former Ministry of Housing, Planning and Environment (now the Ministry of Infrastructure and the Environment, abbreviated to Ministry of I&M) and the Minister of Economic Affairs decided to commission ZonMw to develop a programme to support research into potential health effects from electromagnetic fields. With this programme, the government aimed to structurally strengthen the Dutch knowledge infrastructure in the field of EMF&H by combining national and international knowledge in this field, by conducting basic, applied and experimental research, and by achieving a good connection and cooperation with international developments, institutes and programmes.[2] In order to develop an efficient and effective programme from an international perspective, it was felt necessary to have an up-to-date view of the international research agenda of completed, ongoing and planned studies.[3] For this reason the Health Council was asked to give an opinion on the following questions:

1. What will outline the international EMF research agenda regarding health effects for the next few years? What are the key questions awaiting answers?
2. What useful contribution could be given from the Netherlands, given the expertise available here? Where is it desirable to seek connection and collaboration with research groups in other countries? What research activities contribute to strengthening the research infrastructure in this field of study in the Netherlands?
3. What research deserves priority? Both scientific and social aspects as well as the optimal use of available resources and timing should be taken into consideration[4].

The advice from the Health Council, more specifically the Council's Committee on Electromagnetic Fields, was published in 2006 and included a list of proposals for research into the effects of electromagnetic fields on health.[5] In drawing up the proposals the Committee took account of the expertise present in the Netherlands and of the World Health Organisation's recommendations for research in this area. The Committee did not make any specific proposals for prioritisation. It did, however, present a list of social and scientific arguments that could play a role in prioritisation, which could be used by the programme committee that oversees the ZonMw research programme to set priorities for research. A more detailed description of the content of the programme is provided in section 1.3.

1.2 Actors involved with the organisation of the programme

In this paragraph we briefly describe the most important actors involved in the organisation of the programme.

ZonMw programme office

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[2] Letter of the Minister of Economic Affairs and the State Secretary of Housing, Planning and Environment (11 April 2005). National Antenna Policy (document 27561 nr. 23)

[3] Letter of the Minister of Economic Affairs and the State Secretary of Housing, Planning and Environment (16 November 2005). National Antenna Policy (document 27561 nr. 24)

[4] Letter of the State Secretary of Housing, Planning and Environment (9 September 2005) to the chair of the Health Council (ref. SAS/2005180309)

[5] Health Council of the Netherlands. Proposals for research into health effects of electromagnetic fields (0 Hz - 300 GHz). The Hague: Health Council of the Netherlands, 2006; publication no. 2006/11.

The role of ZonMw was to ensure the relevance, reliability, quality and independence of the research funded under the programme, irrespective of the results or the source of funding of individual projects or of the programme as a whole.

Project leaders and other stakeholders to the programme indicated to be very appreciative of the work done by ZonMw in the creation and subsequent management of the programme. Throughout the programme, there had been one consistent point-of-contact in the form of the programme manager. Researchers experienced the interaction with ZonMw as professional and responsive.

Programme Committee

The Programme Committee, instituted by the board of ZonMw, was responsible for the design and implementation of the programme and for the prioritisation of the various proposals. In addition its tasks were to ensure that the projects formed a coherent whole, and that once grants had been awarded the projects tied in with international research in this field.[6]The members of the Programme Committee were appointed in a personal capacity. At the time of this evaluation the committee had 12 members, of which seven are foreign. Membership of the committee has varied over the years, but has always been multidisciplinary and international.[7] The international representation is important since the Dutch EMF&H field is fairly small. Among the Dutch members have also been grant recipients of the EMF&H programme.[8] Observers from the commissioner of the EMF&H programme (Ministry of I&M) and the secretary of the Knowledge Platform EMF have attended committee meetings.

The Programme Committee had a strongly academic representation. Although stakeholders involved in this evaluation highly valued the scientific expertise of the committee members, some also felt that, as a result, the discussions within the committee regarding ongoing projects were often overly scientific in nature, with less emphasis on the societal added value of projects.

Supervisory Committee

A Supervisory Committee was installed to oversee the awarded grants. The intention was for all EMF&H project leaders to meet with the Supervisory Committee once a year. The committee had a large diversity of members (universities, public (health) organisations and interest groups), in order to bring in as much expertise as possible, and to make recommendations on the design and implementation of projects.[9] The Supervisory Committee's role was also to advise on the communication and implementation of results, as well as keeping the Programme Committee informed of progress. At the time of the evaluation, the committee had six members (all Dutch). As with the Programme Committee, a representative of the Ministry of I&M and the secretary of the Knowledge Platform EMV attended committee meetings as observers.

Some adjustments to the format of activities of the Supervisory Committee were made during the programme, in response to complaints from some project leaders and others regarding the, at times, overly critical treatment they received from a small number of committee members. Whilst discussions in the field of EMF are often starkly polarised and charged with emotion, it was felt that the tone of these discussions had become too sharp for constructive scientific debate and the complaints were upheld. Consequently, the composition of the committee was altered and the committee from then on only assessed the progress of projects by studying the progress reports. The committee no longer met the project leaders, unless there was a specific reason for it. Furthermore, at the request of project leaders it was decided that the Ministry of I&M and the secretary

[6] ZonMw (2007). EMFH Programme proposal

[7] ZonMw (2012). Interim evaluation of the ZonMw programme Electromagnetic Fields & Health

[8] ZonMw has specific procedures to avoid any conflicts of interest.

[9] ZonMw (2012). Interim evaluation of the ZonMw programme Electromagnetic Fields & Health

of the Knowledge Platform EMF would not attend the committee meetings anymore to avoid any potential conflict of interest. A number of interviewees indicated that they welcomed these changes, as earlier interactions with the committee had frequently been experienced as unpleasant or challenging. Others, however, welcomed the critical tone of the discussions encountered at these meetings, as it was felt to sharpen the design and implementation of individual projects.

Knowledge Platform on Electromagnetic Fields and Health

Because of the complexity of the EMF debate in 2007 the government decided to set up an independent knowledge platform which would inform society, but also professionals from the private sector and the public sector about the potential relationship between electromagnetic fields and health. The information provided by the thus-created Knowledge Platform on Electromagnetic Fields should be based on the latest scientific insights, and be independent, reliable and scientifically sound.[10]The Knowledge Platform EMF is a collaboration between RIVM, telecoms agency (Agentschap Telecom), the association of municipal health services (GGD-NL), research institutes TNO and DNV GL (former KEMA), and ZonMw. The platform is advised by the EMF Focus Group ('klankbordgroep'), comprising members of national civil society organisations, on the topics to discuss or issues that need specific attention by the Knowledge Platform EMF. An EMF Focus Group meeting has been held at least once a year. ZonMw is represented in the Knowledge Platform EMF by the programme office of the EMF&H programme and the director of ZonMw.

Many researchers and a number of other stakeholders have expressed their appreciation of the work done by the platform in liaising between the scientific community and the general public. It is felt to have brought different stakeholders closer together, and has brought greater nuance to the discussions. It was recently decided that the platform will continue for an additional four years.

1.3 Programme composition

The contents of the ZonMw EMF&H research programme were based on recommendations issued in 2006 by the Health Council, developed through consultations with the private sector, citizens' groups and researchers, and based on the input from the programme committee. The purpose of the programme, as stated in the programme proposal, was: *'To enhance the Dutch knowledge infrastructure in the field of electromagnetic fields (0-300 GHz) and health, giving the Netherlands its 'own' scientific authority in this area'.* The core aims were to keep track of new EMF applications and to clarify some of the actual effects of EMF. At the onset, three thematic areas were defined:[11]

1) Sociological research and epidemiological research;

2) Biological research;

3) Technological research.

The first area was primarily designed to investigate the role of perception of risk and risk communication in relation to EMFs to the general public. In addition, it was felt that a major epidemiological study could help uncover the health impacts of EMFs. In this evaluation sociological and epidemiological research has been treated as two separate thematic domains. The second area focuses in more depth on the potential health impacts at the molecular and cellular level, using both in vivo and in vitro studies. The third area sought to address the lack of adequate monitoring equipment and models required for study in the field of EMF&H.

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[10] VROM (2007). Instellingsbesluit Kennisplatform Elektromagnetische Velden en Gezondheid

[11] During the programme it was decide to separate sociological research and epidemiological research. For this reason the data in the following paragraphs is presented on four thematic areas.

Because all these areas were considered relevant – within the frequency range of 0-300 GHz – all needed to be covered in the programme. Also, because the goal of the programme was to build an infrastructure in the field of EMF research the scope of the programme was deliberately very broad.[12] According to the programme proposal this immediately raised the risk that the available funds would be spread too thinly over the field, which could do serious harm to the actual or perceived authority of the infrastructure. To avoid this, the programme proposal prioritised two to four types of research per thematic area. The prioritisation was based on:

- a combination of scientific and social arguments stated in the Health Council's advisory report
- an estimation of the most logical order in which the different research areas should be addressed
- the available budget.

It resulted in the development of a number of funding instruments for different types of (research) projects within each of the areas (Figure 1). An important component of the programme included the creation of three special university 'chairs' (leerstoelen). The responsibility of the chairs was to coordinate the projects within the area, and to be a figurehead for the area of research. This and the other instruments are briefly described in the table below. This table also shows the year(s) of the call of these instruments and the number of projects granted.[13]

Figure 1 Funding instruments in EMV programme

Funding instrument	Background	Year of call*	Projects granted
Chairs	A chair and associated research group is to be established in each of the three research areas listed above. The professors are to take centre stage in the research in the area in question, working closely with other projects in the programme.	2006	3
Basic research	The aim of this call is to identify the biological mechanism behind exposure to EMF.	2006	2
		2010	4
Technological research	Studies to improve the measuring and modelling of EMF.	2006	3
Multidisciplinary research	EMF studies involving several disciplines.	2007	4
Cohort study	A major long-term epidemiological study of the possible effects of exposure to EMF.	2007	1
Practically-oriented research	This type of grant is intended to facilitate collaboration between universities and practitioner institutions, such as municipal health services.	2008	1
		2009	1
		2010	4
Meta-analysis of practically-oriented studies	Combining the results of several smaller practically-oriented studies allows a meta-analysis to be performed.	-	0
International cooperation and exchange	A single grant of € 500,000 was available in this call for participation in a major international study (granted in the first round), as well as 14 grants of up to € 50,000 for smaller international projects, such as	2008	2
		2009	3
		2009	1

[12] ZonMw (2012). Interim evaluation of the ZonMw programme Electromagnetic Fields & Health

[13] This evaluation does not include an evaluation of the (selection) processes. For this reason we did not look into the total number of submitted project proposals, success rates or the selection criteria and procedures.

Funding instrument	Background	Year of call*	Projects granted
	attending or organising seminars with international speakers, visiting labs in other countries, and learning research techniques that are then brought back to the Netherlands. After the first call the procedure for granting € 50k projects was curtailed to allow for faster decision-making. The calls for € 10k projects were since then continuous.	2010	4
		2010	4
		2010	1
		2011	1
		2011	2
		2011	2
		2012	1
		2013	2
		continuous	10
Diagnostic Tool for Electrohypersensitivity	The aim of this call is to develop a definition or diagnostic tool for EHS. The needs for such as tool was identified during meetings organised by the Knowledge Platform. The results of these meetings led the programme committee to make a budget available for a call to facilitate the development of a diagnostic tool for electro sensitivity.	2011	1
Dissemination and Implementation Impulse			3

ZonMw (2012), Interim evaluation of the ZonMw programme Electromagnetic Fields & Health; ZonMw EMV programme website (visited 8 April 2015). * Year of deadline for full applications.

Stakeholders who had been closely involved with the implementation of the programme and external experts were asked to reflect on the programme as a whole and on the project portfolio within the thematic areas. A recurring observation was that the programme lacked sufficient prioritisation of areas for research and that there was no identifiable overarching theme. Many projects were driven by available expertise rather than by a focused effort to replicate existing studies or to deepen the knowledge about previously investigated effects.

1.4 Funding allocation

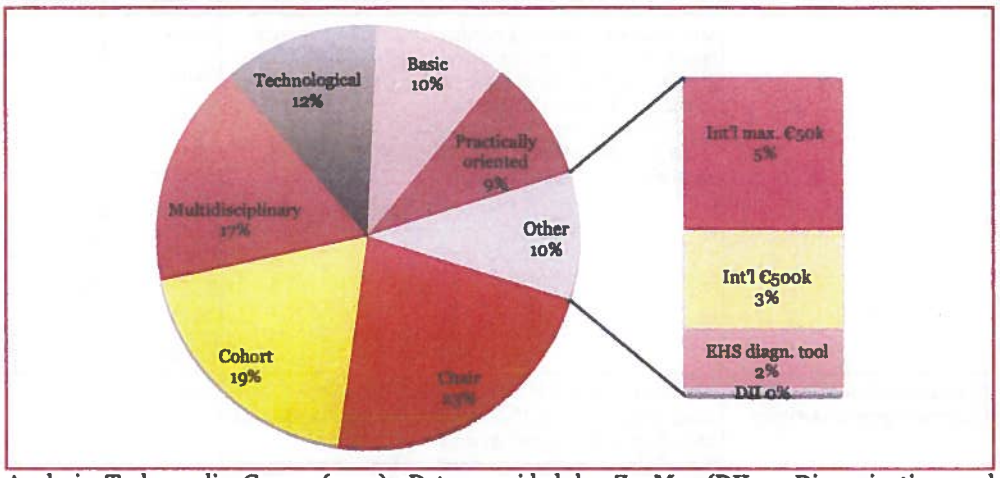
The EMF&H programme was provided with a budget of € 16.6 million for a period of eight years (2006-2014)[14] to be allocated to research groups in the Netherlands. The commissioners of the programme, the former Ministry of VROM and the Ministry of Economic Affairs both invested in the programme. Financial contributions from private partners were also sought (as instructed by the government[15]) but not found: no financial commitments by industry were made.

A total of 60 grants were awarded, all but two of which will be completed in 2015. The instruments by which a large part of the funding has been allocated include the three chairs (23% of the total grant budget), a cohort study (19%) and a number of multidisciplinary projects (17%)(Figure 2).

[14] Some projects will run beyond this eight-year period, until 2019.

[15] Letter of the Minister of Economic Affairs and the State Secretary of Housing, Planning and Environment (11 April 2005).National Antenna Policy (document 27561 nr. 23)

Figure 2 Budget allocations across funding instruments



Analysis Technopolis Group (2015). Data provided by ZonMw (DII = Dissemination and Implementation Impulse)

The largest share of the funding was allocated to projects in the thematic area of epidemiology (Figure 3): this was twice the amount of funding allocated to biology or technology projects and almost half of the total budget of the EMF&H programme. This imbalance in allocation of funding between the different thematic areas may be a reflection of the Dutch EMF&H research landscape prior to the programme.

Figure 3 Funding allocations across thematic areas

	No. projects granted	Budget granted	Budget share
Epidemiology	24	€ 7.888.529	48%
Biology	14	€ 3.732.021	23%
Technology	12	€ 3.718.672	22%
Sociology	9	€ 1.238.639	7%
Total	59	€ 16.577.862	100%

Analysis Technopolis Group (2015). Data provided by ZonMw

In the EMF&H programme proposal (2007) the initial plan was to make budget available according to the following structure:

- sociological/epidemiological research: € 6.600.000
- biological research: € 7.450.000
- technological research: € 2.550.000

There are a number of reasons why the budget was divided differently than originally intended, mostly related to the quality of the proposals. According to the interim evaluation report of the programme, the number of applications per call was relatively low compared to the available budget, due to the low number of research groups working on EMF&H at the beginning of the programme. The quality of the applications

was also highly variable[16], with some of the calls resulting in too few proposals of sufficient quality. ZonMw reacted to the low level of quality in a number of ways:[17]

- In the first call for Practically Oriented research projects only one of the five applications submitted was successful. The scientific quality of the other four was considered inadequate. Furthermore, many of the applications systematically displayed the same shortcomings in terms of their structure and wording. For this reason ZonMw decided to organise a workshop to teach participants how to structure a good research application in English. This resulted in several additional projects granted.
- The budget of the call Meta Practically Oriented (€1 mln) was transferred to the Basic Research call. This decision was made when it became apparent that only a few practically oriented applications could be granted, due to insufficient scientific quality. The dearth of practically oriented studies in the programme made it unlikely that any strong meta-analysis applications would be received during this programme.
- The first Basic Research call had a broad scope. The quality and relevance of the proposals turned out to be insufficient. For this reason the decision was made not to spend the whole budget in this round and to develop a new call with a smaller scope and more specific criteria.
- With the approval of the commissioning organisations, the programme committee decided at its meeting to transfer € 892,055 from the Basic Research call to the Technological call. This was done in response to the large number of good-quality applications for technological research and the absence of good applications for basic research.

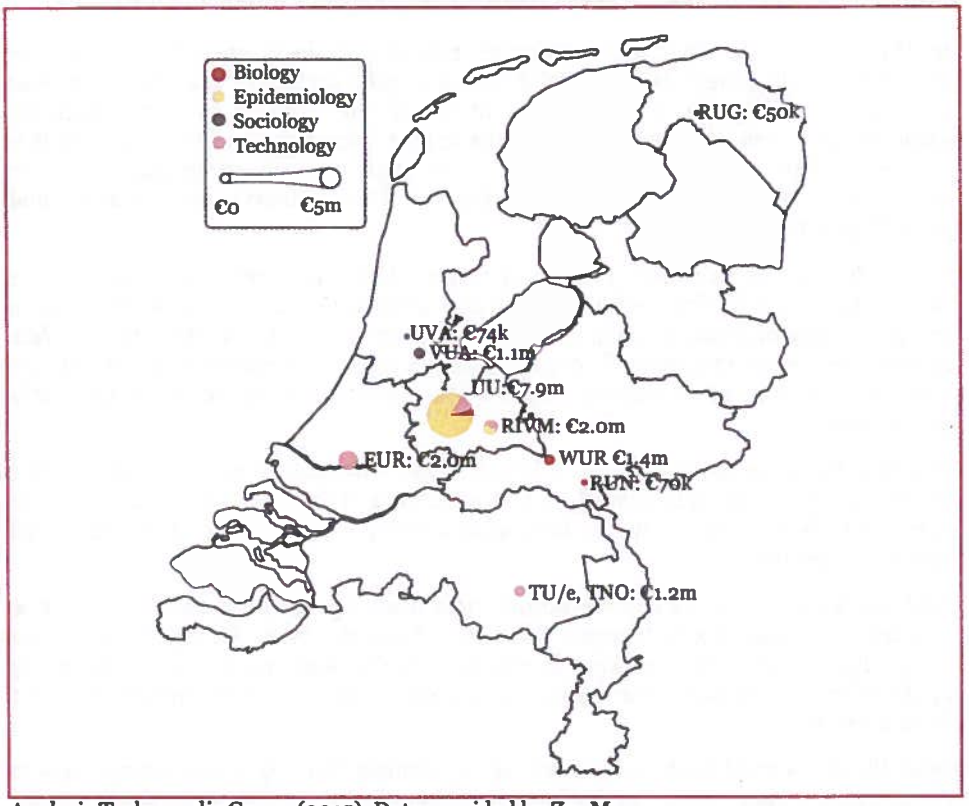
Although the above modifications offered the opportunity to make course corrections to the programme, it also resulted in the late allocation of some of the funds. Additionally, the technological and biological chairs were awarded late, partly due to difficulties in obtaining the required support and matching of funding from the intended host institute. This posed a challenge as it meant that these chair positions could not be leveraged to obtain funding for additional projects to the same extent as achieved by the epidemiological chair, even though projects by these researchers would also have been eligible for funding under prior calls for proposals.

In total, eleven research organisations received funding from the EMF&H programme. There were 24 individual project leaders, with the total number of projects per project leader ranging from one to seven. A large part of the budget was allocated to Utrecht University, which received 42% of the total EMF&H research budget (and 84% of the epidemiology budget). The second highest amount of funding was received by Erasmus University Rotterdam and RIVM (both 12% of the total budget). VU Medical Centre received 94% of the Sociology budget and was responsible for 7 of the 9 Sociology projects. Figure 4 shows how funding was allocated across the thematic areas and organisations.

[16] ZonMw (2012). Interim evaluation of the ZonMw programme Electromagnetic Fields & Health

[17] Source: Interviews and the interim evaluation of the EMF&H programme

Figure 4 Allocation of funding per institute and thematic area



Analysis Technopolis Group (2015). Data provided by ZonMw

Within several of the thematic domains most of the allocated funds were concentrated at a single group or institute. This is especially true for the epidemiological studies, where the group of chair prof. Kromhout received the lion's share of funds. Opinions differ somewhat on whether or not this situation is desirable. Some experts feel that it made sense to concentrate expertise and resources within a small number of top institutes, as this will likely benefit the sustainability of the created infrastructure. Others believe that such concentration may have restricted the opportunities for scientific exchange and that assignment of projects to a greater number of competent groups could have resulted in a more differentiated and holistic approach.

Over the course of the programme, the complete programme budget of €16.6m was disbursed. The evaluation team is not aware of what information the initial budget calculation was based on, other than the anticipated number of projects and researchers. In comparison to other ZonMw programmes with an international component –the category under which ZonMw has classified the EMF&H programme– the EMF&H programme was one of the larger programmes (see Appendix G). Several members of the programme committee have suggested that, for a relatively small country like the Netherlands, the budget may in fact have been too large and that there was not enough absorptive capacity within the research community. They observed that, because of the generous amount of funding available in relation to the size of the field, some of the funds were allocated to projects that, once underway, were found lacking. By allowing termination of such projects, these funds could have been redirected to other, more promising projects. ZonMw regulations, however, specify that, once granted, project funding cannot be withdrawn unless the implementation of the project clearly deviates from what was agreed.

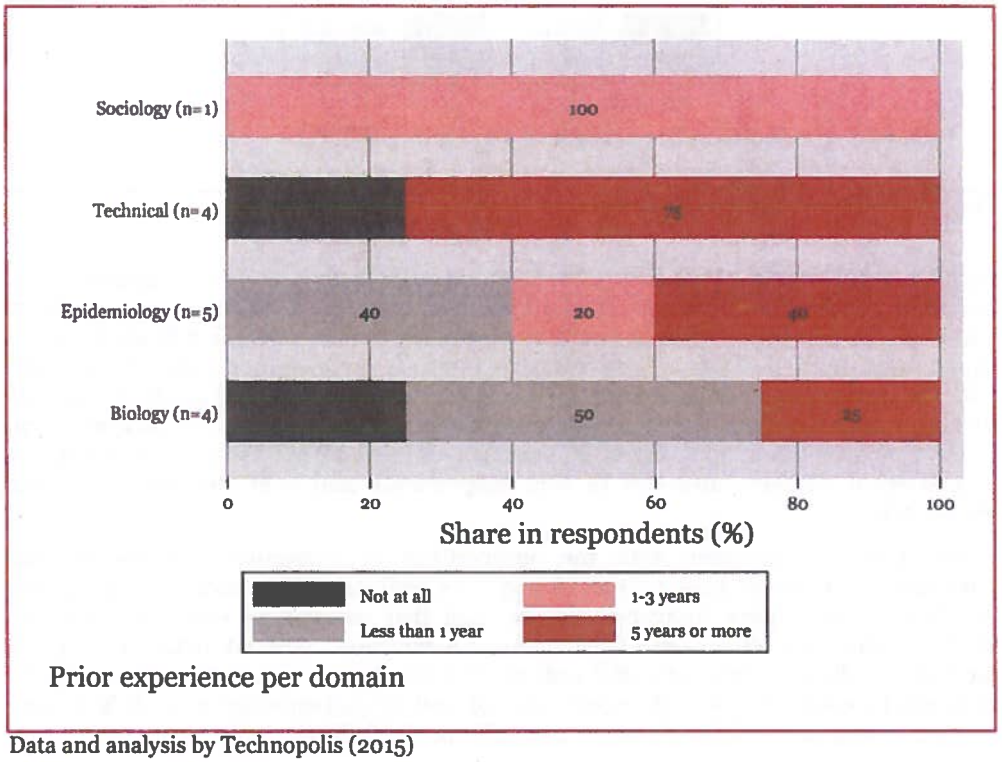
2. Development and support of an EMF&H research infrastructure

2.1 Developing the knowledge base

2.1.1 Bringing new researchers to the field

Although several researchers had been studying various aspects of EMF and its potential applications for a number of years, prior to the start of the programme few researchers within the Netherlands had been actively conducting research on potential health impacts of EMF. The extent of specialist knowledge on this subject was thus rather limited, and mainly concentrated in institutes like RIVM. One of the main objectives of the programme therefore was to bring in more researchers to the field and to broaden the overall national knowledge base. The programme has indeed successfully encouraged a significant number of new researchers from different scientific disciplines to work on EMF and health. Over half (57%) of all survey respondents (N=14) had three years or less of prior experience on this topic before applying for funding (Figure 5).

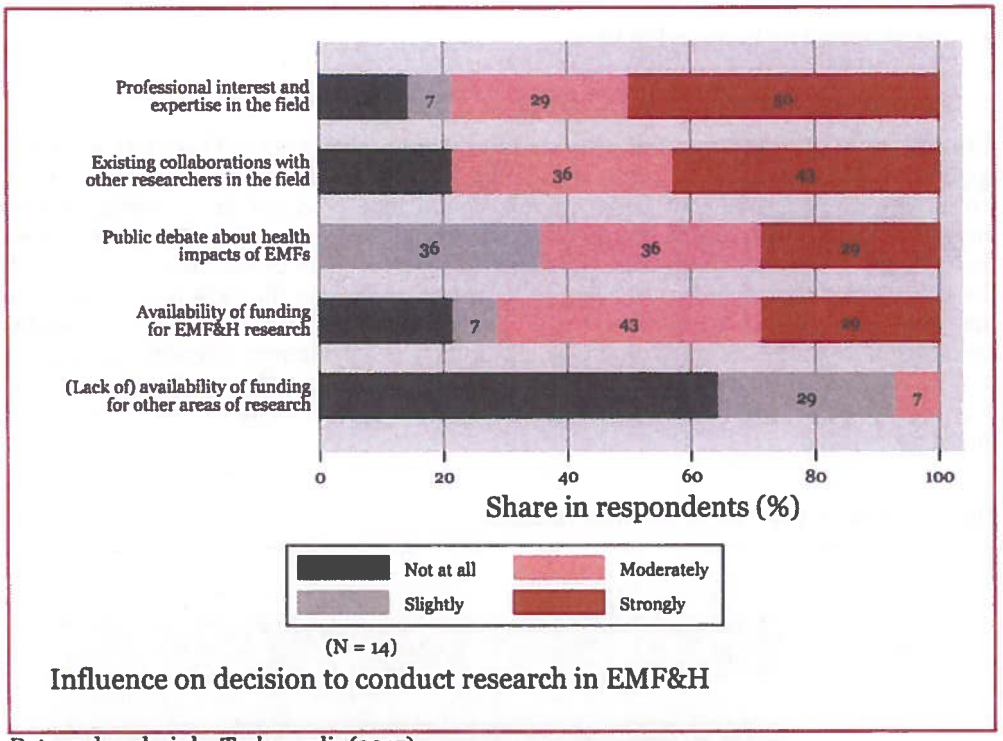
Figure 5 Prior experience in EMF&H research



Data and analysis by Technopolis (2015)

Despite this fairly limited prior experience, 11 out of 14 respondents (79%) expressed professional interest and expertise as one of their main motivators for applying. For several of the project leaders their work on EMF fit naturally within a broader interest in environmental health or in risk communication. Many researchers also added that they had been motivated to participate in the programme because they were interested in working on a subject in which there was significant public interest, and that they wanted to contribute to a better understanding of the health risks associated with EMF because of its possible societal impacts (Figure 6).

Figure 6 Motivation for participation in EMF&H programme



Data and analysis by Technopolis (2015)

Perhaps unsurprisingly, it is clear from both interview data and survey responses that availability of finances itself was also an important incentive to initiate new projects in this field. Many researchers seized on the opportunity to obtain research funds from the programme, even if their primary research interests lay elsewhere. This 'honey pot' effect is particularly visible amongst survey respondents within the thematic domain of biology, where three out of four respondents had less than one year of experience prior to their initial funding application. By contrast, amongst respondents representing the technological domain three out of four respondents had over five years of prior experience.

These data are consistent with the observations of numerous interviewees that particularly for researchers in the biology –as well as epidemiology– domain the 'barriers to entry' were comparatively low, and that researchers were able to apply existing skills and techniques to new research questions without requiring a great amount of subject-specific expertise upfront. Where necessary, such expertise could be obtained by collaboration with experts abroad and by participating in workshops and courses, activities for which the programme also provided funds.

2.1.2 Knowledge and skills development

As indicated previously, despite being unaccustomed with the specifics of EMF&H research, many of the project leaders interviewed indicated that their research projects were designed around established methodologies and techniques. The epidemiological studies in particular were not considered intrinsically different from studies that look at the impact of other environmental factors. Similarly, researchers in the biological projects used existing platforms and model systems for detecting changes in biological systems. An imperative condition in all these experiments, however, was the reliable measurement of EMF exposure. Most biological and epidemiological research groups did not *a priori* have the required expertise or equipment for this. This was therefore often developed in collaboration with more technically oriented groups, both of national and international origin. The knowledge thus generated on new techniques,

multidisciplinary approaches, and experimental designs has been recorded through scientific articles, and has thus contributed to the wider knowledge base for EMF&H research.

Overall, the programme has supported over a dozen (assistant) professors and nearly a hundred graduate and postgraduate researchers. Thus far, eight PhD students have completed their theses, and a further eleven are still expected to do so within the three coming years. Four survey respondents replied that programme funds had been used to provide scholarships or bursaries for researchers. Furthermore, four survey respondents (29%) felt that the programme had contributed to them obtaining tenure or receiving a promotion at their institute.

2.2 Creation of collaborations and networks

In the design of the programme it was envisaged that researchers would seek out collaborations across disciplinary lines. The chairs in particular were expected to act as linking pins in this process. Indeed, all survey respondents indicated that their projects had been conducted in collaboration with one or more research groups, both within the Netherlands (14 unique organisations) and abroad (17 unique organisations). Of these research groups, 21 (68%) are universities, seven (23%) are other publicly funded agencies, and three (10%) are private sector institutes. Overall a significant number of these collaborations were established as a direct result of the programme, although the data are likely somewhat overstated as multiple respondents originated from the same research group and because of reciprocal reporting on the same collaboration by both parties. Respondents also stated that for nearly all of these collaborations the programme increased their intensity and that many had increased in dimensions of multidisciplinarity, productivity and relevance. Furthermore, 62% of survey respondents stated that the programme had contributed to the creation of working groups and formal research networks or consortia.

Interview data support the observation that the programme has galvanised the formation of new collaborations and has improved the standing of Dutch researchers as valuable partners in research consortia. The innovative research on static EMFs emitted by MRI scanners by the group of prof. Kromhout (Utrecht University), for instance, has triggered several new collaborations with groups abroad and led to participation in a number of large EU funded projects.

Despite these newly established connections, some interviewees expressed general disappointment with the degree of collaboration between the different groups represented under the programme. They felt that, particularly earlier on in the programme, there was insufficient interaction between different disciplines and that opportunities for multidisciplinary working across groups were not always capitalised on properly. This can be attributed in part to the concurrence of many projects, which meant that projects in one discipline could not build upon work from groups in another discipline. Multiple stakeholders implied that this improved somewhat over the course of the programme, aided in part by a symposium organised in 2013 by ZonMw to make researchers on the biological and epidemiological projects more aware of the possibilities offered by collaboration with the technological groups. Nonetheless, it was not generally perceived as a structural element of the programme and the sustainability of some of these collaborations in the absence of further financial support for EMF&H research is doubtful. Additionally, one interviewee expressed the opinion that the grants provided specifically for international collaboration and exchange projects (call for projects up to €50k) were not sufficient to build meaningful and lasting collaborations, and that instead it would perhaps have been better to concentrate these funds in a few larger grants that would have allowed for longer-term exchanges.

Figure 7 Institutes identified as collaborators by survey respondents

Country	Institution
Netherlands	Erasmus MC
	Groningen University
	Immunent BV
	Radboud University
	RIVM
	Utrecht University
	VUA, UVA, GGD
	WUR
Belgium	Ghent University
France	INERIS
Italy	University of Modena
South Africa	Bloemfontein
Spain	CREAL
Sweden	Karolinska Institute
Switzerland	IT'IS
	Swiss TPH
United Kingdom	Bristol University
	Imperial College
	Kings College
	Public Health England
USA	NIOSH
	UCLA
	University of Indiana
	University of Texas

Data and analysis by Technopolis (2015)

2.3 Role of special chairs

Initially, three special chairs were envisaged under the programme: one for technological research, one for biological research, and one for sociological and epidemiological research. The purpose of these chairs was to be a focal point of scientific expertise in their specific field, to bring together the different disciplines within the programme and to transmit a clear message to the general public. Hosting institutes were expected to provide long-term support for the group and to ensure embedding of the research within the scientific infrastructure.

Based on the applications received, it was eventually decided to award the following chairs:

- Prof. dr. ir. Peter Zwamborn (TU/e and TNO) and prof. dr. ing. Gerard van Rhoon (Erasmus MC) – Technological research
- Prof. dr. Roland Kanaar (Erasmus MC) – Biological research
- Prof. dr. ir. Hans Kromhout (Utrecht University) – Epidemiological research

The technological chair was filled jointly by prof. Zwamborn and prof. van Rhoon. After the awarding of the biological chair to prof. Kanaar, these three chairs joined their efforts to combine the medical, biological and technological expertise of the two hosting institutes. The epidemiological chair of prof. Kromhout stands further apart from the others. There were no collaborative projects between the epidemiological chair and any of the other chairs. At least in part, this is the logical consequence of the fact that the epidemiological chair had started well before the others, and that collaborations to obtain the required expertise had already been formed with other groups abroad.

The number of projects awarded to the individual chairs varies considerably. A significant share of all project funding (40% overall, 84% of epidemiological studies) was allocated to the group of prof. Kromhout, which conducted a total of 20 projects under various calls. The biological chair, however, was awarded comparatively late in the

programme and was directly associated with only one additional project, stemming from the call for international collaboration and exchange. These large differences in the amount of funding allocated and number of projects awarded to the individual chairs are more indicative of the extent of their engagement with the field than of inherent differences in the costs of the types of research.

To varying extent, all chairs have been involved in education on the subject of EMF&H, to university students as well as to groups of professionals. Where necessary, they have also acted as a point of contact on issues within their area of expertise. However, in other respects significant differences appear to exist in the interpretation of the role and responsibilities of the chairs. Some of these differences may be attributable to the underlying motivations chairs had for applying. The joint holders of the technological chair both had prior experience and a standing interest in EMF related research. This is reflected in their interpretation of the role of chair as an instrument for building long-term commitment and providing guidance to the field. This is clearly distinct from the more project-focused interpretation apparent for the other chairs, who both had pre-existing faculty appointments as full professors and for whom the programme primarily represented an opportunity to apply their expertise to a new subject area.

Several chairs have on occasion contributed to media reports (e.g. prof. Kanaar and prof. Zwamborn have participated in an episode of the TV programme Radar, and prof. van Rhoon has given radio interviews), but in general the chairs – along with other project leaders – indicate they prefer to focus on their research activities and are wary of discussing findings in the public domain prematurely. Therefore they tend to not actively seek out the public debate and their engagement with the media and the public is predominantly reactive rather than proactive.

In line with the narrower interpretation of the chair positions as projects, the embedding of the chairs at the hosting institutions has met with mixed success. Prof. Zwamborn and prof. Kanaar have both indicated that with the conclusion of the programme they are unlikely to continue research in this specific field due to a combination of lack of funding and other professional interests. The chair of prof. van Rhoon will likely continue. Prof. Kromhout is currently still involved in longer-term EU-funded projects relating to EMF&H, though his sustained commitment too will be contingent on additional funding and continuing relevance of the field. This lack of deeper embedding may in part be the result of the fact that applications for the chair positions were initiated by candidates directly rather than that potential hosting institutes were solicited to nominate candidates. Despite the fact that a statement of intent to support the chairs was required from each of the hosting institutes, these positions were not always viewed as an institutional priority. In the case of the biological chair a lack of institutional support contributed to the decision to not allocate the position to the initial candidate.

2.4 Physical infrastructure

Amongst the 13 respondents who completed this part of the survey, nine indicated that some of the funds they had received through the programme had been used to purchase, manufacture or refurbish major items of equipment with a purchasing value exceeding €2,000.[18] These respondents equally represented the thematic domains of biology, epidemiology and technology. Although it is not possible to determine from the survey data alone exactly how much of the overall programme funding has been allocated to such investments in 'hard' infrastructure, the amounts estimated by these survey respondents ranged from €4,500 to €150,000. In all except one case, they indicated that the equipment in question was used exclusively or nearly exclusively for research related to EMF&H, though not necessarily limited to the projects supported by the programme. Five respondents received research funding from their own institutes (Wageningen University and Research Centre (WUR), Erasmus Medical Centre, RIVM and TU/e) and

[18] The amount of €2,000 was arbitrarily chosen as a threshold with the approval of the evaluation committee.

one researcher from Utrecht University received a large amount of funding (nearly €6m) through the EU FP7 programme. In addition, five researchers indicated that the programme had contributed to the creation of shared data repositories, although no information is available on what type of data is contained in these repositories, where they are hosted or to whom they are accessible.

2.5 Sustainability of infrastructure

The intention of the programme in supporting the creation of an infrastructure for research on health effects of EMF has naturally been for this infrastructure to be sustainable beyond the duration of the programme. The chairs in particular were created with an eye towards long-term commitment to the field. Despite the success of the programme in supporting a significant number of projects and drawing new researchers to the field, the sustainability of these efforts is highly uncertain. Nearly three quarters (70%) of survey respondents signalled they were less than likely to continue research in this area, with only one respondent expressing clear intent to continue.

The main reason provided by survey respondents for discontinuing is an anticipated lack of funding availability. Indeed, interview data confirm that financing is a major threat to the sustainability of the created infrastructure, and that aside from the ZonMw programme there have been few other funding sources available to support this type of research. Researchers indicate that EMF&H research funding applications generally have a low success rate in open calls because thus far most studies have produced only negative results. Few groups have been able to leverage the ZonMw funds to secure additional funding. A notable exception to this is the FP7 grant awarded to the group of prof. Kromhout and dr. Hüss. Over the years, the EU Framework Programme for Research has in fact significantly invested in research into health effects of EMF, but there too the attention for the field is felt to be declining. Funding from private sources, including industry, is not widely supported because it creates a potential conflict of interest in an already sensitive research area. Understandably, without sufficient funding opportunities researchers will redirect their attention elsewhere.

Data from interviews and assessment reports by external experts, however, suggest several other factors that play a role in the lack of sustainability of the infrastructure and of long-term commitment from researchers. The EMF&H programme was originally created in response to a feeling that significant knowledge gaps existed in the scientific evidence base concerning potential health effects of EMF. Since then, however, many of the original research questions have been extensively explored, both within the programme and elsewhere. Consequently, many of the researchers interviewed expressed a feeling that the scientific relevance of the field is waning and that specific questions have by now been sufficiently answered, mostly with negative outcomes. Without new hypotheses to test, there is little to no incentive for these researchers to continue in this direction. As one principal investigator stated: "if you do not find any positive effects, you essentially have two choices: either continue looking to see if you can still find anything, anywhere, *or* you draw the conclusion there is nothing there. I fall into that second category: I'm done with it." Also from a broader career perspective, the field does not appear to have much to offer to researchers who are judged on scientific output and publications in leading academic journals, whereas it is felt that, in general, negative findings are less likely to get published. Consequently, EMF&H research is not viewed as a prestigious area of expertise.

The overall outlook is that for most principal investigators, particularly those in the biological stream of the programme, their EMF&H research will cease with the conclusion of the programme. As also discussed in more detail in section 2.3, this includes several of the chairs. Mainly those groups that already had some track in EMF-related research prior to the programme and those that are part of international collaborations and ongoing research consortia – such as the group of prof. Kromhout at IRAS– are expected to maintain some degree of activities in the area in the coming years.

The question of sustainability not only affects the 'human capital', but also the physical infrastructure that was created under the programme. Some equipment that was developed or procured has already become out-dated again, whereas upon the conclusion of projects some of the larger set-ups –including a climate room– have been dismantled to make space for other research projects.

It can be questioned whether the ambition of creating a sustainable research infrastructure within the scope and duration of the programme was in fact realistic. Although the programme calls sought to prioritise on no more than four types of research per thematic area, in practice the bottom-up programme design enabled researchers to explore a great many different research questions. As a result, many awarded projects were stand-alone initiatives without suitable embedding in a coherent long-term research agenda. This lack of focus also meant that, in some cases, resources were spread too thinly to meaningfully contribute to a sustainable infrastructure within the time horizon of the programme. Furthermore, the late appointment of some of the chairs meant that they too were not able to adequate fulfil their roles as promoters and nexuses for the field.

Although the above paints a seemingly bleak picture for the sustainability of a dedicated infrastructure for EMF&H research, it is debatable whether such an infrastructure –of the magnitude envisaged under the programme– is indeed required. As observed previously, much of the research performed under the programme has built on methodologies and techniques that are more widely available. This expertise can be relatively easily called upon again if and when the need arises, for instance because of novel technologies or new hypotheses for testing. More specific EMF&H related knowledge, such as required for dosimetry, has been appropriately written down so that these techniques can be reproduced. Nonetheless, for the Netherlands to keep abreast of ongoing research in this area and to maintain its position as an important participant in research consortia, it may be necessary to sustain a core centre of expertise.

3. Insights into health impacts of EMF

3.1 Project findings

The primary objective of the programme has been to obtain a better understanding of the potential health impacts of EMF. Because of the broad focus taken by the programme, it was not defined upfront which specific research questions should be given priority under the programme. Therefore, outcomes of individual projects cannot easily be matched to specific programme objectives. Rather, following sections present an inventory of the key insights the programme has generated within each of the thematic areas, based on a summary of project reports submitted to ZonMw and on the opinions of project leaders, external experts and other stakeholders.

3.1.1 Biology

The studies investigated under the biological thematic area of the programme investigated a number of potential mechanisms of action across a wide range of the electromagnetic spectrum. The studies can be categorised into:

- DNA damage and protein expression in response to EMF exposure (prof. Kanaar, Erasmus MC)
- Effects of exposure to LF-EMF on the immune response (Dr. van Kemenade, (WUR)
- Effects of RF-EMF on immune sensing and embryo development (Dr. Woelders, WUR)
- Influence of RF-EMF on honey bees development and behaviour (Dr. Blacquière, WUR)
- Evaluation of potential effects on the immune response from LF-EMF exposure (Prof. Hermans, Radboud University)
- Impact of EMF stimulation in treatment of depression (prof. Kortekaas, UMC Groningen)
- *In vitro* studies on neurotoxicity of ELF-EMF in embryonic cells (Dr. Westerink, Utrecht University)

The group of prof. Kanaar analysed whether exposure to ELF and RF radiation induced DNA damage in mouse and human cell lines. They did not observe any significant or consistent effect and conclude that the radiation thresholds of the Dutch and European government offer adequate protection. Additionally, they found no significant effect in studies to identify potential changes in protein expression levels upon exposure of cells to non-ionising EMF.

At the WUR three separate research groups conducted studies independently from each other. The group led by Dr. van Kemenade used mouse models to test for effects on immune system functioning upon short-term continuous exposure with ELF-EMF. Their results suggest an association with increased leucocyte count, although the meaning of this finding is still unclear. Additionally, the group conducted experiments with exposure to LF-EMF and impact in animal models (carp). Although *in vitro* results revealed no substantial effects, the researchers do not definitively exclude the possibility of an effect. A third study performed by the group focused on the impact of ELF-EMF and LF-EMF exposure on various intracellular processes. The project was only recently concluded and final results are not yet available. Preliminary results suggest an increased formation of neutrophylic extracellular traps (NET) in samples from human volunteers, though the mechanism of action is not clear. It should be noted that in the early implementation phase of this study the supervisory committee had raised concerns about the lack of theoretical underpinning of this study and the quality of the work. In later stages amendments to the study had alleviated some of these concerns. Overall, the

principal investigator for all aforementioned studies indicated she felt that, although observed effects were small, they merit further investigation.

A second group from the WUR led by Dr. Woelders, investigated effects of EMF exposure (GSM, WLAN, DECT, and UMTS) in chicken embryos. They conclude that the results do not provide strong evidence to suggest that these fields lead to defects in embryonic development. Nonetheless, they recommend follow-up research to reproduce and validate specific observations, as they do observe biological effects on various quantitative characteristics. A separate study by this group, analysing possible effects on immunological processes at cellular level, found no indications for an effect. A separate study by Dr. Blacquière found no impact from UMTS exposure on the development and physiological performance of honeybees.

Lastly, based on a study in mice, prof. Hermans from Radboud University concludes that short-term exposure to modulated LF-EMF induces changes in stress regulation in mice, although the underlying mechanism is not resolved. By contrast, *in vitro* studies in immune cells show no cellular effects. Studies by Dr. Westerink and prof. Kortekaas are still ongoing.

Overall, the studies in the biological domain of the programme have provided some leads that may warrant further investigation, although the majority of studies show no significant effect on any of the parameters studied.

3.1.2 Epidemiology

Within the thematic domain of epidemiology, all funds were awarded to just two institutions: the Institute for Risk Assessment Studies (IRAS) at the University of Utrecht and RIVM. The combined research focused on the following themes:

- Effects of occupational exposure to MRI-related electromagnetic fields (Prof. Kromhout, IRAS)
- Cohort studies on health effects of exposure to ELF-EMF and RF-EMF (Prof. Kromhout, Dr. Slottje, and Dr. R. Vermeulen, IRAS)
- Cognitive effects in children related to maternal and environmental EMF exposures (Dr. A. Hüss, IRAS)
- Electrohypersensitivity and non-specific physical symptoms in relation to exposure to EMF (Dr. I. van Kamp, RIVM; Dr.ir. R. Bogers, RIVM and Dr. A. Hüss, IRAS)
- Evaluation and refinement of an ELF-EMF Job Exposure Matrix for use in epidemiological studies (Dr.ir. Y. Christopher-de Vries, IRAS)

Several of the above studies aimed primarily at the development of models and methods for analysing exposure. Such tools provide much needed information on actual exposure levels encountered in daily life, which is a prerequisite for understanding possible linkages between EMF exposure and health effects.

Based on opinions of interviewees and external experts, some of the most interesting new insights resulting from the epidemiological studies come from studies on people with high probability of occupational exposure to static magnetic fields, such as hospital radiologists, performed at IRAS. Levels of exposure were assessed, as were potential acute and long-term neuropsychological and physical impacts. Several small, but significant transient effects were found on cognition, balance and coordination. These findings are particularly relevant because of increasing levels of exposure for health care workers working with MRI scanners.

Several cohort studies are still ongoing. The GERoNiMo, COSMOS and MOBI-Kids studies in which the group of prof. Kromhout participates are longer-term international studies with an anticipated duration extending beyond the programme. Therefore, results from these studies are not yet available. One completed cohort study did not reveal any clear associations between ELF-EMF exposure and the risk for cardiovascular

and neurological diseases and cancer incidence, except for an increased risk for Amyotrophic Lateral Sclerosis (ALS) connected to electric shocks.

A project led by Dr. Bogers at the RIVM, in which the association between exposure to EMF and the occurrence of non-specific physical symptoms was studied in sub-groups of electrohypersensitive individuals, was not yet completely finished. At the time of this evaluation no final report had been submitted to ZonMw. A separate pilot study by Dr. van Kamp (RIVM) found that actual distance to base stations and high voltage overhead power lines was not associated with self-reported non-specific physical symptoms, but that perceived proximity is. A project by Dr. Hüss (IRAS) to investigate utility of personalised testing of electromagnetic sensibility is currently under way.

3.1.3 Sociology

In comparison to the biological and epidemiological domains, very few projects were awarded within the sociological domain. Most of this research was performed in the group of Prof. Timmermans at the VU University Amsterdam who conducted multiple projects. The first focused on perception of risks posed by EMF in different population groups, including people who report as electrohypersensitive. It found that perceived risk was not so much associated with the strength of the EMF, but more with lack of knowledge about exposure to EMF. Also the role of the government was identified as an important factor in public risk perception of EMF. In a separate project this group explored how communication about scientific uncertainties and policy decisions in relation to EMF can be improved. Results from a third study, in which people's perception and concerns of EMF health risks and their complaints before, during and after the introduction of new EMF equipment are investigated, are not yet available.

Lastly, a project looking at the relationship between political processes around the placement of mobile phone base stations and risk perception was awarded to Dr. Broër at the University of Amsterdam. At the time of this evaluation no results were available yet.

3.1.4 Technology

A significant share of programme funds was allocated to projects within the technological domain. The largest project was conducted in the group of prof. Zwamborn, one of the technological chairs. That project has resulted in the development of new EMF dosimetry models and tools necessary for experimental and epidemiological studies, which have subsequently been applied in several other ZonMw projects, including the research conducted in the group of the biological chair, Prof. Kanaar, and at the WUR. A project led by the other technological chair, prof. van Rhoon, aimed at the assessment of daily EMF exposure in children of different ages. This work has resulted in a lowering of allowable exposure levels for children.

At the RIVM, Dr. Bolte led a project to determine personal exposure during different daily activities using portable exposimeters. Findings show that, even though averaged exposures vary across activities, areas, and times of day, their ranges overlap, permitting a group-based approach to exposure prediction.

Dr. van den Berg, at the University of Utrecht, investigated EMF induced tissue heating and physiological changes in 15 healthy volunteers, using newly developed techniques. It finds that, although exposure of the calf region to RF-EMF induces local tissue heating and increased perfusion, even at maximum allowed exposure levels these effects are considerably lower than those achieved by exercise. Furthermore, the group has developed new methods to determine the temperature effects of MRI and thus improve MRI safety protocols.

3.2 Quality and relevance of projects

3.2.1 Scientific quality and relevance

Members of the programme committee generally viewed the quality of the projects as reasonable to good, with several positive outliers. External experts, who each reviewed the major projects within their own area of expertise, similarly rated the scientific quality as above average by international standards. Most projects were considered sufficiently grounded in scientific theory, and informed by the international state-of-the-art. One expert even described some of the technological projects as "at the frontier of science". The assessed studies were mostly considered well-designed, using acceptable methods that are sufficiently free from bias and confounding. Nonetheless, experts noted several potential biases and sources of confounding in some of the epidemiological and biological projects. These related primarily to small sample sizes and various sub-optimal methodological choices.

Overall, the research questions addressed by the projects were considered sufficiently pertinent from a scientific perspective. Nonetheless, various stakeholders expressed disappointment with the relevance of particular projects. This mainly concerned some of the biological projects, where it was not always considered evident which knowledge gaps the research sought to fill. Several stakeholders indicated they felt these projects appeared method-driven rather than hypothesis-driven, meaning that researchers had fitted their research questions around familiar methods and models, instead of grounding them in sound theories regarding potential mechanisms of action. One interviewee compared these research projects without adequate theoretical underpinning to "searching for a needle in a haystack, without even knowing if the needle is there", regardless of the scientific excellence of the research. By contrast, the technological projects on dosimetry and epidemiological studies, particularly those on occupational exposure, were widely perceived as highly relevant. A number of projects, such as those focused on the potential carcinogenity of EMF or on perception of risks from environmental factors, complemented pre-existing research. Their relevance therefore lies mainly in broadening and solidifying the evidence base, rather than in having provided completely new insights.

3.2.2 Social relevance

At the base of the programme lie concerns about potential public health risks resulting from exposure to EMF. The programme objectives were formulated with the need to investigate these risks in mind. It is therefore of interest to see whether the awarded projects have yielded any results that can be considered of direct societal relevance.

One of the most pressing societal questions, as articulated by interviewees, concerns the issue of electrohypersensitivity. Particularly in the early phase of the programme, stakeholder organisations representing the interests of people with EHS felt that the programme did not sufficiently address this issue. After discussion between the members of the EMF Focus Group and ZonMw, this was subsequently tackled by an additional call for EHS-related projects. Thus far this research has resulted in better information on personal levels of exposure, which may prove of value to EHS patients, and has provided guidance to improve risk communication and strategies for risk mitigation. At the same time, although not all studies have been concluded, exposure studies have thus far not uncovered any conclusive association between EMF and the symptoms experienced by people with EHS. Although from a scientific point of view these negative results are very valuable, they do little to alleviate the concerns of people with unexplained health complaints who feel that these epidemiological studies do not sufficiently take their individual characteristics into account. Some members of the EMF Focus Group of the Knowledge Platform have also expressed discontent with the, in their view undue, emphasis some studies placed on psychological factors as an explanatory or contributing factor to EHS. In their perception, the research performed within the programme has shown insufficient alignment with the specific needs and concerns of people with EHS.

It should be noted that, despite the above-discussed criticisms, the programme has contributed to research on several other important societal concerns such as the relation between EMF and cancer, and risks from occupational exposure to EMF.

External experts and other stakeholders were also asked to provide their opinion on the overall balance between the societal relevance of projects and their scientific quality. Generally, this balance was considered adequate, although some felt it had tilted too far towards scientific quality. As one expert stated: "I do not know examples of proposals with a low scientific quality that were granted, but I could find some examples of proposals with a high scientific quality that were granted and that had less relevance to the real (short term public) social EMF questions."

3.2.3 International alignment

The EMF&H programme has sought international alignment in several ways. First of all, it was based on recommendations issued in 2006 by the Health Council of the Netherlands, which had taken the WHO recommendations on EMF research into account. This is most apparent in the granted epidemiology and sociology projects, which according to external experts align well with the priorities for research into EMF and health identified by the WHO.[19] This is somewhat different for the assessed biology projects, where four out of six studies focused on endpoints related to immune responses. According to the expert assessment this does not reflect the international EMF&H research priorities. With regard to the technology projects, the 2010 WHO Research Agenda states that there are 'no high priority and no other research needs' on EMF mechanisms[20], but this is mostly because no mechanisms of interaction have been identified to date.

Furthermore, the programme committee is partly composed of international experts. The committee has currently 12 members, of which seven are foreign members (e.g. from Belgium, Switzerland and the USA). This mixed membership acts to counterbalance the fairly small Dutch EMF field. International experts have also been involved as external reviewers of submitted proposals.

Throughout the programme, several calls for international projects have been launched to set up the research infrastructure in such a way that it makes a high-quality contribution to the international research effort. In the first round €500k was granted for participation in an international cohort study. Additionally, around 30 smaller, international projects (maximum of €50k) were granted, such as attending or organising seminars with international speakers, visiting laboratories in other countries, and learning research techniques that were then brought back to the Netherlands. A number of international collaborations were initiated (see also section 2.2). Nonetheless, based on expert assessment of the technological projects, even closer cooperation with national and international groups can further benefit the efficiency of projects. Interviewees and experts have stated that, as a result of the above, several of the Dutch research groups have become more imbedded in the international network of EMF research. This is particularly the case for researchers in the sociological and epidemiological projects.

From an international point of view, some of the projects (e.g. on dosimetry and on occupational EMF exposure) may be considered unique and innovative, whilst other projects have focused on similar questions as those being addressed elsewhere. The latter includes, for instance, the sociological projects, where findings largely align with current thinking on risk perception and communication. Although the knowledge gained is not completely new, such studies do contribute important knowledge about the role of contextual factors, such as a country's specific population and information availability. Insights into such factors may improve national strategies regarding communication of EMF risks.

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[19] WHO Research agenda for radiofrequency fields, 2010.

[20] WHO Research agenda for radiofrequency fields, 2010.

Several projects have focused on an important area of research that has also been studied in other European countries. In particular, investigators for some of the epidemiological projects take part in several large international consortia (COSMOS, GERoNiMO, Mobi-KIDS), and of national expert groups on EMF in different countries. Some of the other epidemiological projects rely little on international collaborations but do fit well within the international scope of research in this field and bring to this area a number of novel and improved study approaches.

Most of the biological projects, by contrast, are not expected to greatly contribute to the advancement of international EMF&H research efforts, as they are too diverse in nature. By haphazardly targeting many different mechanisms at a time, without connection to ongoing research efforts, these projects can at best generate new leads but cannot conclusively demonstrate or disprove any effects. The technology projects have provided valuable contributions to related international research, but they are too few to significantly contribute to an overarching agenda.

4. Communication and public perception of health risks of EMF

4.1 Dissemination of findings in the scientific community

4.1.1 Outputs generated

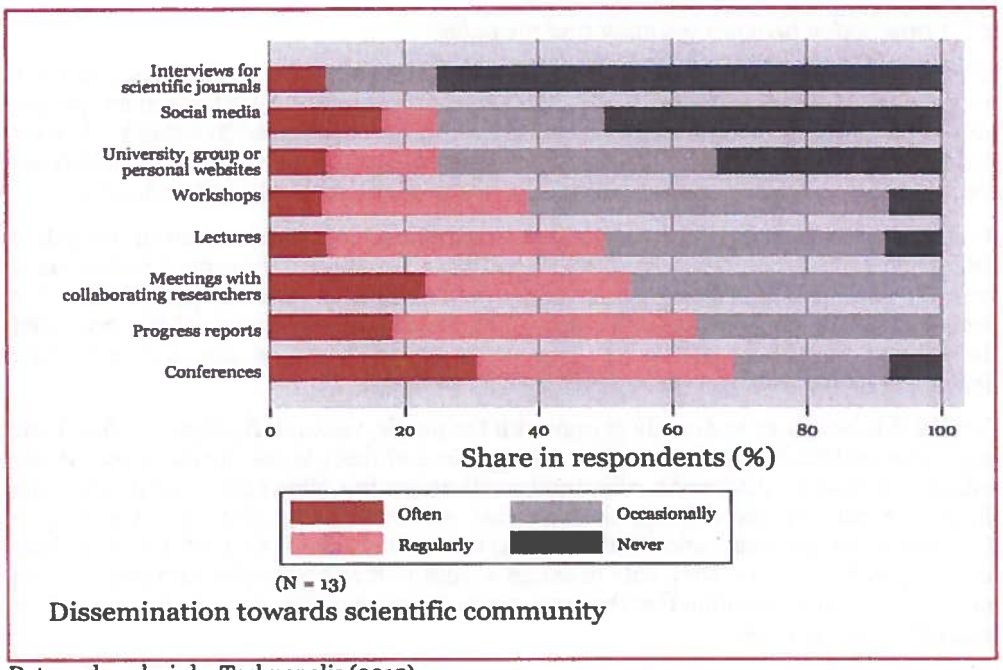
In accordance with ZonMw grant conditions, researchers were expected to publish their results in a peer-reviewed journal (international or national) or – if appropriate – by means of a patent.[21] A follow-up publication in a Dutch journal was recommended. Once a paper had been accepted, researchers were expected to inform ZonMw and send a copy of the paper in advance of publication. ZonMw forwarded this in strictest confidence to the secretariat of the Knowledge Platform EMF to allow the platform to prepare itself and the researchers for any public debate.

Based on a list of publications thus provided by ZonMw, at the time of this evaluation a total of 110 articles (including reviews, comments and study protocols) that could be attributed in whole or in part to projects funded under the programme had been published. Nearly all of these were in international (English language), peer-reviewed journals; only one was published in a Dutch language journal (*Nederlands Tijdschrift voor Stralingsbescherming*). Although it is not possible to provide an estimate of how many more articles may still be expected from the programme, interview data suggest at least a dozen more are in preparation.

Based on survey responses, conference presentations were the primary mode of communication of findings to the scientific community, followed by journal publications and contributions to other scientific publications (e.g. books, reports)(Figure 8). Most researchers additionally reported attending workshops, and providing lectures as ways in which they disseminated results. University, group or personal websites and blogs were used by a slight majority (62%), whereas just five researchers reported ever having used social media channels such as LinkedIn or Twitter to showcase their findings. Interviews for scientific journals were done primarily by the chairs. Several researchers have actively worked with parties such as the municipal health services and health practitioners, as well as with private organisations, such as Philips (a manufacturer of MRI scanners) to discuss findings and translate these into guidelines and protocols. The programme did not yield any patents.

[21] This paragraph is a summary of ZonMw's EMFH Programme proposal (2007)

Figure 8 Methods used for dissemination of scientific results



Data and analysis by Technopolis (2015)

Members of the Supervisory Committee assessed the scientific outputs generated by the programme, in terms of volume and quality, as ranging from 'modest' to 'excellent', with variation across the thematic areas and individual projects.

4.1.2 Debate within the scientific community

A considerable amount of the research on potential health effects from EMF has produced negative findings. Despite increasing recognition within the scientific community of the importance of negative results, in general it is still considered more difficult to publish such negative findings than positive ones. On the other hand, in the field of EMF&H research the scientific consensus leans towards 'no effect', and positive findings therefore may be viewed with greater scepticism. It is therefore interesting to explore how the scientific debate may have influenced the communication and dissemination of research findings.

Overall, most researchers interviewed agree that the scientific community has been starkly divided on the issue of whether or not EMF can cause health effects and that the debate between the different camps has often been heated. At the same time, many of them feel this is not necessarily harmful and that, in fact, science benefits from such critical thinking and discussion, provided the tone of the debate remains sufficiently civil. Despite this polarisation, researchers interviewed indicated they experienced sufficient room for open scientific dialogue. It was recognised that publication of findings that may be considered contradictory to mainstream thinking could be challenging, but this was not considered in any way specific to EMF&H research. One researcher expressed concern that other researchers in the field had engaged in cherry picking, selectively publishing positive results. However, there is insufficient information to verify this claim.

4.2 Dissemination of information to the general public

4.2.1 Interaction between scientists and the public

Although ZonMw encourages researchers to widely disseminate their findings, it has not required individual researchers to directly discuss their findings with the general public. Moreover, as past experience has shown that results are often used by other parties for their own purposes, ZonMw cautioned researchers against discussion of preliminary results as this could have unnecessary negative repercussions for the public debate.

As discussed in section 2.3, the chairs have contributed to various extent to the public discussion and interpretation of scientific findings. However, other project leaders have indicated that they opted to stay out of the public arena as much as possible, as they were acutely aware of the public scrutiny of their research and have at times perceived the tone of the debate as hostile. The extent to which this is the case may vary, depending on the nature of the research and the findings.

Despite this hesitancy to directly engage with the public, research findings can find their way to the public domain in a variety of ways. One of these is the mention, potentially with accompanying discussion, of journal publications in online and social media. This dispersion can be traced using the so-called *Altmetric* score. Such a score can be determined for any publication with a Digital Object Identifier (DOI). Of the 110 unique journal publications, we were able to assign a valid DOI to 66 articles. Of these, 22 had an *Altmetric* score, meaning that these papers had been mentioned in one or more of the tracked online channels.

Not surprisingly, the most commonly used channel was *Mendeley*, an online platform for managing and sharing research papers that is primarily used by researchers. A reference on Mendeley should therefore not be considered a reference made by the general public. The second most popular platform was Twitter, on which 18 of 22 studies had at least one reference. The average amount of references on Twitter was 3.7 mentions per study. The most referenced publication was tweeted ten times[22]. The third most popular platform was Facebook, where 11 publications had at least one reference and the most popular article was referenced five times[23]. Other dissemination channels included news websites, Wikipedia, blog posts and references in peer review websites (Publons). All of these channels were encountered once. Because of the low number of articles with an *Altmetric* score, we could not conduct a meaningful analysis of the results in terms of types of articles referenced or the context in which this occurred.

These findings should lead to the conclusion that the programme outputs have not found a broad reach through social or other online media, at least not in a way that is traceable by *Altmetric*. This is consistent with the observation that researchers themselves indicate they do not routinely engage with these types of media for professional purposes. Furthermore, the lack of public attention for these studies is hardly surprising, given that the outcomes from most studies are consistent with mainstream scientific consensus and that so far no strong indications have been found for potential harmful effects. However, it should be noted that we did not conduct a search for mention of articles or even names of researchers on the websites of civil society groups, such as *Stop UMTS!* or *Stichting EHS*, who are known to regularly comment on publications relating to EMF.

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[22] Schaap K, Christopher-de Vries Y, Mason CK, de Vocht F, Portengen L, Kromhout H (2014) *Occupational exposure of healthcare and research staff to static magnetic stray fields from 1.5-7 Tesla MRI scanners is associated with reporting of transient symptoms.* Occup Environ Med 71(6):423-9.

[23] Calderón C1, Addison D, Mee T, Findlay R, Maslanyj M, Conil E, Kromhout H, Lee AK, Sim MR, Taki M, Varsier N, Wiart J, Cardis E. (2014) *Assessment of extremely low frequency magnetic field exposure from GSM mobile phones.* Bioelectromagnetics 35(3):210-21.

4.2.2 Role of the Knowledge Platform EMF and ZonMw in information dissemination

The Knowledge Platform EMF was specifically created to provide reliable information to the public on matters concerning EMF&H. Although not a part of the programme, it therefore plays an important role in collecting scientific findings emanating from the programme, placing this in context and making it accessible to the general public. Many interviewees, project leaders as well as other stakeholders, indicated that they valued the work of the platform and that they attended the meetings whenever possible. Many researchers considered the platform the preferred way for sharing their findings with a wider audience, and several have presented their work at meetings of the platform. On the one hand, this is indicative of the value researchers attribute to the platform. On the other, it reflects their reluctance to directly engage with the general public.

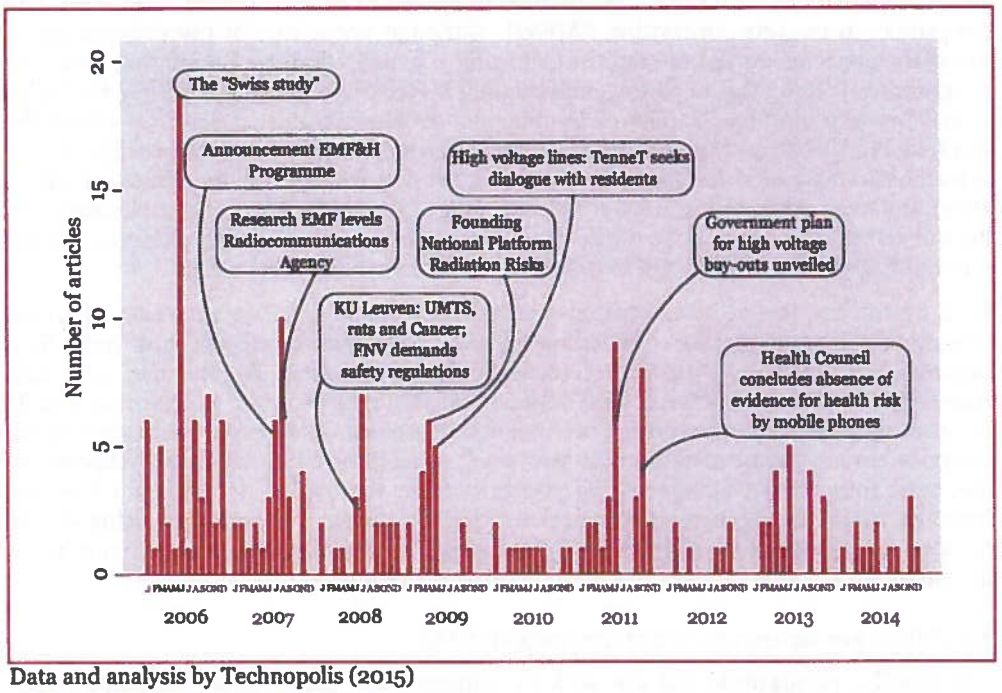
As is customary, ZonMw has created a website for the EMF&H programme where all programme documentation –including project descriptions, though not (yet) final reports– are available. During the course of the programme, ZonMw has cautioned researchers against premature dissemination of findings to avoid causing potentially unwarranted distress. However, now that most projects have been concluded, some interviewees have suggested that ZonMw could, proactively communicate a summary of the most important findings of the programme to the public. It could do this, for instance, by preparing laymen summaries of project results and press kits. This should be done in collaboration with the EMF Knowledge Platform, which is the primary point of contact for the general public in matters relating to EMF&H.

4.3 Public perception of health impacts of EMF

The ZonMw programme did not seek to influence the public debate around health impacts of EMF in any other way than to support generation of knowledge on this issue. Changes in the public perception of health risks associated with EMF should therefore not be seen as a programme objective. It is, however, of interest to see how this debate may have evolved over the course of the project, whether the programme has contributed to this, and which concerns are at present most evident. To this effect a review was conducted of articles published in Dutch national newspapers.

In total, 217 unique articles were identified that reported on EMF in connection to health. Figure 9 shows the monthly reporting frequency, which suggests that reporting is often clustered around spikes that deviate from a mostly non-zero baseline. The main peaks in reporting occur in 2006, 2007, 2008, 2009 and 2011. Based on the content of the articles within these periods, most peaks could be correlated to specific events. These include the publication of high-profile studies (in 2006, 2008 and 2011), the announcement of new programmes or platforms (in 2007 and 2009, or the announcement of policy measures (in 2009 and 2011). For instance, in 2006 a Swiss research team published a study that, contrary to a previous study by TNO, found no effects from EMF on wellbeing or cognitive performance, whilst in 2011 the government announced its intention to offer a buy-out to residents near high voltage power lines. Interestingly, the frequency of reporting appears to have decreased in intensity over the years, although the reason for this trend is unknown.

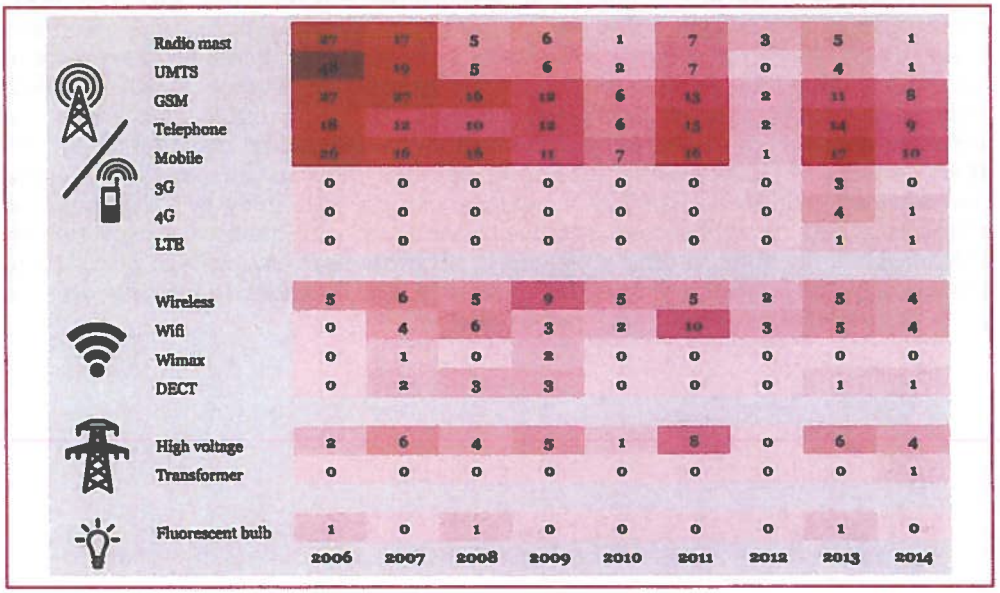
Figure 9 Timeline of EMF related publications in Dutch national newspapers



Data and analysis by Technopolis (2015)

To investigate more specific trends in reporting over time, keyword searches were conducted within the identified newspaper articles for individual technologies (Figure 10) and for health issues most frequently linked to exposure to EMF (data not shown). Figure 10 shows the frequency of appearance of technologies by type and year of publication. Note that articles may contain multiple keywords so can be counted more than once.

Figure 10 Annual frequency of reporting on technologies.



Data and analysis by Technopolis (2015).[24]

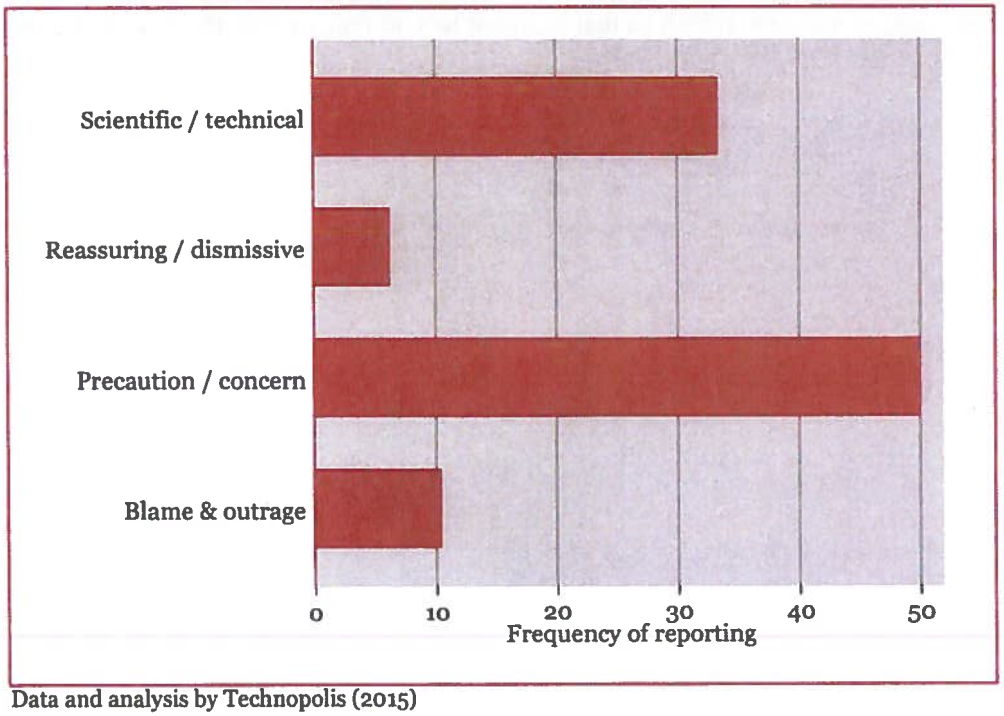
[24] Images courtesy of NAS, Olivier Guin, and Shane David Kenna from the Noun Project.

As both Figure 9 and Figure 10 show, 2006 is clearly the year with the most reporting on EMF and health in Dutch national newspapers. In this period, UMTS was the most frequently reported technology. GSM remains a fairly frequently used keyword throughout the period of analysis, alongside the more generic keywords telephone and mobile. It should be born in mind that the term GSM is often used to describe mobile telecommunications in general, although in the strict sense it refers to a second-generation technology that has been supplemented by UMTS and subsequently 3G and 4G/LTE. Aside from GSM and related technologies, high voltage power lines are most consistently subject of coverage throughout the reporting period; they are often mentioned in conjunction with other technologies in articles reviewing EMF in general. Furthermore, Wifi picks up attention with some regularity, but mostly as part of a broader discussion. Analysis of the mention of various diseases and health complaints showed no clear trends, other than that cancer was the most frequently and constantly cited concern.[25]

The ZonMw programme was explicitly mentioned 14 times during the reporting period and project leaders funded by the programme were mentioned 29 times. No particular trends were observable in these data.

For newspaper articles longer than 600 words, the content was analysed and categorised into one or more of the following four categories: 1) Scientific/Technical (mostly neutral in tone, summarising available evidence), 2) Reassuring/Dismissive (primarily focused on alleviating concerns), 3) Precautionary/Concerned (focusing mainly on potential risks), or 4) Blame & Outrage (expressing anger over particular actions or policies). The content for 34 articles was thus categorised (Figure 11).

Figure 11 Content categorisation of analysed newspaper articles



Data and analysis by Technopolis (2015)

[25] Articles were scanned for the following (parts of) terms: Allergi*,Alzheimer, kanker, elektrosens*, elektrohypers*, EHS,sensiti*, elektrogevoelig*, elektrostress, elektrosmog.

Two frames were found dominant: over two thirds of all articles could be considered precautionary/concerned (24 of 34) and nearly half as Scientific/Technical (16 articles). Only three articles were categorised as Reassuring/Dismissive, and five as Blame & Outrage. There was no discernible change in tone of reporting over time.

Overall, it can be said that Dutch media report on EMF and health mainly in a cautionary or scientific-neutral way. Dismissive articles were found only on a few occasions and articles describing outrage are always placed in a broader cautionary context. Upticks in reporting by Dutch media are largely associated with new scientific findings or government interventions. Broader technological terms, such as "mobile", "telephone" or "high voltage", are always in scope, whereas more specific terms are shorter-lived, probably due to the short lifespan of (most) communications-related technologies. Clear trends in reporting on either individual technologies or on health issues could not be identified. The ZonMw research programme has sporadically appeared in national media, mostly in connection to the announcement of the programme. Researchers making the news mostly did so in a consultative role and never directly in relation to findings due to the programme.

Based on the preceding analysis, it is difficult to conclude if or how the programme has shaped the public debate, as there has been little direct mention of the programme and its outputs in the media. Representatives from the EMF Knowledge Platform suggest that the research by the programme –in conjunction with research conducted elsewhere– may have contributed to a feeling in the general population that at least some questions have now been sufficiently investigated and will have helped to reduce some of the predominant concerns. However, for particular groups the creation of the programme itself may have achieved the opposite by signalling that "where there is smoke, there is fire". Also, over the course of the programme new technologies that rely on EMF have emerged and others have become more prevalent. Consequently, some of the concerns will have shifted so that it cannot be said that, overall, the concerns about health effects from EMF have abated.

5. Conclusions and recommendations

5.1 Conclusions

This evaluation intended to address three main questions. Based on the information provided in the preceding chapters, the following section provides succinct answers to each of these.

Has the Dutch scientific infrastructure in the field of EMF been strengthened?

The scientific infrastructure has been defined as the collective of researchers, research facilities, and supporting structures such as professional networks and collaborations. Over the years, the ZonMw programme has enabled over a dozen (assistant) professors and nearly a hundred graduate and postgraduate researchers to work on topics related to EMF&H. Many of these researchers had little to no prior experience in this field. By drawing new researchers into the field and allowing them to acquire the required skills and expertise, the programme has contributed to a significant expansion of the knowledge base. The programme has also fostered greater collaboration between research groups, both nationally and internationally. A physical infrastructure essential to this type of research was developed as well as new methodologies. It can therefore certainly be said that, at least in the short-term, the infrastructure in the field of EMF&H was strengthened.

In the long run however, the created infrastructure will likely prove not very sustainable. For most researchers their engagement in the field has been temporary, due to a lack of continued interest and because of expectations of reduced funding availability. With the notable exception of groups at Utrecht University and, to a lesser extent, Erasmus University, most groups have only received funds to support a small number of one-off projects. It can therefore be argued that a considerable portion of the funding was spread too thinly to make a meaningful and lasting contribution to a research infrastructure. This is further underscored by the fact that at several institutes the physical infrastructure has already been partly dismantled.

The financing of several chairs was intended to embed EMF&H research within the broader scientific infrastructure, by ensuring continued institutional commitment. This expectation has not been realised. Late appointments of the chairs in the technological and biological domains has meant that only a limited number of projects were allocated to these research groups, and that overall collaboration between groups and disciplines did not materialise to the intended extent. Also the interpretation of some of the chairs as short-term projects, rather than as instruments for developing a strong, interlinked knowledge infrastructure for EMF&H research, has meant that the infrastructure was not effectively rooted. At present, only the epidemiological chair and one of the technological chairs are expected to continue in the field after the programme's conclusion.

Although the ZonMw programme has made an important contribution to the scientific infrastructure for EMF&H research, its long-term impact will probably be limited. However, the expectation of building a long-term sustainable infrastructure is likely to have been unduly optimistic for a scientific field that has little professional appeal to researchers and in which limited funds are available. Additionally, it can be questioned whether there is in fact a need to sustain such a dedicated infrastructure, as much of the required expertise appears to be generic and relatively easily transferable.

Did the granted research proposals contribute to clarifying possible effects of EMF on health?

Because of a lack of obvious scientific leads for investigation in many areas, the programme has been characterised by a very broad focus. Many projects were driven by available expertise rather than by a concerted effort to replicate studies and deepen the knowledge about previously investigated effects, or by robust hypotheses for mechanisms of action. Consequently, there has been no well-defined overarching

research question. It is difficult for a programme of this nature to provide conclusive answers on any aspect of the problem. Nevertheless, the programme has yielded a number of smaller contributions.

Some of the most important contributions have arisen from studies on occupational exposure to static magnetic fields, such as those found in MRI scanners. Small, but significant transient effects were found on cognition, balance and coordination. This, and other work, has contributed to the development of improved MRI safety protocols. Furthermore, biological studies have provided leads that may warrant further investigation, mainly in connection to effects on the immune response. However, the majority of these studies have found no significant effect on any of the parameters studied. A study on risk communication in relation to EMF has found that perceived risk from exposure to EMF is associated with lack of knowledge about EMF and a lack of trust in the role of the government. These findings may be of use in development of better communication protocols. In addition to the aforementioned studies, the programme has supported the development of new techniques and models of great importance to biological and epidemiological studies involving EMF exposure.

A number of projects are either still running, or have been concluded but final results are not yet available. Several large international cohort studies that investigate the relationship between EMF exposure and various health problems are still ongoing. Results from these will not be available for some time still. Furthermore, some notable projects that investigate the potential association between exposure to EMF and the occurrence of non-specific physical symptoms (including electrohypersensitivity) were started late in the programme and final results from these are not yet available.

Eventually, the quality of awarded projects was generally considered reasonable to good, with some projects even considered leading in the field. Initially, however, the programme struggled to attract a sufficient number of good quality proposals. This difficulty suggests that there was inadequate absorptive capacity within the Dutch research community in comparison to the amount of funding available. Consequently, also some projects were funded of sufficient, though by no means remarkable quality. More problematic perhaps is that, notwithstanding their scientific soundness, various projects were deemed lacking in relevance. Scientifically, these projects did not align with international research priorities so that their results have little power. Because of their lack of connection to a broader research agenda, these projects also fell short of standards of societal relevance. In retrospect, a better balance between scientific and social merit might have been achieved by greater involvement of all stakeholders in the definition of calls.

Overall, the contributions the programme has made in clarifying possible effects of EMF on health, be it by demonstrating them or by conclusively refuting them, are fairly modest, despite some high quality research. To a significant extent this can be attributed to the open design of the programme, which has provided limited connection between separate projects. Consequently, the statistical power of individual findings is quite low and few overarching conclusions can be drawn with any certainty.

What was the impact of the programme on society and on the public concern about possible health effects of EMF?

The programme was not intended as a vehicle to exert influence over the public concern with exposure to EMF. Rather, its main role was to support research that would contribute to clarifying potential health effects and, in doing so, provide the government and the public the information necessary for evidence-informed decision-making. It is difficult to determine to what extent information generated by the programme has influenced public thinking regarding EMF and health. For most project leaders, communication with a broader audience beyond the scientific community has been limited to presentations given within the setting of the Knowledge Platform EMF. This platform is considered the most appropriate forum for facilitating such dialogue.

It has been argued that not so much the activities of the programme, but its creation itself has had an impact on public concern by sending the signal that, if research is being

conducted, there must be legitimate cause for concern. The evidence for this, however, is strictly anecdotal and the impact, if at all present, likely limited in scope. Thus far, there has been little mention of the programme or any of the projects conducted under it in national media. Any trends in reporting on EMF and health appear associated mainly with the publication of high-profile studies or announcement of new regulations.

It can be concluded that it is unlikely that the programme has had much direct impact on society and on the public concern about possible health effects of EMF. However, with the results of the majority of projects now available, ZonMw and the EMF Knowledge Platform could still seize the opportunity to reach a broader audience by preparing accessible project summaries and communicating the main findings to the media.

Overall conclusion

The EMF&H programme was instituted by the Dutch government because of a felt obligation for the Netherlands to actively contribute to, and participate in international research efforts in the field of EMF and health. Despite concerns in Dutch society about increasing exposure levels and new technologies, at the time few researchers were actively working in this area. It is evident that without the EMF&H programme this situation would likely not have changed much and that the majority of projects would not have been conducted at all. Nonetheless, the programme has not been as efficient as it could have been, in large part because of the way in which it was designed.

In its report the Health Council refrained from prioritising specific research areas. Rather, it offered a number of social and scientific arguments that could be used in prioritisation. In translation of the recommendations into a research programme, the Programme Committee did recognise the danger of spreading resources too thinly and selected a number of priorities in each of the thematic domains, which formed the basis of the calls for proposals. Nonetheless, the selected priorities were still fairly wide-ranging and did not adequately form a coherent, overarching theme. Although this decision is understandable in the context of the lack of clear scientific leads and limited available expertise at the time, in hindsight it should be concluded this approach has proved a stumbling block to the realisation of the programme objectives. A better tactic could have been to use a more staggered approach with subsequently narrowing focus in later calls and more time spacing between calls. Such an approach would entail starting from a relatively broad initial base, consisting of a limited number of pilot projects. In a subsequent stage, only the most promising projects would be selected for follow-up and new projects would build further on the hypotheses and findings of these initial pilots, rather than pursue completely separate research questions.

Based on the considerations above, it must be concluded that, although the programme has contributed to some high quality and important research, it has had limited success in creating a sustainable scientific infrastructure for EMF&H research in the Netherlands. Likewise, it has yielded valuable new insights in several areas, but the lack of an overarching theme has meant that the overall contribution to the international EMF& research agenda has been fairly modest.

5.2 Recommendations

The evaluation is primarily retrospective in nature and is not intended to directly advice on continuation of the programme or the possible contents of such a programme. Nonetheless, a number of observations were made that may serve as input for decision-making.

First, many stakeholders still see grounds for continued and properly focused research as unanswered questions remain. This should involve a clear prioritisation of research questions, based on both scientific considerations (e.g. need to reproduce findings, promising leads) and societal relevance. This prioritisation process should appropriately involve all relevant stakeholders. A future EMF&H research agenda should, furthermore, be based on a long-term strategy and on ensuring financial continuity for extended projects. If no more dedicated funds for EMF&H research will become

available, researchers in the field should be supported in applying for funds from other sources, e.g. from EU or national basic research funding programmes.

A significant number of project leaders have indicated that they personally will not be pursuing further research in the field. This raises the question of whether there will be enough critical mass to implement an eventual EMF&H research agenda. To maintain some of the created scientific infrastructure in the Netherlands, expertise could be concentrated in a small number of institutes, with sufficient emphasis on multidisciplinary collaboration.

Prospective funding for new EMF&H projects should be viewed both in terms of prioritisation of other research agenda's, and of prioritisation within the EMF&H agenda. The latter includes deciding on which research questions should be considered conclusively answered, and which ones merit further investigation. In the latter category, stakeholders have flagged several options. One of the most pressing matters is continued investment in projects that investigate potential long-term impacts to allow for a sufficiently long time horizon. Furthermore, to reap the full benefits of the programme, follow-up funding could be provided to projects that have yielded promising leads. Several other areas have been identified. The following should, however, not be taken as a comprehensive needs assessment, as this would require a broader stakeholder consultation.

- The most frequently suggested need for further study concerns electrohypersensitivity. Proposed approaches range from studies into possible links between EHS and neurological disorders and the role of chronic stress, to studies into the effectiveness of treatment interventions for people suffering from symptoms attributed to EHS.
- Continued work on further elucidation of occupational risks from exposure to static fields (MRI) and how to mitigate these.
- Potential use of EMF for therapeutic applications, such as in treatment of depression or cancer. Potential applications for cancer treatment involve EMF-induced hyperthermia or electroporation of cells, whereas neurotherapeutic applications are based on transcranial magnetic stimulation. Both types of applications require EMF exposure at dosages greatly exceeding normal exposure levels. They may, however, offer valuable new insights into potential mechanisms of action for impacts of EMF at the cellular level.
- Development of improved risk communication protocols.

Appendix A Survey results

The survey results have been supplied as a separate attachment to this report.

Appendix B List of interviewees

Name	Organisation	Role
Dr. E. van Rongen	Gezondheidsraad	--
Prof. dr. ing. G.C. van Rhoon	Erasmus MC	Chair
Prof. dr. ir. A.P.M. Zwamborn	TU/e, TNO	Chair
Prof. dr. H. Kromhout	Utrecht University	Chair
Prof. dr. R. Kanaar	Erasmus MC	Chair
Dr. G. Ferwerda	Radboud MC	Project leader (biology)
Dr. H. Woelders	WUR	Project leader (biology)
Dr. B.M.L. van Kemenade	WUR	Project leader (biology)
Dr. A. Hüss	Utrecht University	Project leader (epidemiology)
Dr.ir. R.P. Bogers	Utrecht University	Project leader (epidemiology)
Prof.dr. D.R.M. Timmermans	RIVM	Project leader (sociology)
Dr.ir. C.A.T. van den Berg	Utrecht University	Project leader (technology)
Dr. J.F.B. Bolte	University of Amsterdam	Project leader (technology)
Prof. Dr. T.J.F. Savelkoul	VUMedical Centre	Programme committee
Prof. dr. M. Mevissen	University of Bern	Programme committee
Mr. H. Schooneveld Mr. J. Timmer	Stichting EHS	EMF Focus Group
Mr. A.C.G. Veldhuizen	TenneT	EMF Focus Group
Mr. E. Lebret Mr. F. Woudenberg	RIVM GGD Amsterdam	Knowledge Platform
Ms. S. van 't Padje	ZonMw	Programme officer

Appendix C Interview guides

C.1 Programma commissie

Wetenschappelijke kwaliteit & relevantie van projecten

- In hoeverre sluit de samenstelling van de project portfolio aan op de naar uw mening meest urgente kennishiaten binnen het EMV&G onderzoek?
  - Zijn er onderzoeksvelden niet of onvoldoende vertegenwoordigd? Zo ja, is hierop niet ingediend of zijn deze voorstellen niet geselecteerd?
  - In hoeverre sluit de portfolio aan bij internationale onderzoeksagenda's en onderzoeksprioriteiten op dit gebied? Bijv. van WHO en de EU.

- Wat is uw algemene indruk van de wetenschappelijke kwaliteit van het onderzoek dat verricht is in het kader van het programma?
  - Verschilt dit per domein? Waarom wel/niet?
  - Is de kwaliteit veranderd gedurende het programma? Zo ja, waardoor?
  - Was het onderzoek voldoende origineel en innovatief?
  - Hoe verhoudt de kwaliteit van het onderzoek zich tot dat van dergelijk onderzoek in het buitenland?
- In hoeverre zijn de resultaten van het onderzoek dat verricht is in het kader van het programma voldoende gedeeld binnen het vakgebied?

Maatschappelijke relevantie van projecten & rol van samenleving

- Welke rol heeft het maatschappelijke debat omtrent EMV&G gespeeld in de selectie van projecten?
- In hoeverre komt de samenstelling van de project portfolio naar uw inzien overeen met de vragen en zorgen vanuit de samenleving over EMV?
- Is er vanuit de projecten voldoende gedaan om onderzoeksresultaten te delen en bespreken met de samenleving?

Realisatie verwachtingen & doelstellingen

- Naar uw mening, in hoeverre heeft het programma bijgedragen aan het opbouwen van een duurzame onderzoeksinfrastructuur voor onderzoek naar EMV&G in Nederland? T.a.v.:
  - Training van individuele onderzoekers
  - Benoemingen van onderzoekers en oprichten onderzoeksgroepen
  - Fysieke infrastructuur (apparatuur, gebouwen)
- Naar uw mening, in hoeverre heeft het programma bijgedragen aan het bevorderen van samenwerkingen tussen onderzoeksgroepen en het opbouwen van netwerken? T.a.v.:
  - Op nationaal niveau

- Op internationaal niveau
- Van multidisciplinaire aard

- In hoeverre hebben de onder het programma ingestelde leerstoelen bijgedragen aan het opbouwen van een duurzame EMV&G onderzoeksinfrastructuur?
- Naar uw mening, wat zijn de 3 belangrijkste nieuwe inzichten die het programma tot nog toe heeft opgeleverd met betrekking tot de mogelijke gezondheidseffecten van EMV?
  - Kunnen er in de komende 5 jaar op dit vlak nog andere nieuwe inzichten resulterend uit het programma worden verwacht?
  - In hoeverre zijn de behaalde inzichten al vertaald naar de praktijk, of is het de verwachting dat dit nog zal gebeuren?
- Naar uw mening, wat zijn de 3 meest succesvolle projecten en de 3 minst succesvolle projecten binnen het programma geweest?
  - Wat heeft deze projecten wel of juist niet succesvol gemaakt?
- Hebben de uitgevoerde projecten ook bijgedragen aan ontwikkelingen van inzichten of technieken die relevant zijn in andere wetenschappelijke gebieden? Zo ja, welke?

Opzet van het programma

- In hoeverre was het opzetten van een EMV&G onderzoeksprogramma noodzakelijk voor het stimuleren van onderzoek op het gebied van EMV&G?
- In hoeverre waren de oorspronkelijke doelstellingen[26] van het programma voldoende realistisch, dan wel voldoende ambitieus ?
  - Zijn de beschikbare financiële middelen voor het programma voldoende geweest voor het realiseren van de beoogde programma doelstellingen?
- Is het programma voldoende in staat geweest om in te kunnen spelen op nieuwe ontwikkelingen binnen de looptijd van het programma? *(uitvoering d.m.v. single calls[27])*. T.a.v.:
  - Nieuwe inzichten en ontwikkelingen binnen het EMV&G onderzoek
  - Nieuwe technologische ontwikkelingen (bijv. sterke toename mobiel internet)
  - Ontwikkelingen in het maatschappelijke debat

Toekomst

- Is voortzetting van een dergelijk financieringsprogramma wenselijk? Waarom wel/niet en zo ja, op welke wijze?

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[26] De twee voornaamste doelstellingen van het programma waren: 1) Het opbouwen van een duurzame onderzoeksinfrastructuur voor EMV&G onderzoek in Nederland; 2) Het bijdragen aan nieuwe inzichten naar de mogelijke gezondheidseffecten van EMV.

[27] Er zijn 8 verschillende soorten calls geweest, maar slechts 1 van elk soort.

C.2 Klankbordgroep

Relevantie & kwaliteit van het programma

- Wat zijn naar uw mening op dit moment de belangrijkste vragen en zorgen vanuit de samenleving over EMV?
  - Is dit in de afgelopen 10 jaar veranderd? Zo ja, wat is hiervoor de oorzaak?
- In hoeverre is het EMV&G onderzoeksprogramma naar uw mening tegemoet gekomen aan deze vragen?
  - Zijn er specifieke vragen of onderwerpen die in het programma onvoldoende aan bod komen, dan wel oververtegenwoordigd zijn?
  - Op welke wijze zijn de adviezen van de klankbordgroep meegenomen in het ontwerp van het programma en de selectie van de projecten?
- Wat is uw algemene indruk van de kwaliteit en wetenschappelijke onafhankelijkheid van het programma en de gefinancierde onderzoeksprojecten?

Communicatie rond het programma

- Naar uw mening, is er vanuit de projectleiders en onderzoeksgroepen zelf voldoende gedaan om studie resultaten te delen en bespreken met een breed publiek?
- Op welke wijze zou u graag zien dat EMV&G wetenschappers hun resultaten delen en bespreken?
- Hoe heeft u de samenwerking en communicatie tussen ZonMw en de klankbordgroep met betrekking tot het programma ervaren?

Realisatie verwachtingen & doelstellingen

- Naar uw mening, wat zijn de 3 belangrijkste nieuwe inzichten die het programma tot nog toe heeft opgeleverd met betrekking tot de mogelijke gezondheidseffecten van EMV?

Opzet van het programma

- In hoeverre was het opzetten van een EMV&G onderzoeksprogramma noodzakelijk voor het stimuleren van onderzoek op het gebied van EMV&G in Nederland?
- In hoeverre waren de oorspronkelijke doelstellingen van het programma voldoende realistisch, dan wel voldoende ambitieus?

Toekomst

- Is voortzetting van een dergelijk financieringsprogramma wenselijk? Waarom wel/niet en zo ja, op welke wijze?

C.3 Kennisplatform

Wetenschappelijke kwaliteit & relevantie van projecten

- Wat zijn naar uw mening op dit moment de belangrijkste vragen en zorgen vanuit de samenleving over EMV?
  - Is dit in de afgelopen 10 jaar veranderd? Zo ja, wat is hiervoor de oorzaak?
- In hoeverre komen deze vragen en zorgen vanuit de samenleving overeen met de werkelijke (wetenschappelijke) kennishiaten binnen het EMV&G onderzoek?
- In hoeverre sluit de samenstelling van de project portfolio aan op de vragen en zorgen vanuit de samenleving over EMV, dan wel op de bestaande kennishiaten?
- Wat is uw algemene indruk van de wetenschappelijke kwaliteit van het onderzoek dat verricht is in het kader van het programma?
- Wat is uw algemene indruk van de wetenschappelijke onafhankelijkheid van het programma en de gefinancierde onderzoeksprojecten?

Communicatie rond het programma

- Naar uw mening, is er vanuit de projectleiders en onderzoeksgroepen zelf voldoende gedaan om studie resultaten te delen en bespreken met een breed publiek?
- Op welke wijze zou u graag zien dat EMV&G wetenschappers hun resultaten delen en bespreken?
- In hoeverre heeft het ZonMw programma als geheel bijgedragen aan het maatschappelijk debat rond de mogelijke gezondheidseffecten van EMV?
  - Op welke wijze zou dit verder verbeterd kunnen worden?

Realisatie verwachtingen & doelstellingen

- Naar uw mening, in hoeverre heeft het programma bijgedragen aan het opbouwen van een duurzame onderzoeksinfrastructuur voor onderzoek naar EMV&G in Nederland?
- Naar uw mening, wat zijn de 3 belangrijkste nieuwe inzichten die het programma tot nog toe heeft opgeleverd met betrekking tot de mogelijke gezondheidseffecten van EMV?
  - Kunnen er in de komende 5 jaar op dit vlak nog andere nieuwe inzichten resulterend uit het programma worden verwacht?
  - In hoeverre zijn de behaalde inzichten al vertaald naar de praktijk, of is het de verwachting dat dit nog zal gebeuren?

Opzet van het programma

- In hoeverre was het opzetten van een EMV&G onderzoeksprogramma noodzakelijk voor het stimuleren van onderzoek op het gebied van EMV&G?
- In hoeverre waren de oorspronkelijke doelstellingen van het programma voldoende realistisch, dan wel voldoende ambitieus?
- Hoe is de samenwerking en communicatie tussen ZonMw en het kennisplatform geweest?

Toekomst

- Is voortzetting van een dergelijk financieringsprogramma wenselijk? Waarom wel/niet en zo ja, op welke wijze?

C.4 Leerstoelhouders

Leerstoel

- Op welke manier hoorde u van het bestaan van dit onderzoeksprogramma en de mogelijkheid om een aanvraag hiervoor in te dienen?
- Wat waren uw voornaamste redenen om een aanvraag voor een leerstoel, en dus niet alleen voor financiering van individuele projecten, in te dienen bij dit programma?
- Wat ziet u als uw belangrijkste taken als leerstoelhouder binnen dit vakgebied?
  - Op welke wijze heeft u hier invulling aangegeven?

Onderzoeksinfrastructuur

- Vanuit uw perspectief bezien, hoe heeft het programma bijgedragen aan het opbouwen van een infrastructuur voor onderzoek naar EMV&G in Nederland?
  - Wat is er, naar uw mening, in dit stadium nog meer voor nodig om in Nederland het onderzoek naar gezondheidseffecten van EMV voor de lange termijn te versterken?
- In welke mate verwacht u dat onderzoekers die binnen het programma op uw thematisch gebied actief zijn geweest hier in de toekomst mee door zullen gaan?
  - Wat zijn de voornaamste factoren die hier op van invloed zijn?
- Welke factoren zijn voor u zelf van belang in de beslissing om al dan niet deze lijn van onderzoek voort te zetten?

Inzichten in gezondheidseffecten van EMV

- Wat ziet u zelf als de belangrijkste nieuwe inzichten die de door ZonMw gefinancierde onderzoeksprojecten binnen uw thematisch gebied hebben opgeleverd?
  - Als projecten nog niet volledig zijn afgerond, welke inzichten verwacht u hiervan wellicht nog?
- In het algemeen, welke vragen rond de mogelijke gezondheidseffecten EMV&G zijn naar uw mening inmiddels afdoende beantwoord, en welke zijn dat nog niet?
- Is er voor onderzoekers binnen het wetenschappelijk veld voldoende ruimte om resultaten die afwijken van de consensus te presenteren en bespreken?
  - Zo nee, op welke wijze zou dit wel bereikt kunnen worden?
  - Welke rol ziet u voor ZonMw in het faciliteren van een dialoog tussen wetenschappers onderling?
  - Welke rol kunnen leerstoelhouders hier bij spelen?

Communicatie met het publiek

- In hoeverre, en op welke wijze, volgt u zelf het maatschappelijk debat rond de mogelijke gezondheidseffecten van EMV?
- In hoeverre, en op welke wijze, zoekt u zelf actief de dialoog op met het maatschappelijk veld (bijv. met patiëntenverenigingen, actiegroepen), of vermijdt u deze juist? Waarom wel/niet?
  - Ziet u dit als leerstoelhouder ook meer als uw taak dan wanneer u dat niet zou zijn?
- Welke rol ziet u voor partijen zoals ZonMw en de EMV Klankbordgroep in het faciliteren van de dialoog tussen wetenschappers en het publiek?

Opzet van het programma & toekomst

- Hoe heeft u de interactie met ZonMw en de programma commissie rond de uitgevoerde projecten ervaren?
  - Naar uw mening, is voortzetting van een dergelijk specifiek onderzoekfinancieringsprogramma wenselijk en noodzakelijk? Zo ja, waarom en in welke vorm? Zo nee, waarom niet?

C.5 Projectleiders

Algemeen

- Op welke manier hoorde u van het bestaan van dit onderzoeksprogramma en de mogelijkheid om een aanvraag hiervoor in te dienen?
- Wat waren uw voornaamste redenen om een onderzoeksaanvraag in te dienen bij dit programma?
  - Op welke wijze zijn uw onderzoeksinteresses en -vragen rond EMV&G beïnvloed door het maatschappelijk debat hierover?

Onderzoeksinfrastructuur

- Op welke wijze sluit het EMV&G onderzoek in uw groep aan bij andere onderzoeksactiviteiten binnen in uw groep of instituut?
- In hoeverre zijn de kennis en vaardigheden die nodig zijn voor onderzoek in dit specifieke gebied uniek, dan wel overdraagbaar?
- Vanuit uw perspectief bezien, hoe heeft het programma bijgedragen aan het opbouwen van een infrastructuur voor onderzoek naar EMV&G in Nederland?
  - Wat is er, naar uw mening, in dit stadium nog meer voor nodig om in Nederland het onderzoek naar gezondheidseffecten van EMV voor de lange termijn te versterken?
- In welke mate verwacht u dat onderzoekers die in uw groep op dit onderwerp gewerkt hebben hier in de toekomst mee door zullen gaan? Wat zijn de voornaamste factoren die hier op van invloed zijn?
- Welke factoren zijn voor u zelf van belang in de beslissing om al dan niet deze lijn van onderzoek voort te zetten?

Inzichten in gezondheidseffecten van EMV

- Wat ziet u zelf als de belangrijkste nieuwe inzichten die uw onderzoek binnen het kader van dit programma heeft opgeleverd?
  - Als projecten nog niet volledig zijn afgerond, welke inzichten verwacht u hiervan wellicht nog?
- In het algemeen, welke vragen rond de mogelijke gezondheidseffecten EMV&G zijn naar uw mening inmiddels afdoende beantwoord, en welke zijn dat nog niet?
- Is er voor onderzoekers binnen het wetenschappelijk veld voldoende ruimte om resultaten die afwijken van de consensus te presenteren en bespreken?
  - Zo nee, op welke wijze zou dit wel bereikt kunnen worden?
  - Welke rol ziet u voor ZonMw in het faciliteren van een dialoog tussen wetenschappers onderling?

Communicatie met het publiek

- In hoeverre, en op welke wijze, volgt u zelf het maatschappelijk debat rond de mogelijke gezondheidseffecten van EMV?
- In hoeverre, en op welke wijze, zoekt u zelf actief de dialoog op met het maatschappelijk veld (bijv. patiëntenverenigingen, actiegroepen), of vermijdt u deze juist? Waarom wel/niet?
- Welke rol ziet u voor partijen zoals ZonMw en de EMV Klankbordgroep in het faciliteren van de dialoog tussen wetenschappers en het publiek?

Opzet van het programma & toekomst

- Hoe heeft u de interactie met ZonMw en de programma commissie rond de uitgevoerde projecten ervaren?
  - Naar uw mening, is voortzetting van een dergelijk specifiek onderzoekfinancieringsprogramma wenselijk en noodzakelijk? Zo ja, waarom en in welke vorm? Zo nee, waarom niet?

Appendix D Assessment instructions

D.1 Supervisory committee members

Objectives

The self-assessment serves two main purposes:

1) To provide an understanding of the **quality** and **relevance** of the research projects financed by the ZonMw programme Electromagnetic Fields & Health (EMF&H), and to place the project portfolio in a national context.
2) As input for an external expert assessment that will **benchmark** the research portfolio against international research in this field, and provide additional, international context.

Input documentation

The self-assessment should be based on an analysis of the following documents:

- Proposals of all projects in the portfolio[28];
- The end report of finalised projects (where available). For projects where no final report is available, the mostrecent progress report can be used.

Committee meeting reports and other documentation may also be used if considered relevant, but are not essential.

Focus

The self-assessment primarily focuses on *awarded* projects. However, if you are aware of significant differences between awarded and non-awarded project proposals in any of the assessment dimensions, a brief discussion of this can be included if considered relevant.

Furthermore, the self-assessment should focus on the *collective* of projects within each of the four thematic areas rather than on individual projects. However, individual projects may be discussed to illustrate general points or to highlight exceptions.

Format

The self-assessment report should be between **4 and 8 pages**, and should preferably be written in English. The assessment dimensions listed below are intended as a guide, but may be discussed in any preferred order. Additional dimensions may also be added, if considered relevant.

If you don't have enough information to address a particular dimension, or you do not feel sufficiently qualified to make an assessment on it, you may omit this dimension but please clearly indicate doing so in the report. Please use headings or paragraphs to structure the report and to indicate which dimension or thematic area is being discussed.

Assessment dimensions

For *each* of the four thematic domains in the portfolio, please assess:

[28]Note that, based on feedback from the members of the supervisory committee, the instructions for the self-assessment were somewhat adjust and subsequently asked to only focus on the larger projects within each of the portfolios.

- The extent to which the thematic focus of the awarded research projects was aligned with the main public concerns about EMFs[29], and the extent to which the projects were designed to address the most pressing evidence gaps.
- The extent to which the research questions of the granted projects were supported by existing scientific theories and proposed mechanisms of action.
- The extent to which the research projects used appropriate, and state-of-the-art scientific methods and equipment.
- The extent to which the project findings (including negative results) have been translated into scientific outputs and have been shared with the scientific community.
- The extent to which project leaders have shared and discussed their research findings (including negative results) with the general public.

On the level of the *entire* programme (i.e. cutting across the four thematic areas), please assess:

- Whether there was sufficient balance between the different thematic areas in the overall composition of the project portfolio.
- The extent to which the programme has contributed to the development of a sustainable EMF&H research infrastructure (i.e. human resources, equipment and physical infrastructure, national and international collaborations) in the Netherlands.
- The extent to which the programme has led to significant new insights into the potential health impacts of EMFs.
- The current and anticipated investment needs, availability of other funds and need for continuation of a dedicated research funding programme to support EMF&H research in the Netherlands.

D.2 Programme committee members

Objectives

This short assessment serves two main purposes:

1) To provide an understanding of the strengths and weaknesses in the design and implementation of the ZonMw programme Electromagnetic Fields & Health (EMF&H), and view these in a national context.
2) As input for an external expert assessment that will **benchmark** the research portfolio against international research in this field, and will provide additional, international context.

Format

The self-assessment report should be no more than **3 pages**, and preferably be written in English. The assessment questions listed below are intended merely as a guide, and questions may be discussed in any preferred order. Additional topics may also be added, if considered relevant. If you don't have enough information to address a particular

[29] The EMF&H programme was created in response to a growing public concern with technological advances, such as cell phone towers, full-body scanners and wireless communication, and a feeling that research into their potential biomedical effects had not kept in step with the rate of these developments.

question, or if you do not feel sufficiently qualified to make an assessment on it (e.g. because you were not involved in that particular process or decision), you can omit this question from your report.

Assessment questions

- In the design of the programme and the formulation of the calls for proposals, what were the main:
  - Scientific considerations
  - Societal considerations?
- In the selection of proposals, what was the relative importance attributed to scientific quality compared to societal relevance of proposed projects? For example, were any projects selected that were of high scientific quality, but that were of limited interest from the perspective of societal concerns regarding EMF? Alternatively, were any projects selected that scientifically were not of the highest quality but that were of great societal relevance?
- On average, how would you judge the scientific quality and relevance of:
  - *All* submitted proposals, including those that were not granted,
  - Granted proposals?
- In your opinion, has there been sufficient balance between the different thematic areas in the overall composition of the portfolio of granted projects? Should the programme strive for such balance at all?
- Did the set-up of the programme, with separate calls for proposals for each thematic area, allow sufficient flexibility to (re)allocate programme funds where necessary (e.g. because of lack of good proposals in specific areas, or because of newly emerging research questions)?
- In your opinion, has the composition of the programme committee been sufficiently balanced across scientific disciplines and types of stakeholders? If not, please explain who were over- or underrepresented and how this could have affected the programme.
- What do you consider to have been the 2 main strengths and 2 main weaknesses of the programme?

D.3 External experts

We would like to ask you to review the projects for their quality and relevance, and in particular to place these into an international context. Please note that it is not necessary to review each of the projects individually. Rather, we ask that you look at the collective of projects within the thematic area. Specifically, in your assessment report could you please address the following questions:

- Were the research questions sufficiently relevant, and aligned with international priorities for research into health effects of EMF?
- Were these projects sufficiently grounded in scientific theory, and informed by the international state-of-the-art in the field?
- Were the methods used generally acceptable and sufficiently free from bias or confounding?

- How do the projects fit within the international scope of research in this field?
- How does the overall quality of these research projects compare to that observed in other countries?

Your assessment report does not need to be longer than 2-3 pages, though of course we appreciate any information that you can share with us.

Appendix E Media study methodology

The goals of this media study were two-fold:

1) To see how outputs generated by the programme, in particular journal publications, were disseminated through traditional and social media (perspective 1)

2) To shed light on how, during the ZonMw EMF&H programme period (2006-2015) media have autonomously reported on subjects related to both potential health impacts of electromagnetic fields and the EMF&H programme (perspective 2).

For each of these goals a separate methodology was developed.

Perspective 1: Frequency and content of reports on EMF by Dutch national news media

The scope of this perspective was limited to reports that are directly related to any of the thematic areas of the ZonMw programme. That means that publications had to report on EMF and health impacts within the domains of biology, epidemiology, sociology or technology. We conducted a search of the LexisNexis newspaper database using the following search terms, connected by Boolean operators[30]:

#1 (gezond! OR kanker!)

#2 (Elektromagn! OR straling)

#3 (hoogspannings! OR transformator! OR zendmast! OR mast! OR UMTS! OR GSM! OR 4G! OR LTE! OR DECT! OR Draadlo! OR Wifi!)

#4 #1 AND #2 AND #3

#5 Elektrostress

#6 Elektrosmog

#7 Elektrohypersens!

#8 Elektrogevoelig

#9 #4 OR #5 OR #6 or #7 OR #8

The search was limited to articles published between 01/01/2006 and 31/12/2014 in Dutch national newspapers[31]. All thus retrieved titles were manually screened to remove duplicates and to remove those articles that, although they contained one or more of the search terms, had no relevance to the evaluation questions ('false positives'). Also letters sent to in response to newspaper articles (as opposed to original letters sent to and published by the newspapers) were excluded. Within the thus compiled list of articles, explicit references to the ZonMw programme were identified using a search within the

[30]In LexisNexis the search string looks as follows: ((gezond! OR kanker) AND (Elektromagn! OR straling) AND (hoogspannings! OR transformator! OR zendmast! OR mast! OR UMTS! OR GSM! OR 4G! OR LTE! OR DECT! OR Draadlo! OR Wifi!)) OR Elektrostress OR Elektrosmog OR Elektrohypersens! OR elektrogevoelig!

[31]National newspapers indexed in LexisNexis are: AD/Algemeen Dagblad, Algemeen Dagblad, Boerderij Vandaag, Dag, Dagblad De Pers, De Telegraaf, De Volkskrant, Het Financieele Dagblad, Het Parool, Metro (NL), Nederlands Dagblad, NRC.NEXT, NRC Handelsblad, Reformatorisch Dagblad, Spits en Trouw.

body text for keywords such as "ZonMw", "Elektromagnetische Velden en Gezondheid", "EMV&G", "kennisplatform", "onderzoeksprogramma" and any of the names of the principal researchers funded by the programme. Similar keyword searches were be performed to classify all articles according to the type of technology or technologies they refer to, using terms such as 'hoogspanning', 'transformator', 'zendmast', 'UMTS', 'GSM', '4G', 'LTE', 'telefoon', 'DECT', 'draadloos', 'Wifi'. The thus assigned categories were used to identify and plot trends in reporting over time.

Furthermore, for articles longer than 600 words the full text was analysed and the contents were classified using an analytical framework based on the work of Timmermans and others[32]. This threshold was introduced to keep the full text analysis manageable within the constraints of time and budget for this study. The content analysis focused on the context within which information on potential health impacts is discussed. It distinguished between four –not mutually exclusive– context classifications:

- Scientific-Technical (neutral)
- Reassuring & Dismissive
- Precautionary & Concerned
- Blame & Outrage

Finally, we have analysed whether there were observable trends over time in type and frequency of reporting, and where possible have identified the relevant factors contributing to these trends (e.g. emergence of new technologies, changes in policy or regulation, publication of scientific recommendations).

Perspective 2: Dispersion of journal publications throughout (social) media

The scope of this perspective was limited to journal publications that have directly resulted from the ZonMw EMF&H programme. *Altmetrics*were used to assess, for each item that possessed a valid DOI, how (if) that item has been dispersed through online media, including social media sites, as far as measurable by *Altmetrics*.

The synthesis focused on providing a quantitative overview of in what types of publicly accessible media the publications were mentioned, and through which sources (i.e. specific websites, discussion forums, social media accounts) this was done. It should be noted that the Altmetric analysis requires *explicit* reference to the source material, in the form of a reference citation or through hyperlinking to the publication, and was therefore not able to pick up indirect references.

[32] Claassen L, Smid T, Woudenberg F, Timmermans DRM (2012). Media coverage on electromagnetic fields and health: Content analysis of Dutch newspaper articles and websites. Health, Risk & Society 14 (7-8): 681–696.

Appendix F Recommendations of the Health Council for research on EMF&H

Epidemiological research

Radio frequencies (RF)

- Prospective cohort study of adult mobile phone users
- Large-scale international patient-control study of the relationship between the use of mobile phones and the occurrence of brain tumours in children
- Prospective cohort study among children examining the relationship between the use of mobile phones and health effects other than brain tumours
- Large-scale studies of health effects in individuals subjected to high occupational exposure

Extremely low frequencies (ELF)

- Further research into the possible link between miscarriage and exposure to ELF magnetic fields
- Further research into the risk of amyotrophic lateral sclerosis in 'electrical' professions and into Alzheimer's disease in relation to exposure to ELF magnetic fields

Static magnetic fields

- Studies of the long-term effects of static magnetic fields

Social science research

- Research into determinants of perception of risks from electromagnetic fields
- Impact of precautionary measures on risk perception

Experimental research involving humans

Radio frequencies

- Laboratory studies of the relationship between RF exposure and health problems, and effects on cognition
- Health problems among people living in the vicinity of base stations: research in the human environment
- Laboratory studies into acute effects on cognition and brain activity in children

Extremely low frequencies

- Study of cognitive effects, sleep and brain function in adults (including those with occupational exposure) and children using a range of ELF frequencies and high field strengths

Static magnetic fields

- Effects of strong static magnetic fields on cognition and behaviour
- Effects of strong static magnetic fields on heart function

Experimental research on animals

Various frequencies

- Effects on the development and functioning of the immune and haematological systems
- Effects on the development of the central nervous system
- Effects on the development of cognitive functions
- Effects at molecular level in brain tissue
- Effects on carcinogenesis

Extremely low frequencies

- Development of an adequate animal model for childhood leukaemia

In vitro research

- Effects of existing and new signal types
- Possible interaction between electromagnetic fields and chemical and physical agents

Characterization of exposure

Research at micro-level

- Research into effects on cellular and subcellular structures, including effects on formation of radical pairs and into effects that can influence cellular communication

Research at macro-level

- Characterization of exposure in epidemiological studies: characteristics of exposure and distribution among populations studied; development of methods for valid estimation of exposure resulting, for example, from mobile phone use; measuring exposure to electromagnetic fields in the workplace and the living environment
- Translation of basic restrictions into reference values for near-field exposure
- Calculations for actual exposure situations using recent models: exposure to several sources simultaneously and near-field exposures; development of models for women (and expectant mothers) and children.

Appendix G ZonMw programme budgets

Budget of ZonMw programmes with an international component

Programme	€ (mln)
Memorabel	32.5
Ambient Assisted Living	19
Horizon II	18.8
Elektromagnetische Velden en Gezondheid	16.6
Priority Medicines Antimicrobiële Resistentie	14.8
Centra voor Systeembiologie Research (CSBR)	13
Life Sciences Pre-seed Grant	9
ISBE	4.75
Joint Programming Initiative Neurodegenerative Diseases (JPND)	4.1
Gezonde voeding	4
CASyM	3
Priority Medicines for Children	3
ERASysBio	2.2
ERANID	2
ERASysApp	2
Toegang tot data #TTData	0.2

Source: http://www.zonmw.nl/nl/themas/thema-detail/internationaal/thema-detail/ (accessed 21 April 2015)

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