REPORT 3/2016

Reaping Benefits of EU Framework Programmes

Evaluation of Tekes' Safety and Security and Fuel Cell Programmes

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Evaluation Report

technopolis |group| in collaboration with

4FRONT ludwig bölkow systemtechnik KASIN consulting

Tekes

Tekes Report 3/2016
Helsinki 2016

Tekes – the Finnish Funding Agency for Innovation
Tekes is the main public funding organisation for research, development and innovation in Finland. Tekes funds wide-ranging innovation activities in research communities, industry and service sectors and especially promotes cooperative and risk-intensive projects. Tekes' current strategy puts strong emphasis on growth seeking SMEs.

Tekes programmes – Tekes´ choices for the greatest impact of R&D funding
Tekes uses programmes to allocate its financing, networking and expert services to areas that are important for business and society. Tekes programmes have been contributing to changes in the Finnish innovation environment over twenty years.

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Foreword

Framework programmes and the current Horizon 2020 have been EU-level funding instruments for research, technology and innovation in order to create economic growth and solve societal challenges. Currently, the evaluation of FP7 has been published, there are open calls for Horizon 2020 and discussions about FP9 have started. Parallel to the framework programmes, there have been several national-level programmes. However, there are not many studies about the interaction between national and EU level. Is it a good idea to run national programme in parallel with European ones?

This evaluation tackles the interaction through two Tekes funded programmes. The Fuel Cell programme (2007–2013) aimed to speed the development and application of innovative fuel cell technologies for growing global markets. At European level there was a Joint Undertaking Fuel Cells and Hydrogen. Its aim was to accelerate the market introduction of these technologies, realising their potential as an instrument in achieving a carbon-lean energy system. The Safety and Security Programme (2007–2013) funded and fostered innovations in the field of safety and security, especially in ICT applications and an active partnership with the public end-user community. Security was also one of ten Themes in FP7. The Theme aimed to reinforce the competitiveness of the European security industry by stimulating the cooperation of providers and users for civil security solutions.

In addition to the relevance, efficiency and result evaluation of the programmes, two international cases were studied and an analysis of cybersecurity was made. One observation emphasizes the role of having a national strategy for exploitation of the FPs. It is found to be crucial to proactively participate in the planning of future EU programmes and activities. At the same time, there is need to create financial incentives and support functions for FP proposers.

The evaluation was carried out by a team led by Technopolis Group Sweden and consisting of Swedish, German and Finnish experts. Tekes wishes to express its warmest gratitude to the evaluators: Tomas Åström, Johanna Enberg, AnnaKarin Swenning, Kimmo Halme, Helka Lamminkoski, Reinhold Wurster and Timo Kotilainen. Tekes thanks also all those who contributed to the evaluation by participating in interviews, surveys, workshop and steering group. The evaluation gives solid findings and forward-looking policy recommendations for the future internationalization strategies and activities.

Tekes

July 2016

Summary

Tekes has procured an ex-post evaluation of its Safety and Security and Fuel Cell programmes that were designed to facilitate Finnish participation in the EU's Framework Programmes (FPs). The assignment was carried out between January and June 2016 by a team led by Technopolis Group Sweden (Faugert & Co Utvärdering AB) and including 4FRONT Oy, Ludwig-Bölkow-Systemtechnik GmbH and Kasin Consulting Oy.

The empirical evidence consisted of literature and registry studies, interviews with 29 programme stakeholders (mainly project participants), four web surveys of project participants, three case studies and an interpretation seminar.

The two programmes

The Safety and Security programme (2007–2013) ran in parallel with the FP7 Security theme of the Cooperation programme to provide Finnish companies with opportunities to receive funding through FP7 to develop their capacities on the security-related themes emphasised in FP7 Security. The programme targeted a wide, cross-disciplinary field. In total, the programme comprised 256 projects with an overall budget of €135m, of which Tekes contributed €66.9m. 105 R&D projects received €27.3m in Tekes funding, and 151 enterprise projects received €39.6m.

In analogy with the Safety and Security programme, the Fuel Cell Programme (2007–2013) ran in parallel with the Fuel Cell and Hydrogen Joint Undertaking (FCH JU) under FP7. The programme was to improve the opportunities for Finnish industry to generate breakthrough products and to create an innovative development environment to build a knowledge base in the field, and to do this in international cooperation, mainly through the FCH JU. The programme comprised 79 projects with an overall budget of €82m, of which Tekes contributed €44.4m. 53 R&D projects received €26.6m in Tekes funding, and 26 enterprise projects received €17.8m.

The programmes ran in parallel with topically related FP sub-programmes, aimed to facilitate Finnish participation in the FPs, and sought to generate business opportunities for Finnish companies. In contrast, the former programme was an innovation programme that was inspired by developments and needs emerging in the years following the 9/11 terrorist attacks, and the latter a 'classical' technology programme whose creation was closely tied to the interests of one dominating company. The Safety and Security programme had a very wide-ranging scope and addressed a wide array of stakeholders, whereas the Fuel Cell programme focused on a specific technology field with a much smaller number of potential stakeholders.

To a significant extent, the Fuel Cell programme built on previous R&D efforts and achievements of a core group of Finnish actors, whose work in part had been funded through FP6. This meant that Finnish R&D in the field was already of international calibre, and that international networks already existed. In contrast, the Safety and Security programme sought to exploit a broad and quickly developing market that was less dependent on technology development, and the majority of programme participants had considerably less experience of international R&D collaboration.

Both programmes were at the core of Tekes strategies and they were relevant to Finnish organisations' priorities. However, the objectives of the Safety and Security programme were not particularly challenging, whereas the objectives of the Tekes Fuel Cell programme in general were very challenging.

Results and impact of the two programmes

The projects of the two programmes resulted in development of competence, knowledge, technology and hardware. They also produced some patent applications, many scientific publications and some PhD degrees, and led to increased national and international networking. The impact of these results include new products/services/processes and new demonstrators, as well as improved capabilities for R&D&I. The impact is the most obvious for the Safety and Security programme. Several companies report that their projects have contributed to increased turnover, improved profitability and increased employment in Finland, once again mainly for the Safety and Security programme. There are also some accounts of spin-off companies having been founded. R&D providers report impact in terms of improved R&D&I capabilities, increased competitiveness, new demonstrators, additional R&D&I funding and new validation procedures. The vast majority of participants judge that their projects lived up to or exceeded their own expectations, and a majority argue that their projects would not have been conducted had they not received Tekes funding,

meaning that most of the reported results and impact were made possible by the Tekes funding.

The clear minority of the Tekes programme participants that have also participated in the FPs credit the Tekes projects with facilitating their FP participation. More than half of the aforementioned minority believe that their Tekes projects resulted in them being invited to join FP consortia, since the projects made them more attractive as partners, while others formed their own consortia. Having built knowledge and experience 'at home' also resulted in participation in far more proposals and larger shares of proposal budgets. However, arguably the most important is that participants were given larger responsibilities in the consortia and had larger influence on the R&D direction of proposals. Participants of the Tekes programmes have together secured €46m in FP funding, but how much of this that can be attributed to the Tekes programmes cannot be determined. Looking at the entire population of participants in the two Tekes programmes, we find that only 14 percent have participated in FP projects, with a particularly low turnout for participants of enterprise projects in the Safety and Security programme. Overall, the Tekes programmes therefore have not been very effective in facilitating widespread FP participation. Moreover, for some organisations, the programmes actually may have reduced FP participation since the programmes offered more easily accessible funding in Finland. Nonetheless, there is no doubt that the programmes have been very important for the FP participation of a limited number of organisations, perhaps most obvious for companies active in fuel cells.

The evaluation's assessment of the degree of fulfilment of the programme objectives is made difficult by the nature of the objectives. Neither programme has objectives that are quantified or set in time, which means that assessment of their fulfilment by necessity becomes bland. The overall assessment for the Safety and Security programme is that the objectives only to a rather limited degree have been fulfilled, and specifically that no objective has been completely fulfilled. The overall assessment for the Fuel Cell programme is that the objectives to a significant extent have been fulfilled. However, this does not necessarily mean that the latter programme has been more successful than the former, but rather that the objectives of the Fuel Cell programme were formulated in a way that made them easier to reach.

Reflections

It is natural for national policymakers and R&D&I funding agencies to want to increase the nation's payback from European programmes, but FP funding is no panacea in a situation with shrinking national resources. Certain R&D&I needs will always be best addressed at national level, and some organisations will never look to European programmes to satisfy their needs, particularly small and medium-sized enterprises. The issues are therefore arguably how to stimulate organisations that could have their needs satisfied through European projects to participate in the FPs to a greater extent, and how to use the remaining resources to cater for the needs and organisations that cannot be expected to have them solved through European projects.

Evaluations of similar programmes in other countries have come to the same conclusions as this evaluation, namely that national programmes running in parallel with the FPs are not a very efficient way to stimulate FP participation. Such programmes only seem to work for a small minority of organisations, but they appear not to influence the behaviour of most organisations. Moreover, several evaluations have also shown that generous national funding indeed may reduce the appetite for applying to the FPs.

A basic prerequisite for reasonable success in European programmes is that they reflect national needs and priorities, which requires that national representatives are active – and eloquent – in the fora where research agendas are developed and decided upon. The importance of being proactive in agenda setting probably cannot be overemphasised, which is also evident from experiences of other countries.

We argue that proposers for R&D&I funding are rational and that words and good intentions of funding agencies are not enough. Experiences from other countries indicate that the most powerful incentives are financial. Such incentives may be devised by distributing funding to R&D providers as top-up funding on FP funding already received, either on a project-by-project basis or by allowing past FP performance to influence government base funding. There is little doubt that sound financial incentives are key for increasing FP participation, but they can of course be designed in a multitude of different ways that need to be adapted to the detailed context (country, type of organisation, topic etc.).

The threshold to FP participation is quite high for newcomers in general and for small organisations in specific, and providing assistance to proposers is a proven way to lower the threshold. Such assistance may be in the form of information on FP funding opportunities, helplines, proposal writing workshops etc., but the most effective way to assist is to provide hands-on support with forming when ambitious hands-on support with forming a consortium and writing a proposal is made available. Such support may be made available through 'grants offices' that most large universities and RTOs around Europe have established. These usually only cater to internal needs, but some RTOs receive public co-funding to assist companies. An alternative way is to provide public funding directly to proposers to buy consultancy services on commercial terms.

The evaluation report is rounded off with recommendations for making better use of the FPs. These address research and innovation policy, Tekes and actors in R&D&I activities.

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1 Introduction

An evaluation of Tekes' EU framework programme-connected programmes Safety and Security and Fuel Cell was commissioned by Tekes in 2015. This final evaluation report presents the results, analyses, conclusions and recommendations of the evaluation. These are based on analyses of empirical data from literature and registry studies, four web surveys of project participants, interviews with programme managers and project participants, three case studies, and an interpretation seminar.

1.1 Evaluation questions

Tekes' evaluation questions were structured into four work packages:

Work package 1 (WP1): Literature review of operating environment

1. What have been the major global trends and drivers?
2. How have they affected EU and Finnish innovation policies, regulation and actions?
3. What kind of lessons can be learnt from EU or national evaluations and studies about EU additionality for similar type of national programmes and activities?

Work package 2 (WP2): Results achieved, relevance and efficiency

4. How relevant and challenging can the programmes' objectives be considered? To what extent have they helped to implement Finland's strategic choices, and Tekes' own strategies?
5. To what extent have the objectives set for the programmes been achieved? What are the important results supporting the main objectives of the programmes?
6. What other programme results can be found that were not listed as programme objectives? Which of the results would not have been achieved without the programmes?
7. How well were the most important customer groups reached?
8. How resilient were the programmes concerning the changes in operating environment? How well did the programmes, their services and administration meet the needs of the participants?
9. How should the results and programme services of the programmes be utilised so that performance can be improved and more impacts generated after the programme and in future programmes?
10. How efficient have the programmes been?

Work package 3 (WP3): International collaboration, co-financing and impact

11. What were the main results and the impact of running national innovation programmes at the same time as larger European Union initiatives?
12. Was there a larger participation in international collaborative research, development and innovation (R&D&I) as a result of the Tekes programmes being parallel?
13. How does international co-funding obtained for the two themes in question compare to other EU Framework Programme 7 (FP7) themes/Joint Undertakings (JUs)? Can we see a leverage effect?
14. Were capabilities related to internationalization, entering international markets or doing collaborative R&D&I enhanced?
15. In the case of collaborative international research and development (R&D), where are innovations utilized and who benefits from the added value? What role did Tekes programme play in pertaining value added in Finland?
16. Was international networking more effective in a situation of a parallel European programme? What is the value of the international networks created? How did parallel EU programmes affect Tekes programme customers' networking activities in Europe?

Work package 4 (WP4): Conclusions

17. For the R&D and innovation activities: How could the R&D and innovation activities be developed in the future? What is the best strategy for Finnish players in the fields in question for international collaboration, especially for the current EU Framework Programme, Horizon 2020?
18. For Tekes: Give the good practices that are concrete and workable and that can be used in the development of programme services and the programmes themselves. What role should Tekes take in collaboration with European and international research, development and innovation initiatives? In particular, how do we maximize

the benefits of such initiatives for Finnish and European economy?

19. For research and innovation policy: What do the findings imply for policy? What other research and innovation policy measures, in addition to the measures taken by Tekes, should be applied so that impacts can be strengthened? What is the best strategy for Finnish players in the fields in question for international collaboration, especially for the current EU Framework Programme, Horizon 2020?

Although the conventional ex-post evaluation questions thus were included, it was clear that the questions of WP3 required special attention. In essence: Was it a good idea to run national programmes in parallel with European ones? And then, ultimately, in the questions of WP4: What are the forward-looking policy implications of the experiences of the two programmes?

1.2 Empirical data

The team combined qualitative and quantitative methods and a number of data sources in order to answer the evaluation questions. This is called methods triangulation, which is an effective way to arrive at well-founded, high quality answers to evaluation questions using multiple data streams and cross-tabulations in order to provide a greater level of confidence in the correctness of the analysis. The evaluation made use of each of the following methods:

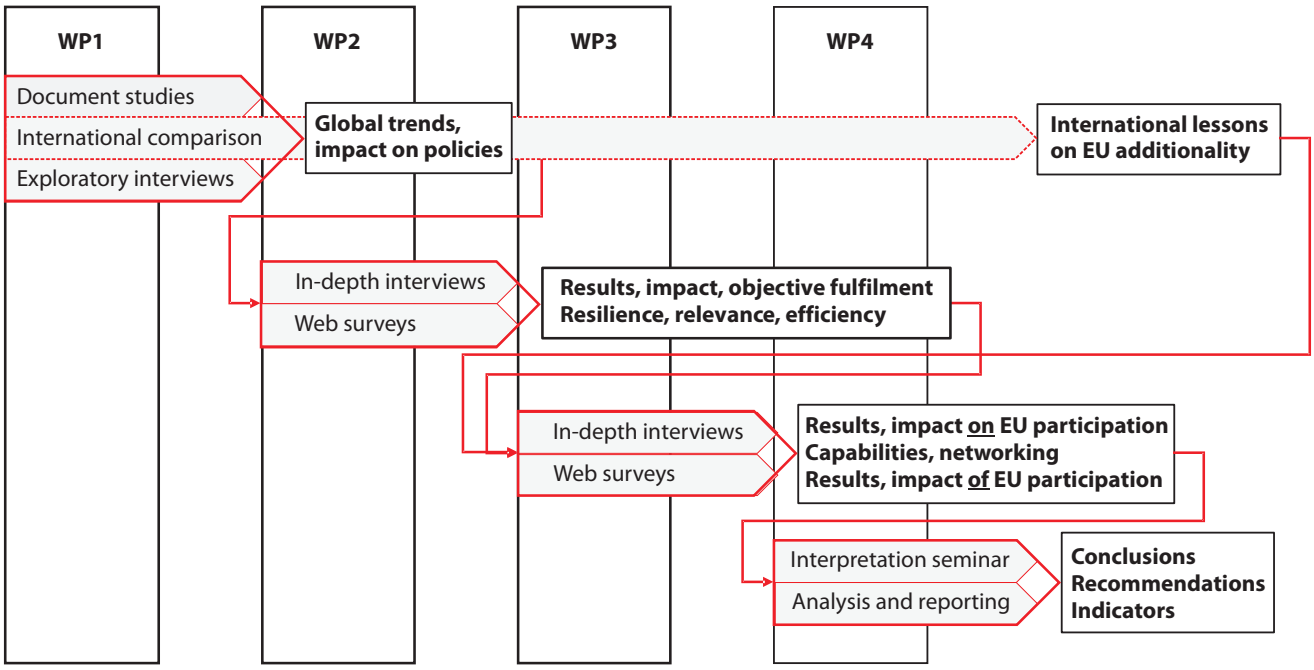
- Document studies, comprising literature and registry studies
- Exploratory interviews
- Four participant surveys
- In-depth interviews
- Two case studies for international benchmarking and one case study on Finnish cybersecurity
- Interpretation seminar

The way in which the methods were intended to contribute to answering the evaluation questions is schematically illustrated in Figure 1. The methods are described in more detail below.

1.2.1 Literature and registry studies

Literature and registry studies provided the basis for the subsequent primary data collection. The literature analysed consisted of information on the planning and implementation phases of the two programmes, including programme management documents, memorandums, planning papers and general presentation material, which were provided by Tekes. This extensive set of programme documents, mostly in Finnish, covered the entire time-span of programmes. However, the documentation was partly incomplete, which made it difficult to compare and analyse all chains of events.

Figure 1. Conceptual framework for the evaluation.



The registers analysed include:

- Project lists of the two Tekes programmes (provided by Tekes)
- Monitoring survey data for completed projects (provided by Tekes)
- Project lists of all Finnish participants in FP7 Security, Horizon 2020 (H2020) Secure Societies, FCH JU and FCH2 JU (E-Corda data provided by EUTI)
- Project lists of FP7 and JU projects (public E-Corda data from the European Union Open Data Portal)

1.2.2 Exploratory interviews

Five semi-structured exploratory interviews with programme managers, previous programme managers and EU collaboration experts were conducted in February 2016, with an additional follow-up interview in April.

1.2.3 Surveys

The project team designed four web surveys addressed to different categories of recipients:

- R&D providers (higher-education institutions (HEI) and RTOs/research institutes[1]) participating in the Fuel Cell programme
- Companies participating in the Fuel Cell programme
- R&D providers participating in the Safety and Security programme
- Companies participating in the Safety and Security programme

The questions of the survey to companies that participated in the Fuel Cell programme are provided in Appendix F. Table 1 provides an overview of the number of participants with complete e-mail addresses that survey invitations were sent to, including the number of invalid addresses, the number of responses and response rate. The survey invitations were sent on 9 March, and reminders were sent out on 21 March and 6 April. The surveys closed on 8 April 2016.

The response rates are much lower than what we are used to. This is particularly a problem with participants in enterprise projects of the Safety and Security programme. It is understandable that not all participants feel equally committed to respond to a survey, and there may be several reasons for this. Many of the companies that received funding from the Safety and Security programme are small and medium-sized enterprises (SMEs), which we know from experience are significantly less inclined to respond to surveys than large companies and R&D providers, since they feel that they have more important things spend their time on. Other stated reasons for not responding that have been communicated to us are high personnel turnover, and that some organisations had such a small role, or such a short engagement, that they do not consider themselves qualified to respond.

1.2.4 In-depth interviews

The distribution of interviewees on types of stakeholders is outlined in Table 2, and their identity is provided in Appendix A.1. The interview guide to companies participating in the Fuel Cell programme is provided as an example in Appendix E. The interview campaign was completed by 13 May 2016.

Also with interviewees, we found that it was much more difficult to get former participants to agree to be interviewed than we are used to. This was a particular challenge with the Safety and Security programme, where a large number of participants never even bothered to respond to repeated e-mails and made themselves unavailable when we tried to reach them on the telephone. Two of the SME representatives that after all did respond, informed us that they did not have the time to be interviewed. The lack of commitment to contribute to an evaluation (through survey or interview) after having received substantial amounts of public funding is remarkable – and rather disturbing from a tax payer's perspective.

Table 1. Invitations to the surveys.

Programme, category	Number of invitations	Number of valid addresses	Number of responses	Response rate
Fuel Cells, R&D providers	32	22	12	55%
Fuel Cells, Companies	18	16	7	44%
Safety and Security, R&D providers	90	67	25	37%
Safety and Security, Companies	140	106	16	15%

[1] RTO stands for research and technology organisation, and is in this report used interchangeably with research institute.

Table 2. Distribution of interviewees on stakeholder groups.

	HEIs	RTOs	Public organisations	SMEs	Large companies	Total
Fuel Cell R&D providers	3	2				5
Fuel Cell companies				4	2	6
Safety and Security R&D providers	4	2	1			7
Safety and Security companies				5	1	6
Total	**7**	**4**	**1**	**9**	**3**	**24**

1.2.5 Case studies

Two country case studies were carried out to highlight other countries' experience of parallel national programmes to stimulate FP participation. The first case study addresses the Austrian national research programme for security, KIRAS, and the efforts to encourage Austrian participation in FP7 Security and in Horizon 2020 Secure Societies. The second case study describes the German National Innovation Programme (NIP) for hydrogen and fuel cell technology and the FCH JU/FCH2 JU participation.

A third case study focuses on cybersecurity and the development of the Finnish cybersecurity industry since 2005. The aim of this case study was to gain a deeper understanding of the relevance and importance of the Safety and Security programme for the cybersecurity area, as well as to outline the future prospects of Finnish cybersecurity.

1.2.6 Interpretation seminar

At the end of the data collection phase, we conducted an interpretation (validation) seminar involving participants from Tekes, the public sector and the projects (see Appendix A.2). At the seminar, the team presented a selection of preliminary results and conclusions for discussion and validation.

1.3 Evaluation team and steering group

The assignment was carried out between January and June 2016 by a team consisting of:

- Tomas Åström, Johanna Enberg and AnnaKarin Swenning, Technopolis Group Sweden (Faugert & Co Utvärdering AB)
- Kimmo Halme and Helka Lamminkoski, 4FRONT Oy
- Reinhold Wurster, Ludwig-Bölkow-Systemtechnik GmbH
- Timo Kotilainen, Kasin Consulting Oy

The assignment was led by Tomas Åström and quality controlled by Reinhold Wurster and Timo Kotilainen.

The team was guided by an evaluation steering group (see Appendix A.3) that the team met with on 21 January (kick-off meeting), 18 February (reporting meeting via Skype), 22 March (presentation of and discussion on inception report), 9 May (interpretation seminar) and 8 June (discussion on report draft via Skype).

1.4 Impact logic model

Tekes' impact assessments, and in particular its programme evaluations, are typically based on the Theory of Change-approach.[2] This approach is well suited to assess targeted policy interventions with a clear focus and predefined objectives. As a general framework, Tekes has developed its own impact model, which synthesises the key objectives and impact mechanisms of Tekes programmes in a concise way.[3]

When applying these models in real-life evaluations, specific logical frameworks ('logframes') are often elaborated for the analysed programme. These logframes provide a simple and useful planning tool and the basis for analysing programme impact mechanisms. For the purposes of this evaluation, we have elaborated a specific 'dual-impact' logic model, see Figure 2, which is applicable to both Tekes programmes, but also takes into account their role in relation to FP7.

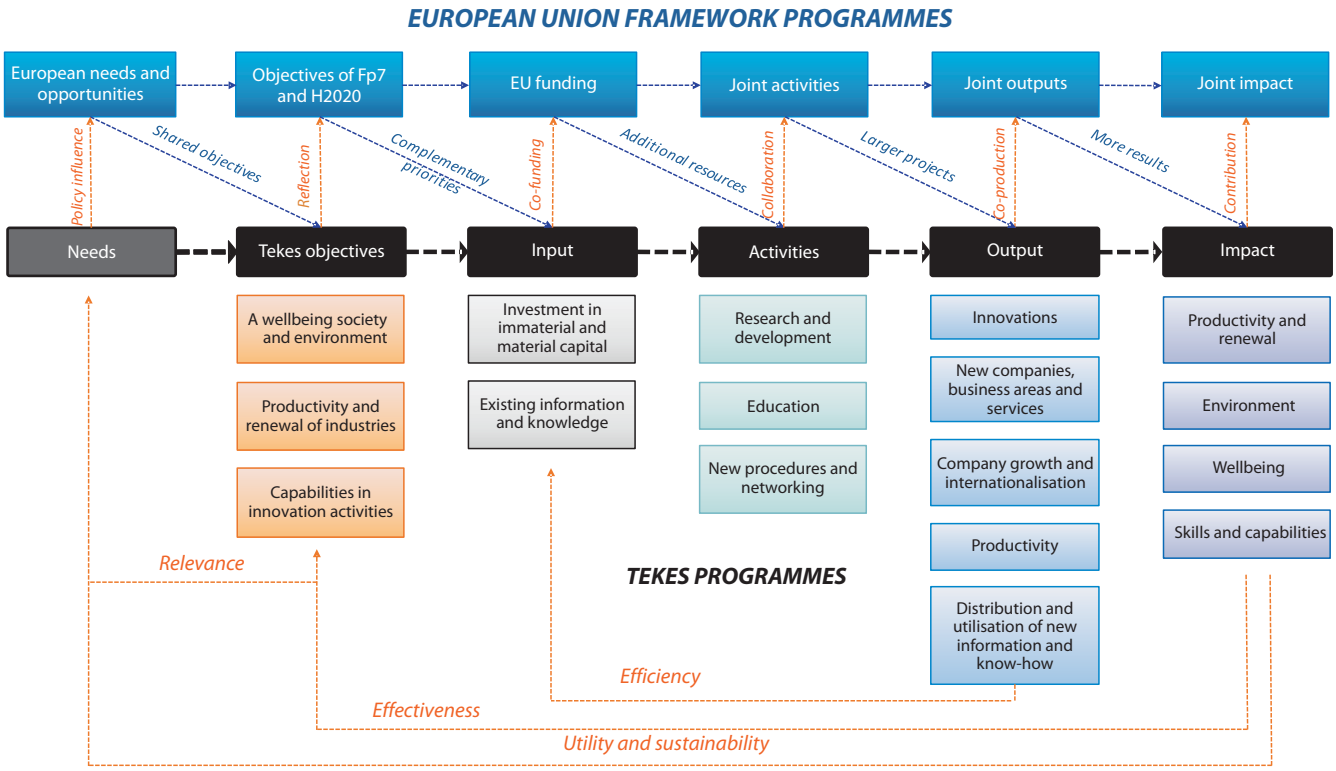
The purpose of the model is to present an overall framework for programme rationale and needs, how the programmes were set up and organised to address these, their key impact mechanisms, the anticipated results and finally impacts. Tekes' generic impact model is described in the lower part of the figure. Furthermore, each step (i.e. objectives, input, activities, output and impact) of the impact model is broken down to specific components, as defined by Tekes. The evaluation is seeking evidence on how the programme has contributed to these elements in each step.

2 See for example: www.theoryofchange.org/what-is-theory-of-change/.

3 J. Hyvärinen, 'TEKES impact goals, logic model and evaluation of socio-economic effects', *Research Evaluation*, 20(4): 313–323, 2011.

Above and parallel to Tekes' impact logic is the logic model of EU funding in FP7. The hypothetical cross-linkages (blue dotted lines) and the nature of these contributions are illustrated with arrows. It is the aim of this evaluation to assess to what extent for example the objectives and funding of FP7 have influenced the choice of thematic priorities of Tekes or opened up new collaboration opportunities.

Figure 2. Impact logic model for evaluating the EU FP7-connected Tekes programmes.



2 The programmes

2.1 The Safety and Security programme

2.1.1 Background and rationale

The 11 September 2001 ('9/11') terrorist attacks initiated discussions among Tekes and its stakeholders on security-related cooperation. Planning of the Safety and Security Programme begun as clear market potential was recognised and a specific security related FP7 theme was introduced.[4] The programme planning document recognises the already high Finnish know-how on safety and security. However, the planning document also noted that companies were not investing in R&D and they were small in comparison to foreign companies. Safety and security was recognised as a growing international business area, and in order to utilise the ensuing market potential a need for a networked, internationally connected and multidimensional innovation cluster was identified, and no such technology programme supporting such activities existed at the time. The purpose of the Safety and Security programme (2007–2013), as stated in the planning document, was to generate a new cluster and strong research entities in a sector where cooperation had so far been limited.[5]

As preparatory work, interviews, questionnaires and area-specific capacity studies, as well as sector-specific analyses were conducted on the public sector (viranomaissektori), building properties (kiinteistöt), safety at work (työturva), built infrastructure (rakennettu infrastruktuuri), security services (turvapalvelut), logistics (logistiikka), industrial processes (teollisuusprosessit), environment (ympäristö), food safety (elintarvike) and Finnish defence industry's security technology (Suomen puolustusteollisuuden turvallisuusteknologia). Country-specific analyses were also conducted on the US, Japan and China, as well as shorter reports on the UK, Germany, the Netherlands, Poland, Austria and France.[6]

At the same time, security-related studies were conducted also by other actors, such as VTT (Security as an area of business, 2007)[7], and the Finnish National Security Research Strategy was adopted in 2009.[8] Furthermore, Finland adopted the Security Strategy for Society in 2010[9] and a national Cybersecurity Strategy in 2013[10].

The Safety and Security programme was designed to run in parallel with the FP7 Security theme of the Cooperation programme to provide Finnish companies with opportunities to receive funding through FP7 by developing their capacities on the security-related themes emphasised in FP7 Security. The programme was also to coordinate the funding to nationally important research areas.[11]

FP7 Security provided an important framework for the programme. The Safety and Security Programme targeted a wide, cross-disciplinary field that was considered most suitable to the Finnish context.[12] The Programme was to promote the Finnish safety and security industry, to encourage networking, identify and stimulate new business opportunities and to coordinate funding of projects.[13] The programme provided funding for innovative and ambitious corporate R&D projects and applied research, and services that supported international cooperation and market entry in the field of safety and security.[14] The main actors in the programme were SMEs and research organisations.[15]

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4 Interview with Suvi Sundquist, 12 April 2016.

5 Moisio, Mikko (2006); 'Turvallisuus-teknologiaohjelma – kansainvälistä liiketoimintaa turvallisuusratkaisuista 2007–2013 / Technology programme for safety and security', Tekes, Ohjelmasuunnitelma, Programme planning paper 10236/33/06 DM 284667.

6 Ibid.

7 Lanne, M. & Kupi, E. (2007); 'Miten hahmottaa security-alaa? – teoreettinen malli Suomen security-liiketoiminta-alueista, VTT Research notes 2388.

8 National Security Research Strategy, Publications of Advisory Board for Sectoral Research 18:2009.

9 Security Strategy for Society, Ministry of Defence. Government Resolution 16.12.2010.

10 Finland's Cybersecurity Strategy, Government Resolution 24.1.2013.

11 Moisio, Mikko (2006); 'Turvallisuus-teknologiaohjelma – kansainvälistä liiketoimintaa turvallisuusratkaisuista 2007–2013 / Technology programme for safety and security', Tekes, Ohjelmasuunnitelma, Programme planning paper 10236/33/06 DM 284667.

12 Interview with Suvi Sundquist, 12 April 2016.

13 Saarnivaara, Veli-Pekka, 'Safety, Security and Tekes – Turvallisuus ja Tekes, Avauspuheenvuoro, ppt. DM#316578.

14 Safety and Security Programme – The Finnish Funding Agency for Technology and Innovation, Tekes (pptx). Available at: www.tekes.fi/globalassets/global/ohjelmat-ja-palvelut/ohjelmat/turvallisuus/safety-presentation.pptx.

15 Safety and Security Programme's website, www.tekes.fi/en/programmes-and-services/tekes-programmes/safety-and-security/, viewed 19 January, 2016.

2.1.2 Linkage to Tekes and EU strategies

Security as a theme was understood as being highly cross-sectoral and it connected closely with Tekes' strategy and was seen as a logical continuation of Tekes' previous programmes. Security was also one of Tekes' six priorities. Moreover, the applicability of the Safety and Security programme also to non-technological fields was recognised.[16]

The general context of Safety and Security programme is illustrated in Figure 3. During different periods Tekes strategy has had different emphasis on EU collaboration. These are described in the grey boxes in the background. In the background of the programme, there have been a number of other Tekes programmes that partly contributed to addressing safety and security issues. Most of these programmes continued alongside the Safety and Security programme. During the course of the programme, several relevant national policy papers were prepared, which also guided the programme. One of these was the National Security Strategy for Society in 2010.

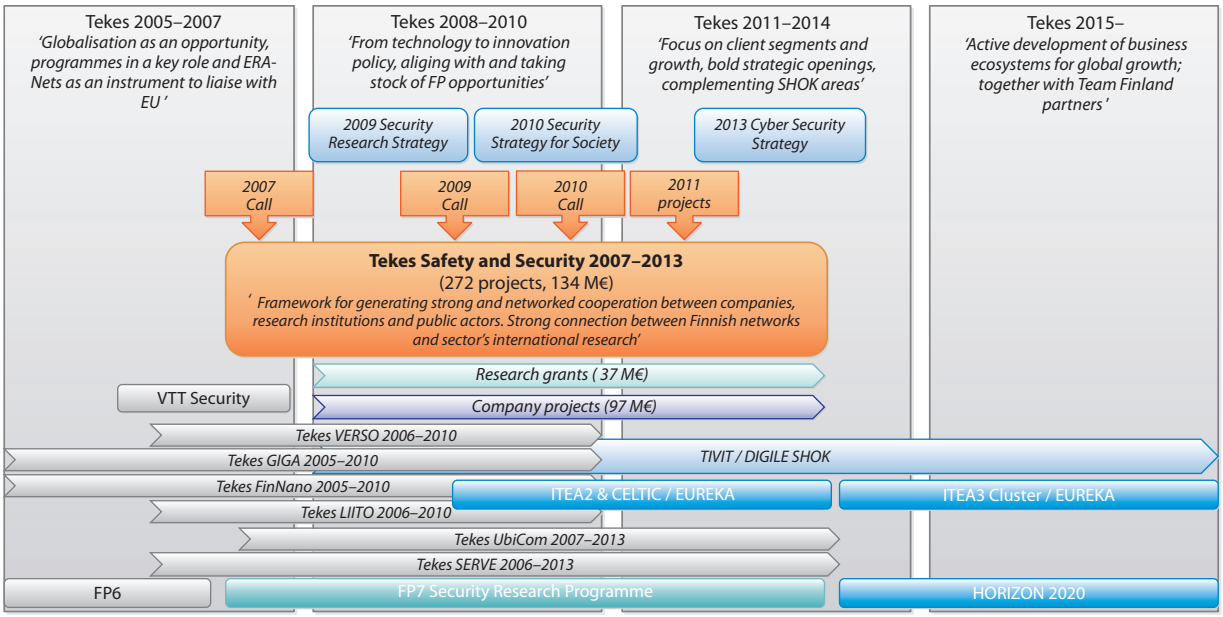
Besides FP7, the Safety and Security programme had a number of projects linked to EUREKA Clusters, ITEA2 and Celtic. Furthermore, Tivit SHOK (later Digile) was established in 2008 and played an important role in coordinating strategic business-driven research, including active participation in the area of Safety and Security. Digile has also been very active in international collaboration (e.g. Artemis JU). The complementarity and division of work between Safety and Security and Digile is one aspect of the evaluation.

2.1.3 Objectives and thematic priorities

The objectives, as listed in the programme planning paper were[17]:

- To create an internationally competitive Finnish safety and security cluster
- As a result of the programme, Finnish safety and security technology actors are networked and utilise both domestic and foreign expertise in their activities
- As a result of the programme, new safety and security related business activities focusing on international markets are generated, including research that can be utilised for this purpose
- Programme is to result safety and security related innovation chains that are able to quickly respond to changes
- To develop those competency areas that were identified in the preparation phase of FP7 Security, and to thereby improve the opportunities of Finnish participants to receive Framework Programme funding

Figure 3. Context of the Safety and Security programme.



16 Moisio, Mikko (2006); 'Turvallisuus-teknologiaohjelma – kansainvälistä liiketoimintaa turvallisuusratkaisuista 2007–2013 / Technology programme for safety and security', Tekes, Ohjelmasuunnitelma, Programme planning paper 10236/33/06 DM 284667.

17 Ibid.

More specific objectives were described applying to the society in general and to public actors.[18] The programme's social objectives were to:

- Create wellbeing and social benefits through the competitiveness and business operations of the sector's companies
- Increase the number of ethically sustainable security solutions through innovation activities and technology development
- Network security sector's actors into an innovation cluster and improve the quality of their security solutions and their productivity

Objectives for the participation of the public sector actors were:

- Domestic demonstrations
- Product development platforms
- Participation in the development activity
- Increase in the productivity of the activities

Specific criteria were also set for participating research institutes and enterprises, such as the need for legitimate reasoning on how to commercialise the research and/or how the project would increase competitiveness, business activity and business competences.

As part of the overall aim to develop business competences, the programme aimed to:[19]

- Create new business models for safety and security solutions and services
- Support internationally competitive business related to safety and security solutions
- Train experts (incl. researcher exchange, European research institutes)
- Pay notice to regulations and standards affecting the sector (encourage Finnish industry to take part in the regulations related processes)
- Generate early demand (communications, possible support programmes, public procurements etc.)
- Produce socioeconomic modelling and tools (programme encourages participation in EU-level projects in order to generate a common knowledge and planning base)

A midterm evaluation of programme was conducted in 2009 in form of self-assessment questionnaires to the programme Board and Steering Groups.[20,21] Among other things, respondents pointed out that more practical operations were needed as well as integration between projects.[22]

In 2009, the programme strategy was further developed by the programme Board and Steering Groups. Three main strategic objectives, which were in line with previous ones, were specified[23]:

1. To increase Finnish companies' international business operations related to security and safety sector
2. To improve the emergence of security and safety clusters in Finland
3. To increase research that supports the sector's business activities

FP7 Security emphasised national authorities as actors in safety and security, but the theme is more broadly understood in the Finnish context and Tekes did not want to restrict or define it. Instead, it was considered more beneficial to allow all kinds of stakeholders in society to suggest possible application areas and projects related to safety and security.[24]

Although it was considered necessary to maintain a broad approach to the programme theme (to include both intentional and unintentional threats), Tekes set the following framework requirements for the programme: applicability, international and cross-technological dimension, and networking and thematic areas.[25] It was also decided to limit the programme emphasis to needs-based missions and existing capabilities. Cross-thematically special emphasis was placed on:[26]

1. Commercial utilisation (Liiketoiminnallinen hyödynnettävyys)
2. International market/research objectives (Kansainväliset markkina-/tutkimustavoitteet)
3. Recognised requirements and capacities within the three thematic areas (to be annually updated during the programme steering process) (Tunnistetut tarve- ja osaamiskentät kolmelta aihe-alueelta (päivitetään vuosittain ohjelman ohjausprosessissa))

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18 Ibid.

19 Ibid.

20 Tekes: Väliarviointi 2009 Turvallisuus Ohjelma, 2009-12-04, DM 11-2009.

21 Tekes: Turvallisuus-ohjelman väliarvioinnin 2009 vapaat kommentit ja tekstivastaukset.

22 ibid.

23 Sundquist, Suvi (2010); 'Turvallisuus – Vuosisuunnitelma 2010', 10228/33/2007 DM 510 966, Tekes.

24 Interview with Suvi Sundquist, 12 April 2016.

25 Moisio, Mikko (2006); 'Turvallisuus-teknologiaohjelma – kansainvälistä liiketoimintaa turvallisuusratkaisuista 2007–2013 / Technology programme for safety and security', Tekes, Ohjelmasuunnitelma, Programme planning paper 10236/33/06 DM 28466

26 Ibid.

The programme planning document provides a list of topics that Tekes' stakeholders originally suggested to be included in the Programme.[27] Based on the capacity and usability mapping some of them were then recognised as common priorities. Out of these topics, six were selected for the programme's initial phase:[28]

- Situational picture systems
- Recognition, supervision, measurement and monitoring systems
- Logistics / transportation
- Safety of broad and networked systems
- Risk analysis, modelling, simulation, and optimisation
- Security sector's international business models.

Themes and application areas were planned to be revised annually.[29] These revisions were made in the programme's three Thematic Steering Groups that consisted of representatives from different stakeholder groups. Steering groups selected such security and safety related topics that at the time were both relevant and had market potential. Suggestions on the application areas to be emphasised were then given to the programme Board, and the decisions made can be seen in the varying weightings listed in the calls for proposals.[30]

The names of the three thematic areas were slightly revised during the course of the programme. For example, Industrial Safety and Security later became Corporate Safety and Security, simply because more market potential was recognised to be found from the corporate sector than from the industrial sector. Day-to-day Safety and Security theme was given a more descriptive name as Consumer Safety and Security.[31]

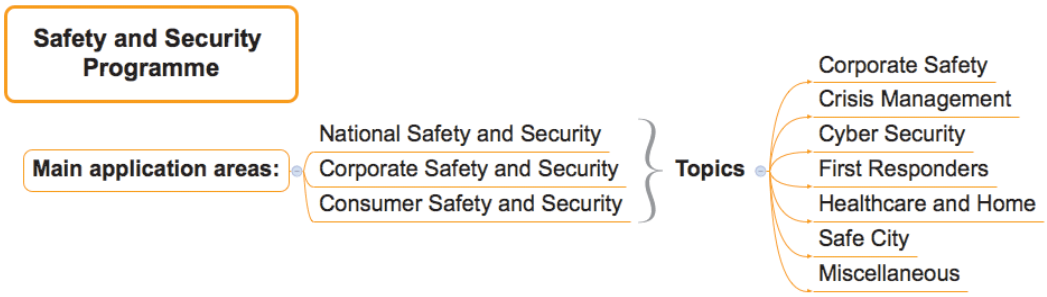
The main application areas were also revised: [32]

- National safety and security:
  - Public procurement procedures
  - Equipment and solutions for fire & rescue, police, crisis management, border security, maritime safety and security, critical infrastructure protection
  - Market entry prerequisites and restrictions
- Corporate safety and security:
  - Business to business market
  - Equipment and solutions for supply chain security, industrial safety, fire protection, IT security, occupational safety, access control, identification
  - Value creation of safety and security solutions
- Consumer safety and security:
  - Business to consumer market
  - Also public procurement by social sector
  - Home solutions, independent assisted living for seniors
  - Cultural values, acceptance, privacy issues

In the course of the programme, the application areas were further prioritised into seven topics[33], see Figure 4. This was also the final thematic structure of the programme.

In terms of international collaboration, the programme aimed to increase capacities to meet international security requirements as well as project participation in FP7 Security. Foreseen international activities were knowledge exchange; researcher exchange; international technology studies and market area studies; follow-up of EU programmes; specific international studies; generating international cooperation; follow-up of events in USA, Japan, China and EU; and organising international visits.[34]

Figure 4. Evolution of the three main application areas of the Safety and Security programme into seven application areas.



27 Interview with Suvi Sundquist, 12 April 2016.

28 Moisio, Mikko (2006); 'Turvallisuus-teknologiaohjelma – kansainvälistä liiketoimintaa turvallisuusratkaisuista 2007–2013 / Technology programme for safety and security', Tekes, Ohjelmasuunnitelma, Programme planning paper 10236/33/06 DM 284667.

29 Ibid.

30 Interview with Suvi Sundquist, 12 April 2016.

31 Ibid.

32 Safety and Security Programme, Presentation material, pptx, www.tekes.fi/globalassets/global/ohjelmat-ja-palvelut/ohjelmat/turvallisuus/safety-presentation.pptx.

33 Safety and Security Programme's website, www.tekes.fi/en/programmes-and-services/tekes-programmes/safety-and-security/, viewed 19 January, 2016.

34 Moisio, Mikko; Ohjelmakuvaus – Johtoryhmän 1. kokous, Tekes, ppt.

2.1.4 Programme vision and mission

Although certain changes were made in the programme's application areas, the programme itself remained as 'a market-based programme with an aim to develop commercial solutions to international markets and to solve how to utilise new market potentials'.[35] The programme's vision and mission remained the same throughout the programme. The vision of the Safety and Security programme was:

> *Finnish safety and security sector's companies together with research institutions and public actors form a strong cross-technological cluster that produces high-level innovative products, R&D and services to international safety and security markets.*

The mission of the programme was:

> *Programme creates and provides a framework for generating strong and networked cooperation between companies, research institutions and public actors. It creates a strong connection between Finnish networks and sector's international research.*[36]

2.1.5 Programme management and execution

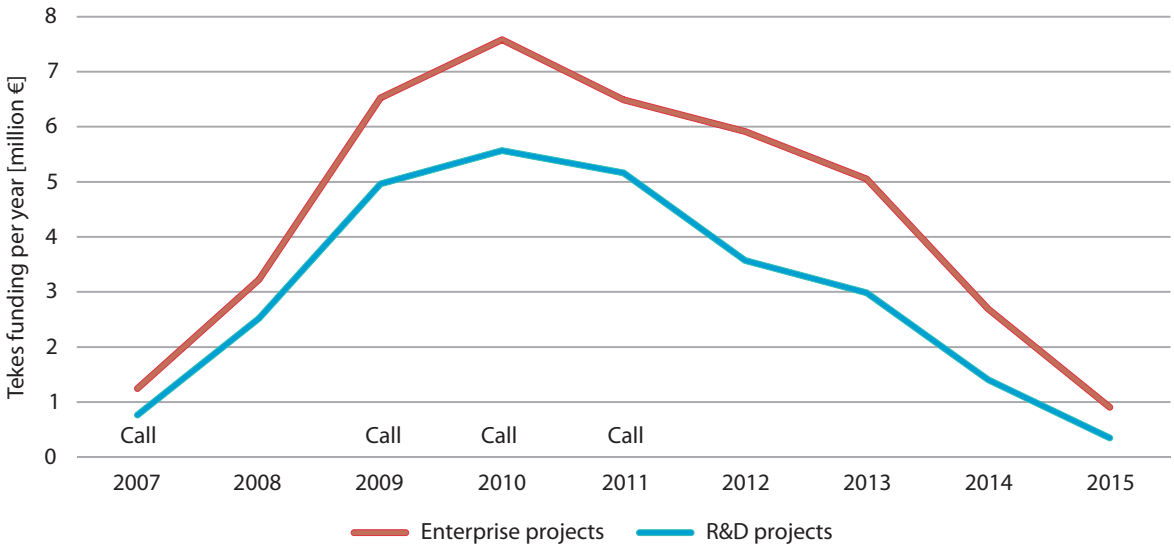
The Safety and Security programme had two layers of management; a programme Board and one Thematic Steering Group for each of the three thematic areas. The roles of the Board and the Steering Groups partly overlapped. The Board met twice a year to make strategic decisions and related changes. The Steering Groups each met 4–6 times per year to monitor the implementation of the processes and prepared materials. The chairpersons of the Steering Groups were also members of the Board. Members of the Steering Groups could also participate in the other two Steering Groups.[37] The members of the Board and Steering Groups were invited in their individual expert capacity, hence not as representing their own organisations.

In total, the Safety and Security programme comprised 256 projects with an overall budget of €135m, of which Tekes contributed €66.9m, see Table 3. The projects were executed between 2007 and 2015, see Figure 5.

Table 3. Overview of projects in the Safety and Security programme. Source: Technopolis analysis of Tekes data.

	R&D projects	Enterprise projects	Total
Number of projects	105	151	256
Overall budget (€ million)	41	94	135
Tekes budget (€ million)	27.3	39.6	66.9
Tekes share of overall budget	66%	42%	50%

Figure 5. Distribution of Tekes funding of enterprise and R&D projects in the Safety and Security programme over time. Source: Technopolis analysis of Tekes data.

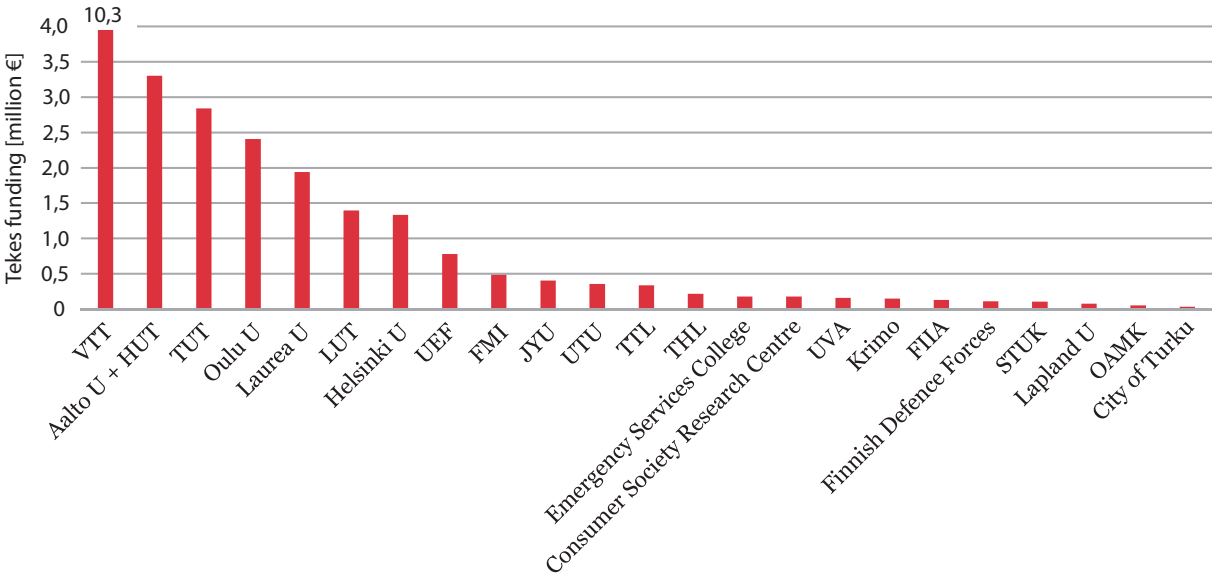


35 Ohjelma status 2/2009.

36 Moisio, Mikko; Ohjelmakuvaus – Johtoryhmän 1. kokous, Tekes, ppt.

37 Tekes: Turva – Teknologiaohjelma, Ohjausryhmän (kansallinen) 1. Kokous (OR_k_1), Pöytäkirja 1./2007 (12.11.2007).

Figure 6. Beneficiaries of Tekes funding of R&D projects in the Safety and Security programme. Source: Technopolis analysis of Tekes data.



The first call for proposals, which focused on generating new business activities, was launched in 2007.[38] The 2009 call emphasised foresight, measurement and situational awareness, evaluation and management of risks, protection, crisis actions and after-care, and market area research.[39] The 2010 call emphasised household safety and security, safety and care, commercial actors' role in crisis management, and information security.[40] In 2011, the programme did not organise a separate call for research proposals, instead, research projects could be linked to enterprise projects, to serve the interest of project topics, which were: Supply chains, Built environment, Command and communication, IT security, Industrial, CBRNE[41], Crisis Management and Rescue, and Care.[42]

The beneficiaries of the Tekes funding of R&D projects are shown in Figure 6. With €10.3m, VTT was granted 38% of all Tekes funding of R&D projects. Other notable beneficiaries were Aalto University (including Helsinki University of Technology (HUT)), Tampere University of Technology (TUT), Oulu University and Laurea University of Applied Sciences. 163 enterprises were granted an average of €243k in Tekes funding, seven of them in excess of €1m.

2.2 The Fuel Cell programme

2.2.1 Background and rationale

In the background of the Tekes Fuel Cell Programme (2007–2013) was a National Strategy for Fuel Cells, which defined a number of Finnish competence areas and a national development programme based on those. The National Strategy included a proposal for a Finnish Fuel Cell Development Programme (FinFC) strategy for Tekes during 2005–2006. The strategy listed the following goals:[43, 44]

- To create a new knowledge base on fuel cell technologies with an innovative development environment in Finland
- To create a new industrial activity (engineering & manufacturing) to serve power, consumer electronics and other industry customers worldwide
- To develop new competitive export products for Finnish companies
- To become a world leader in defined sectors of fuel cell application development

38 Ibid.

39 Tekes: Turvallisuus-kansainvälistä liiketoimintaa turvallisuusratkaisuista, 4. Tutkimushaku 2009, profiili (Johtoryhmä), ppt.

40 Sundquist, S. (2009); Turvallisuus-ohjelman tutkimushaku 2010, Tekes, Ilmoitus 2.12.2009.

41 Chemical, biological, radioactive, nuclear and explosive materials.

42 Tekes: Turvallisuus-ohjelman vuosisuunnitelma 2011, ppt.

43 Tekes (2006); Fuel cell technology development and commercialisation in Finland, ppt DM 217065.

44 Fuel Cell Technology Development and Commercialisation in Finland / National Fuel Cell Development strategy Proposal. Available at: www.tekes.fi/globalassets/global/ohjelmat-ja-palvelut/ohjelmat/polttokennot/aineistot/national_strategy.pdf.

- To develop selected fuel cell technologies in Finland in cooperation with leading R&D institutions and the world fuel cell industry
- To make the use of bio fuels to become a vital part of global fuel cell development
- To develop and diversify Finland's energy supply infrastructure and services

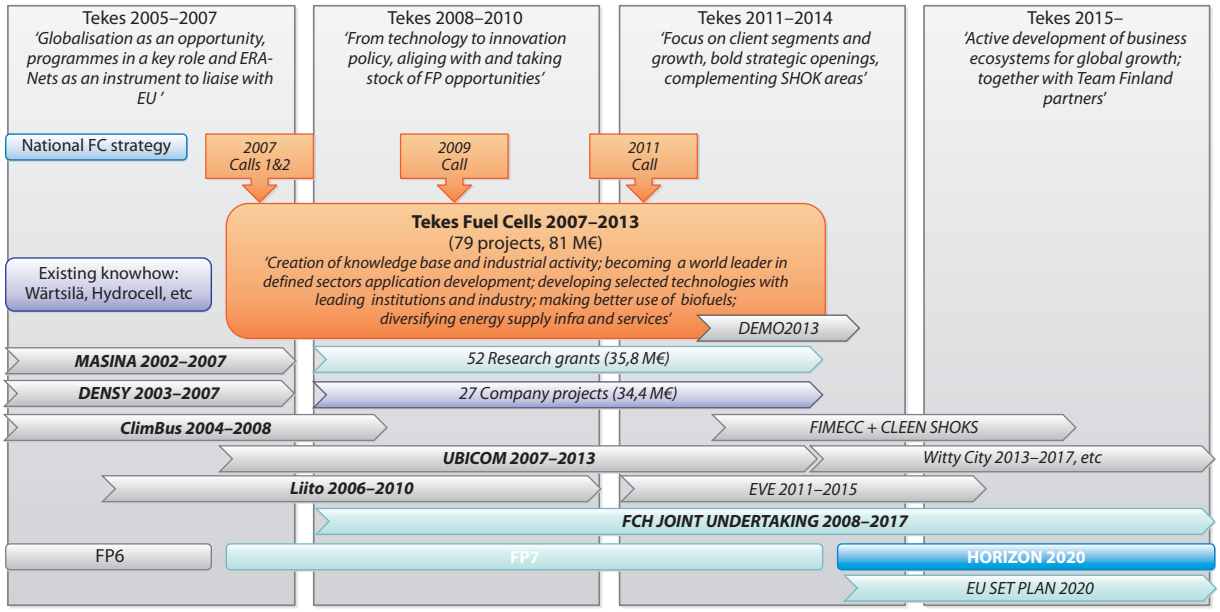
Parallel to that, the European Joint Technology Initiative (JTI) on Fuel Cells and Hydrogen (FCH) was being formed under FP7. The development on fuel cells had already progressed from fundamental research to commercialisation in Japan, USA and Canada. In 2006, Tekes was part of a Finnish group compiling a study on the state of the art of fuel cell and hydrogen development. Later that year, the Tekes proposal for what was to become the Fuel Cell programme argued that the market for fuel cells technology was about to break through internationally. Staying out of this development would have been a strategic choice and the proposal paper suggested that the timing to take part in this development was crucial. However, the opportunities and challenges were recognized to be significant, for which reason a national programme was seen as necessary in order to build a national base for international cooperation, which was considered necessary in light of Finland's own resources.[45] As part of the preparatory work, industry's interest in participating in fuel-cell related R&D was surveyed, as were the existing capacities and knowhow of research institutes. This resulted in specific centres of competence being pointed out, namely Otaniemi, Tampere, Lappeenranta, Turku and Jyväskylä.[46]

According to the midterm evaluation report, there were only a couple of companies actively working with fuel cell technology before the launch of the programme.[47] Among the Finnish companies working with fuel cell technologies, Hydrocell Ltd had long been active in developing low-power power applications. Oy Wärtsilä Ab had also started development work some years earlier. Companies manufacturing working machinery and speciality vehicles had also been active and considered fuel cells as a potential power source for vehicles as well.[48]

2.2.2 Linkage to Tekes and EU strategies

The planning document emphasised that developments were to take place in close synergy with the FCH JTI. The FCH JTI eventually evolved into a Joint Undertaking (JU) aiming to accelerate EU's energy research on fuel cell technology and to support the EU's competitiveness. Participation in the FCH JU was later recognised as being highly important for Finnish projects, mainly because of the access it provided to international networks.[49]

Figure 7. Context of the Fuel Cell programme.



45 Esitys teknologiaohjelman valmistelun käynnistämisestä, 24.8.2006 DM #216553.

46 Kotila, H. (2006); Polttokennot teknologiaohjelman valmistelutyön tilannekatsaus; Esitys Polttokennoalan toimialaryhmän syyskokouksessa 30.11.2006, ppt, DM 246412.

47 Vanhanen, J., Hagström, M., and Hiltunen, J. (2009); Polttokennot-ohjelman väliarviointi, Gaia.

48 Kotila, H. (2006); Polttokennot teknologiaohjelma 2007–2013, Ohjelmasuunnitelma, 10275/33/06, DM 248640, Like ENYM, Tekes.

49 Leppälahti, J. (2013); Energia Horizon 2020 ohjelmassa – esitykseen liitettäväksi FCH JU ja Horizon 2020, Vaasan Energiaviikko 2013, ppt, DM 11-2009.

The general context of the Fuel Cell programme is illustrated in Figure 7. During different periods, Tekes' strategy has had different emphasis on EU collaboration. These are described in the grey boxes in the background. In the background of the Fuel Cell programme was also the National Fuel Cells Strategy, which may have contributed to the programme definition.

The FCH JU was launched during the course of the Fuel Cell programme. In Finland, FIMECC and CLEEN SHOKs were launched and partly operated in these topic areas. Within Tekes' context, other parallel and related programmes, such as EVE and Witty City were launched at a later stage of the Fuel Cell programme. The timings of these programmes are illustrated in the figure.

2.2.3 Objectives and thematic priorities

The objectives spelled out in the Fuel Cell programme's planning document were to improve the opportunities for Finnish industry to generate breakthrough products in selected fuel cell product segments and to create an innovative development environment to build a knowledge base in the field. The chosen product segments were:[50]

1. Stationary fuel cell applications
2. Working machines, speciality vehicles and fuel cell hybrid solutions
3. Portable fuel cell applications

In addition to breakthrough products, another programme objective was to create an innovative development environment to increase the sector's knowledge base (types of fuel cells, system integration, key components, utilisation of bio fuels). An energy-political objective of the programme was to improve the energy safety and security, to decrease CO_2 emissions and to raise national funding from the Ministry of Trade and Industry to enable Finnish demonstrators. As regards commercialisation, the objective was to improve the adaptation of the fuel cell technology, make it better known and to generate commercial interest and new jobs in companies. Criteria for company and R&D projects was also described in the programme plan.[51]

In order to fill the gaps in the value chain, international cooperation was considered necessary from the beginning of the programme. The main opportunity in this respect was the FCH JTI/JU, but Tekes also participated in HY-CO, an FP6 Co-ordination Action (2004–2006) to establish a Hydrogen and Fuel Cell ERA-NET. The programme also planned for:[52]

- Technology monitoring and cooperation with the Department of Energy (DOE) in the US and with Japan's New Energy and Industrial Technology Development Organization (NEDO), including their cooperation frameworks
- Encouraging companies to participate in joint marketing efforts at international events
- Maintaining an active role in the IEA Advanced Fuel Cells IA and to follow-up the IEA Hydrogen IA
- Small-scale cooperation with the Nordic Energy Research programme

After the midterm evaluation in 2009, the attention shifted to stationary, working machines, low-power power application and niche products. More emphasis was also put on hydrogen infrastructure.[53] According to the final report of the programme, market changes caused a greater emphasis on funding of R&D rather than on demonstrations as originally planned. After this change, there were six core areas:[54]

1. Stationary fuel cell applications, system integration and component development
2. Transport, speciality vehicles and fuel cell hybrid solutions
3. Niche products: bio fuel cells and printed solutions
4. Low power applications: back-up power and portable solutions
5. Fuels: Hydrogen, biogas, and hydrogen infrastructure
6. Breakthroughs in basic research, material development and demonstrations

2.2.4 Programme vision and mission

The vision of the Fuel Cell programme was:[55]

> *Finnish industry will develop products and services based on fuel cell technology for global markets. This will take place in cooperation with foreign technology partners, the research community and the Finnish government. The priority areas are stationary and portable fuel cell applications and specialist vehicles with fuel cell power modules.*

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50 Kotila, H. (2006); Polttokennot-teknologiaohjelma 2007–2013, Ohjelmasuunnitelma, 10275/33/06, DM 248640, Like ENYM, Tekes.

51 Ibid.

52 Polttokennot-ohjelma 2007–2013 – Strategian päivityskokous 19.8.2008, DM 288631.

53 Ojanpalo, A. & Poutiainen, T. (2014); 'Polttokennot-ohjelman loppuraportti 2007–2013', Tekes raportti 1/2014. Available at: www.tekes.fi/globalassets/global/ohjelmat-ja-palvelut/ohjelmat/polttokennot/aineistot/01_2014-polttokennot-ohjelman-loppuraportti.pdf.

54 Ibid.

55 Ibid.

The mission of the programme was:

> *The Programme will improve the level of fuel cell research in Finland. It will create new business for Finnish companies by applying fuel cell technology rapidly and by utilising international cooperation frameworks. The Programme will encourage cooperation between the various players through new supply chains and networks.*

2.2.5 Programme management and execution

The Fuel Cell programme was led by a programme board appointed by Tekes. Memberships were personal, meaning that members did not represent their own organisations. Altogether, the programme board met 15 times during the programme and its main function was to provide the programme with strategic guidance and decision-making. The programme board also had an important role in activating companies together with programme's coordination team, and aimed to streamline the research within programme's priority areas.[56]

In total, the Fuel Cell programme comprised 79 projects with an overall budget of €82m, of which Tekes contributed €44.4m, see Table 4. The overall budget was originally €144m. However, as mentioned above market changes brought a shift in emphasis from demonstrations (which were delayed due to the restructuring of many key organisations) to R&D projects.[57]

During the initial years of the programme (2007–2009), the calls for proposals emphasised stationary applications (especially solid oxide fuel cell (SOFC) systems), hybridisation and electronic use of working machineries and mobile solutions (including bio fuel cells). Development of components and materials related to these was also emphasised. During the final years (2010–2013), the programme board redirected the emphasis based on the findings of the mid-term review. Project themes were then to be applicable to the Demo2013 project, which aimed at demonstrating fuel cell technologies, solutions and hydrogen safety in action.[58]

The R&D projects were executed between July 2005 and June 2016, and the enterprise projects between January 2007 and November 2015, see Figure 8. The reason for some projects starting earlier than the programme formally did, is likely that these were individual fuel cell projects that later were reclassified as being part of the Fuel Cell programme.

The beneficiaries of the Tekes funding of R&D projects are shown in Figure 9. With €15.5m, VTT was granted 58% of all Tekes funding of R&D projects. Other big beneficiaries were Aalto University (including HUT) and Lappeenranta University of Technology (LUT). Sixteen enterprises were granted Tekes funding, six of them funding in excess of €1m. This chapter presents the results and impact that the evaluation has been able to document, with focus on results and impact that support the main objectives of the programmes. With 'result', we refer to the immediate outcome of a project, whereas 'impact' materialises in the longer term, normally after the end of a project. It should be noted that it may take many years after the end of a project for an impact to become observable, meaning that for some projects it may still be too soon to say if an impact is about to materialise. The chapter also discusses outcome that is not related to objectives, to what extent results and impact would have been achieved without the Tekes programmes, as well as who benefits from the added value of the programme, including Tekes' role in creating value in Finland.

We describe results and impact of the two programmes in succession, and then devote Section 3.3 to Finnish FP participation in both security and fuel cells.

Table 4. Overview of projects in the Fuel Cell programme. Source: Technopolis analysis of Tekes data.

	R&D projects	Enterprise projects	Total
Number of projects	53	26	79
Overall budget (€ million)	44	38	82
Tekes budget (€ million)	26.6	17.8	44.4
Tekes share of overall budget	60%	47%	54%

56 Ibid.
57 Ibid.
58 Ibid.

Figure 8. Distribution of Tekes funding of enterprise and R&D projects in the Fuel Cell programme over time. Source: Technopolis analysis of Tekes data.

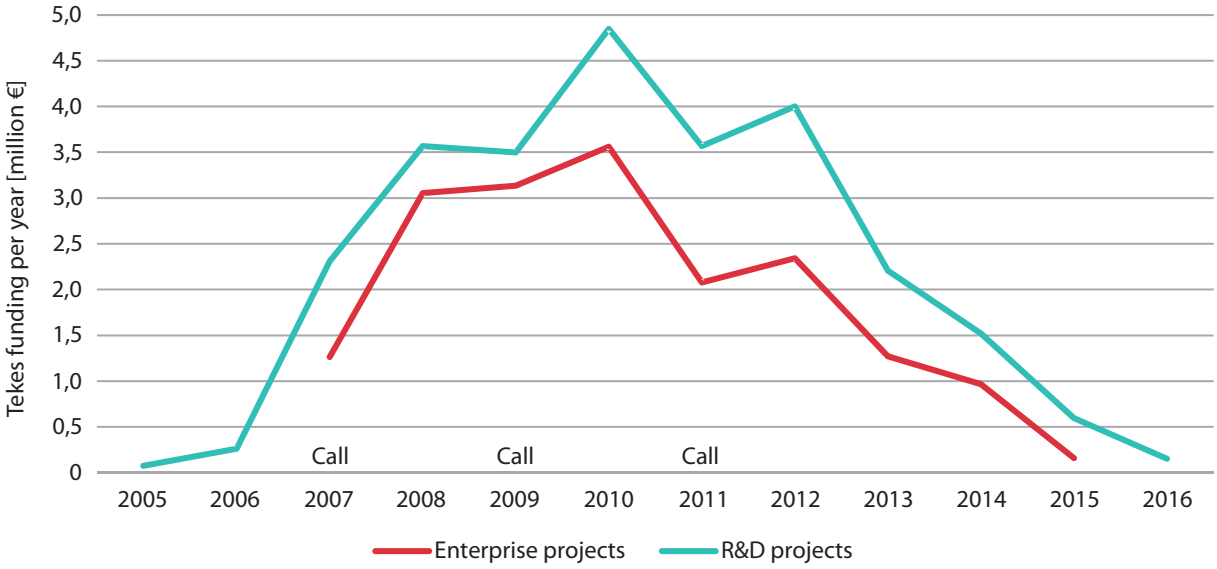
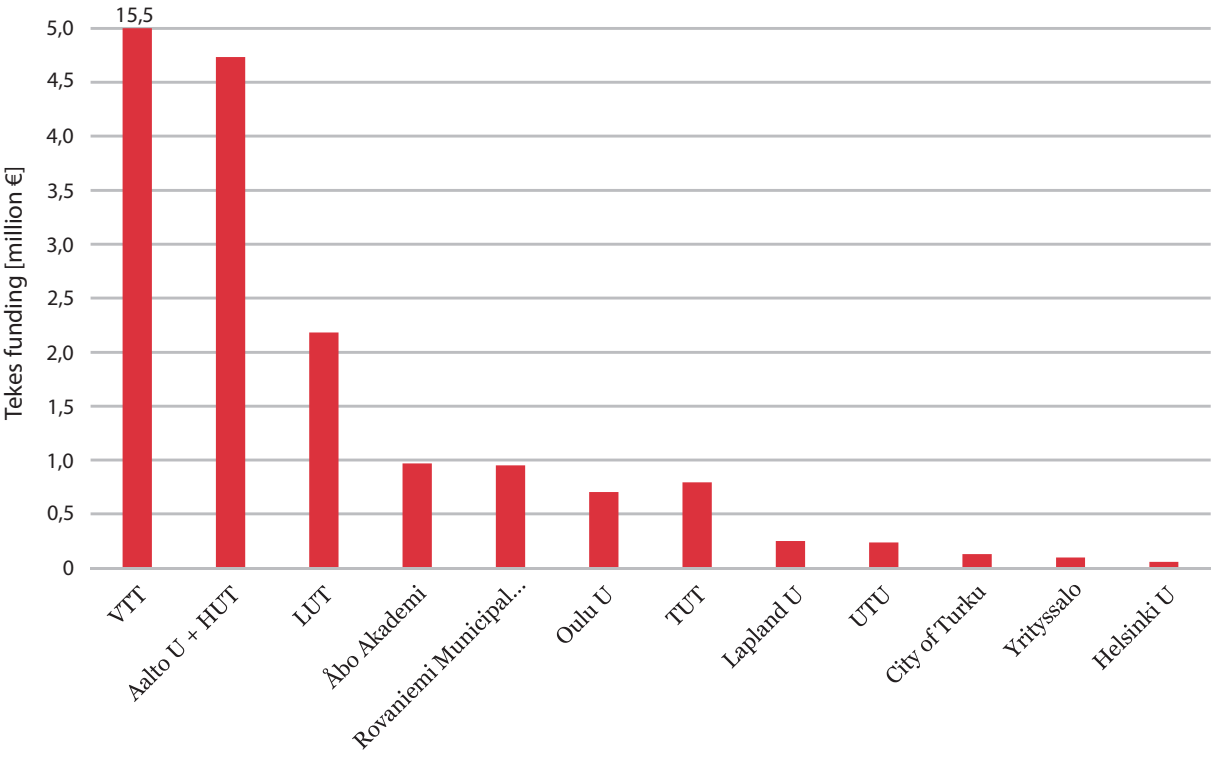


Figure 9. Beneficiaries of Tekes funding of R&D projects in the Fuel Cell programme. Source: Technopolis analysis of Tekes data.



3 Results and impact

3.1 The Safety and Security programme

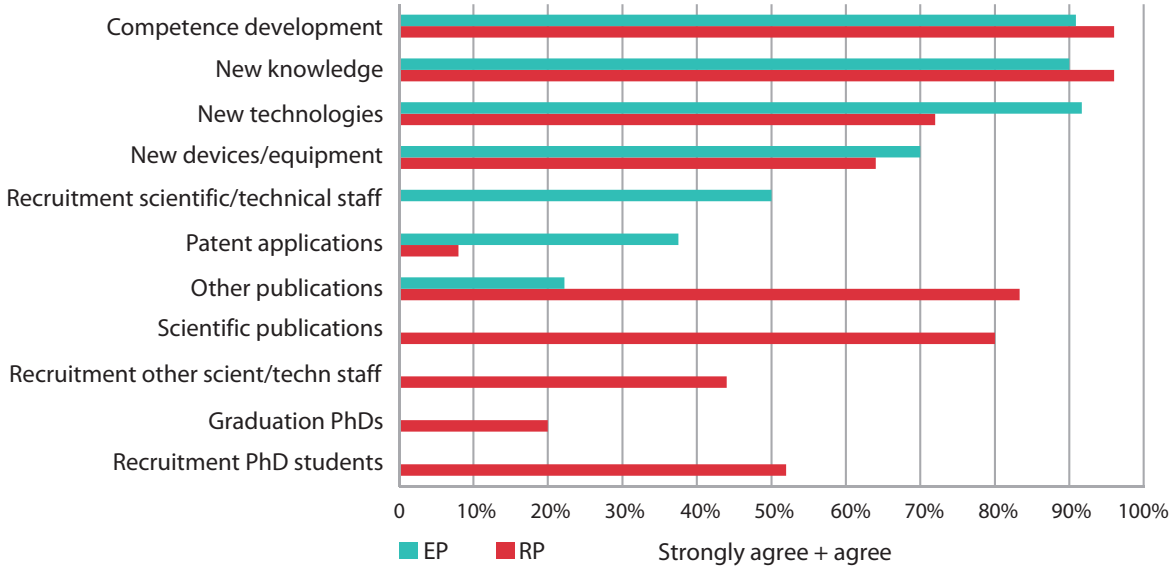
3.1.1 Results

In the surveys to the programme participants, we asked respondents to indicate what kind of results that had been achieved through their projects. Figure 10 shows the responses from participants in enterprise projects (EP) and R&D projects (RP) of the Safety and Security programme. Since the two surveys had slightly different alternatives, answers are not necessarily available for both categories of participants. Competence development and new knowledge are the most widely reported results for both categories of participants. Additionally, many enterprise respondents have seen their projects result in new technologies and new devices/equipment, whereas R&D respondents to a high degree indicate scientific publications and other kinds of publications. The enterprise projects have resulted in quite a few patent applications. However, since there are few responses from enterprise project participants (cf. Section 1.2.3), the responses from this particular survey need to be interpreted with caution.

Many interviewees were involved in several projects. Interviewees stress the development of new knowledge as an important result, ranging from methods for emergency management to increased business knowledge from the application field safety and security technologies. Interviewees also mention development of models, tools and methods used for monitoring, situational awareness and risk assessment. Projects mainly dealt with issues in the security area; only two interviewees mentioned safety-related issues.

Interviewees of enterprise projects state that their projects resulted in development of new technologies and product development, as well as in development of techni-

Figure 10. The extent to which projects in the Safety and Security programme contributed to results for the participating organisation. EP: n=16, RP: n=25.[59]



[59] Survey respondents were asked to rate statements on the following scale: Strongly disagree–Disagree–Neither agree nor disagree–Agree–Strongly agree–Not applicable/don't know. In this and most of the subsequent figures reporting survey results, we have added the responses for Agree and Strongly agree to make figures easier to interpret. Most figures only include the statements that most respondents agreed to, and most statements have been abbreviated for readability reasons; for full formulations, see Appendix F.

cal systems. Interviewees of R&D projects say that recruitment of staff was an important result, which also can be seen in the survey responses. Moreover, interviewees mention scientific publications and conference papers, and some describe that they were invited to give talks on their projects. In the survey free-text fields, two respondents describe how their projects resulted in a new research area for them. In addition, interviewees from HEIs state that their projects contributed to their teaching and to bachelor's, master's and doctoral theses.

However, not all projects were successful and some of them did not achieve what was originally intended. One interviewee emphasises that you need to propose risky projects to get 'risk money'. i.e. public funding. Another interviewee talks about the difficulty of developing a specific product, which meant that the project team could not proceed with the project.

Networking and building of clusters are important aspects in the programme objectives. In the survey, respondents were asked whether the project has resulted in extended networks, and more specifically with what kind of actors. As shown in Figure 11, participants of both enterprise and R&D projects indicate that the projects mainly contributed to extended networks with Finnish companies. Furthermore, participants in enterprise projects state extended networks with foreign companies to a high degree and participants in R&D projects extended networks with Finnish and foreign HEIs.

We may compare these web survey results with those of Tekes' monitoring survey that is sent out immediately when projects are finished. The monitoring survey contains similar, but not identical, options, see Figure 12. As opposed to the web survey, the monitoring survey collates responses of a large number of companies, whereas the number of responses from R&D providers is similar. Obviously, Figure 12 shows that the results on connections appear to be much less pronounced than those on networking in Figure 11. If we for a moment ignore the percentages, we see that some of the trends are similar. R&D providers network more than companies, companies mainly network with companies, and both categories primarily network with Finnish organisations.

There are a few different ways in which to understand the rather considerable differences between the results on connecting and on networking. Either the present web survey data is based on a very positive selection of respondents, or respondents have come to appreciate networking effects more with time. The monitoring survey summarises opinions that on average ought to be around four years older than the web survey data. Differences in how questions were asked, in what language and by whom, may also affect responses. We observed that the number of responses from R&D providers is almost the same in both surveys, and we have good reason to believe that it to a notable degree is the same individuals who have responded to both surveys, and still the magnitude of responses are quite different between surveys. We thus believe that the differences mainly lie in a combination of respondents having come to appreciate networking effects more with time and the way in which the survey questions were asked. This of course does not rule out that the web survey enterprise respondents are a positive selection.

There is no mention in the interviews of the development of any specific safety or security clusters, which constitutes the first sub-objective for the programme. However,

Figure 11. The extent to which projects in the Safety and Security programme contributed to extended networks with other types of organisations. EP: n=16, RP: n=25.

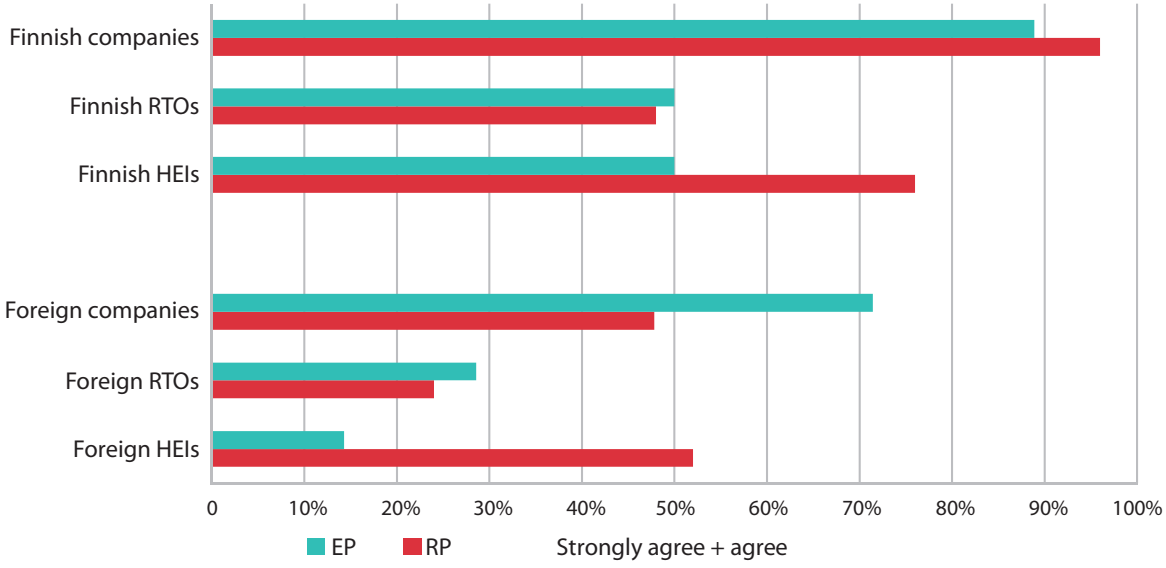
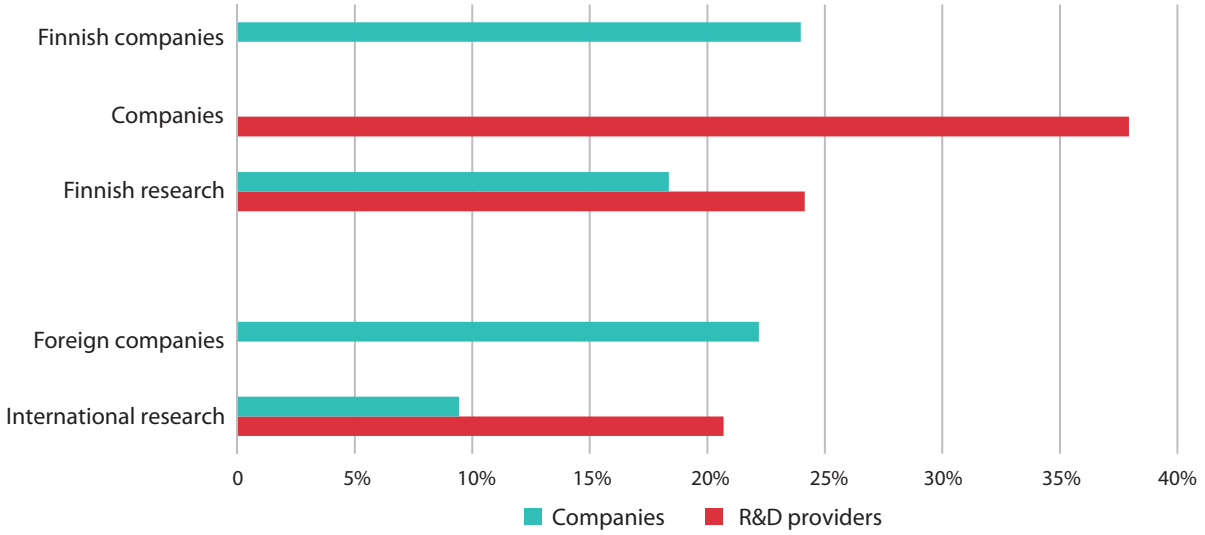


Figure 12. The extent to which participants in the Safety and Security programme agree to increased connections. Companies: n=392, R&D providers: n=29. Source: 4FRONT analysis of Tekes' monitoring survey data.



the case study on cybersecurity in Appendix D argues that the programme supported the creation of the Finnish Information Security Cluster (FISC). However, interviewees underline the importance of the new national and international collaboration realised through the projects. A survey respondent explains that 'the programme has had a significant effect on company cooperation with R&D performers'. Finding the right stakeholders to network and cooperate with is not always an easy task. A participant in an R&D project explains that they could not develop their pilot further into a product, since they could not find the right kind of company to collaborate with.

Some interviewees mention that they had problems convincing public authorities to agree to participate in proposals. Some proposers wanted to involve the police, the customs and the rescue services, but ended up having them as advisors rather than as project participants. On the positive side, others argue that they extended their networks with public authorities. One survey respondent explains that the project led to 'increased and closer cooperation with national security authorities'.

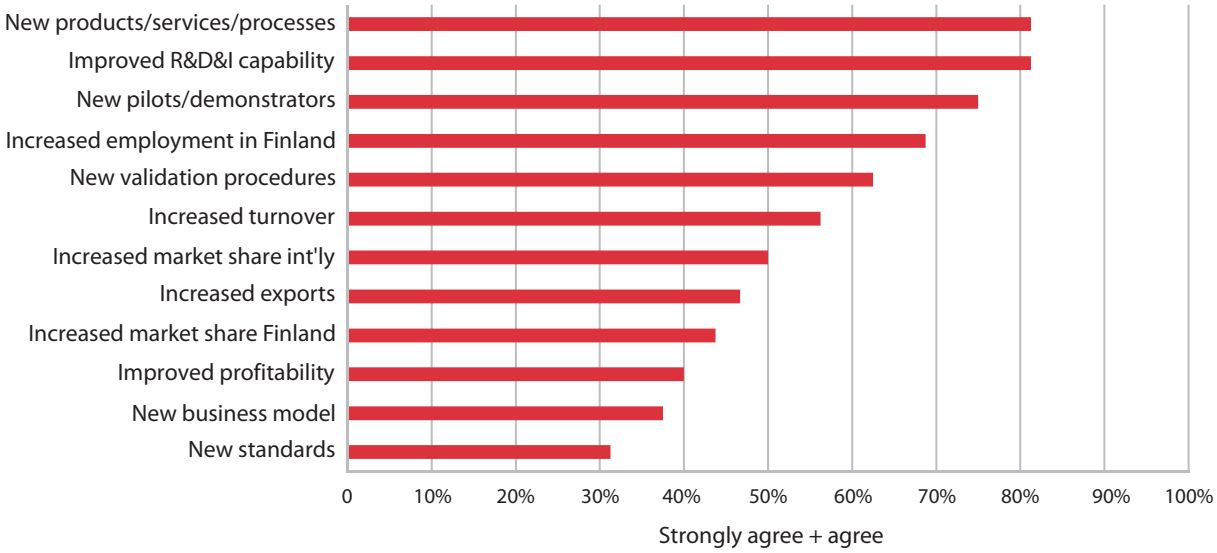
3.1.2 Impact

Survey respondents were also asked to assess longer-term impact on their own organisations. The statements that the respondent had to assess differed between enterprise and R&D projects. Participants in enterprise projects assess the main impact to be new products/services/processes, improved R&D&I capability and new pilots/demonstrators, see Figure 13. It is noteworthy that 56 percent of respondents agree that their projects contributed to increased turnover, 40 percent to improved profitability, 47 percent to increased exports, and 69 percent increased employment in Finland. However, we remind the reader to interpret survey results from enterprise project participants with care, since the number of responses is quite low.

In the survey, one enterprise project participant states that a spin-off company has been established in another country. Four R&D project participants (all from HEIs) agree to spin-off companies having been established in Finland, and one to a spin-off company having been established in another country (one of the same four respondents that agreed to a Finnish spin-off).

The interviews broadly provide examples that agree with survey results. Interviewees describe that their projects have contributed to new and developed products and systems. In addition, some projects were very successful; they resulted in increased market share, increased turnover and successfully commercialised products. Two companies, Blancco and Codenomicon, have had substantial commercial success based on their projects. Both were later sold to UK and US companies, respectively (see cybersecurity case story in Appendix D). An interviewee points out that they did not expect the impact to be as substantial as it turned out to be. There are also examples in the interviews of export of products developed through Safety and Security projects. Some company interviewees report that they have been able to employ more personnel due to the project. One interviewee underlines that participation in the programme gave the company the opportunity to find new customers and helped improve its competitiveness. A survey respondent writes that the company's business intelligence improved due to the project.

Figure 13. The extent to which enterprise projects in the Safety and Security programme contributed to impact for the participating organisation. n=16.



Not all company representatives believe that the company has seen any impact, and a survey respondent laments that 'the project had very little impact on our company'. Another respondent emphasises that already from the beginning of the project, they knew that the company was on the 'giving side' rather than getting any real benefits from the project.

One interviewee explains that it is important to understand the nature of the customers in the safety and security area. Many of them are public organisations such as government agencies or municipalities that can be quite conservative in their approach to technology development. Consequently, they can be described as followers, rather than leaders when it comes to technology, according to this interviewee. Since they are not very inclined to take risks, it may be difficult to engage them in technology development. Another problem concerning technology development in safety and security is that public organisations are often ruled by political decisions, with the effect that decision-making processes for buying new products are not always rational.

For R&D projects, the most widely reported impact was improved R&D&I capability; increased competitiveness compared to Finnish HEIs and RTOs/research institutes, and new R&D&I speciality, see Figure 14. Almost a third agree to 'additional foreign funding', which is linked to the sub-objective to improve the opportunities for Finnish participants to receive FP funding.

In interviews, participants in R&D projects emphasise the development of pilots, demonstrators and products, although not all of them were successful. One interviewee explains how the project has led to the development of a business model for how innovations can be used in the development of security solutions, and another interviewee states that the project contributed to business development in SMEs. Moreover, a survey respondent from a university writes about the establishment of a new innovation policy, where the project contributed to the basic idea and implementation of the innovation policy. Another interviewee describes the process of establishing a spin-off company. However, an academic explains that researchers are not always well suited to establish and manage a company, which Tekes seems to ignore.

Undoubtedly, there are also results and impact that were not explicit programme objectives. Such include increased turnover, increased profitability and increased employment in Finland, which is the kind of impact that you often see in successful R&D&I programmes. The Austrian National Research Development Programme for Security, KIRAS, requires that projects shall aim to contribute to creation of skilled jobs in Austria (see Austrian case study in Appendix B).

We may compare also the web survey data with data from Tekes' monitoring survey. Figure 15 shows the top ten types of impact reported by companies and R&D providers combined. The large differences in the formulation of options makes any direct comparison impossible, but we can easily see that the same kind of options appear on top in both surveys. In this case, we are confident that the main reason for the considerably higher percentages in the web survey is that it generally takes many years for an impact to emerge and become observable. Such a difference in magnitudes is thus in line with experience.

Figure 14. The extent to which R&D projects in the Safety and Security programme contributed to impact for the participating organisation. n=26.

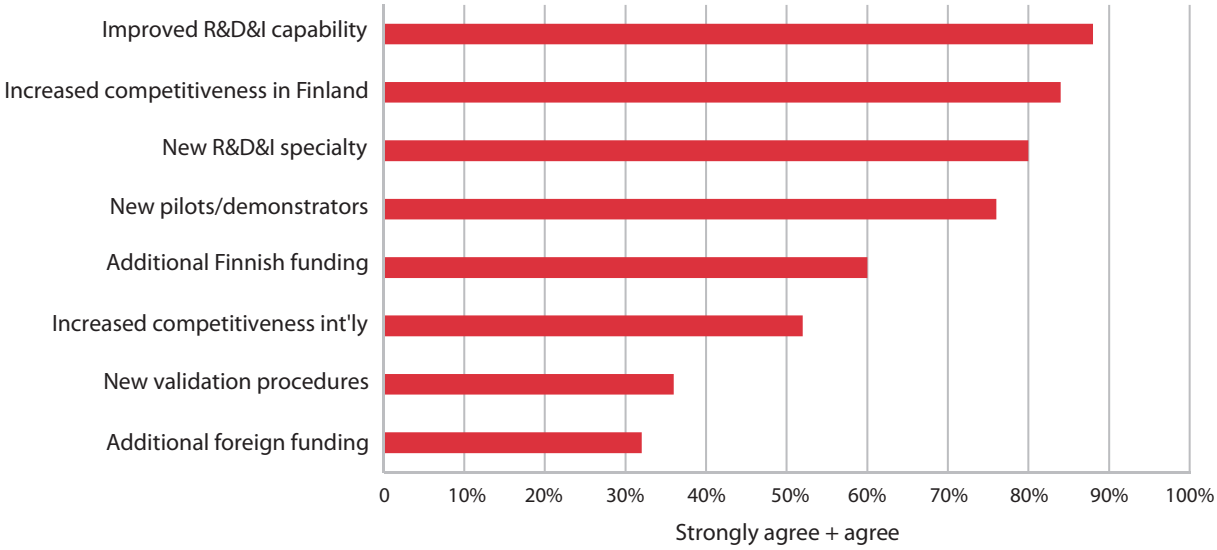
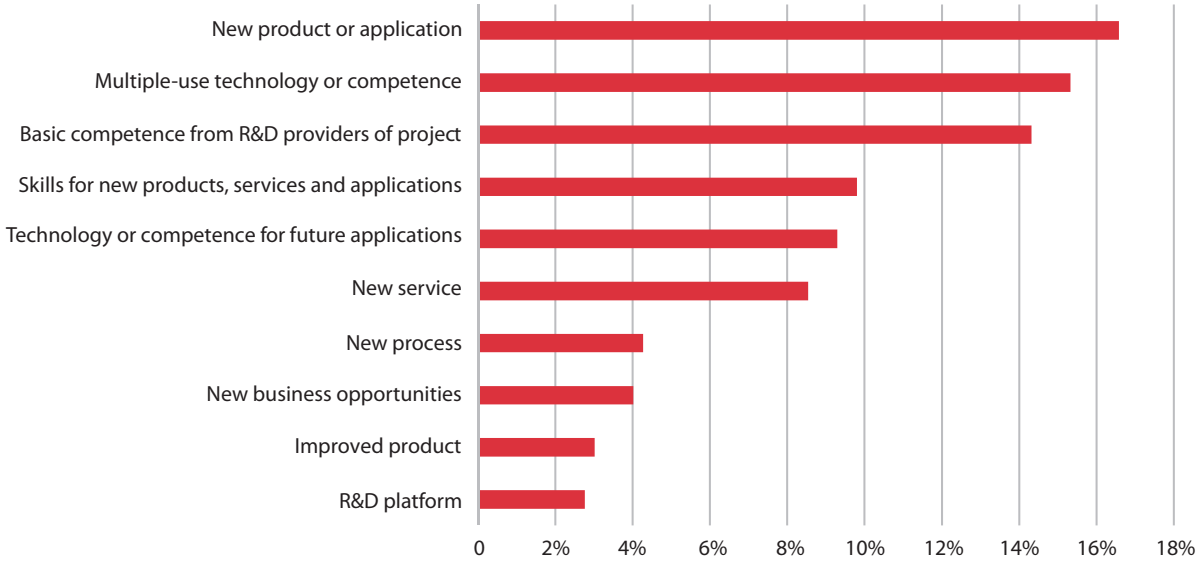


Figure 15. The extent to which participants in the Safety and Security programme agree to impact. n=398. Source: 4FRONT analysis of Tekes' monitoring survey data.



3.1.3 Expectations and added value of the programme

Survey respondents were asked to assess to what extent their project lived up to the organisation's expectations. Nine participants out of ten in R&D projects (88%) answered that the project had fulfilled their expectations, and the remaining respondents (12%) that it had exceeded them. Three out of four participants in enterprise projects (75%) answered that the project fulfilled expectations and 6 percent that it exceeded them; 19 percent believe that the project did not fulfil expectations. In balance, it is obvious that participants are quite satisfied with their Tekes projects.

In the surveys, we also asked what would have happened if projects had not been funded by Tekes, and three out of four participants in R&D projects (76%) answered that the project would not have been conducted at all. For enterprise projects, seven out of ten (69%) responded that the project would have been conducted with reduced scope,

and a third each (31%) that it would have been conducted with fewer partners, and that it would not have been conducted at all, respectively (several alternatives were permitted). These survey results are confirmed by the interviews, and there is a widespread view that projects would not have been realised at all without Tekes funding. In practice, this means that most of the results and impact presented in this section would probably not have been realised without the programme. HEIs and the RTOs would probably not have carried out any of the R&D, while some companies would probably have pursued some of their ideas, but with fewer participants (meaning less networking) and/or with reduced scope (meaning less impact).

In terms of added value of the programme, we recall that more than half of enterprise project participants report increased turnover, almost half increased exports, four out of ten improved profitability, and almost seven out of ten increased employment in Finland (but recall the small number of responses). Furthermore, the programme has contributed to increased international competitiveness for R&D providers and to increased international market share for companies, meaning that the innovations and the products resulting from the programme are likely to result in more added value in the future. Moreover, there may be up to four spin-off companies in Finland (and two in other countries), but the added value of a spin-off company is as always highly uncertain, since many go out of business or are merely set up to own intellectual property (patents) with the hope of eventually finding a buyer.

3.2 The Fuel Cell programme

3.2.1 Results

Figure 16 shows the responses from participants in enterprise projects (EP) and R&D projects (RP) of the Fuel Cell programme. Competence development and new knowledge are the most widely reported results for both categories of respondents. Additionally, many enterprise project participants have seen their projects result in new technologies and new devices/equipment, whereas research respondents indicate that both scientific publications and other kinds of publications to a high degree have resulted. It is noteworthy that R&D project participants state success in all categories to a significantly higher extent than enterprise project participants do. The number of respondents of both categories is quite small, but it should be borne in mind that this is mainly due to the simple fact that there were so few participants in the programme, meaning that the response rates are nevertheless reasonably good (cf. Section 1.2.3).

The survey results are practically unanimously corroborated by the interviews with participants of both enterprise and R&D projects. All interviewees talk about competence development of its personnel, as well as of development of technology. However, only some participants of enterprise projects mention patent applications, recruitment and publications. For participants of R&D projects, achievement of classical academic indicators (publications, and PhD students and degrees) is most prominent.

Figure 16. The extent to which projects in the Fuel Cell programme contributed to results for the participating organisation. EP: n=7, RP: n=12.

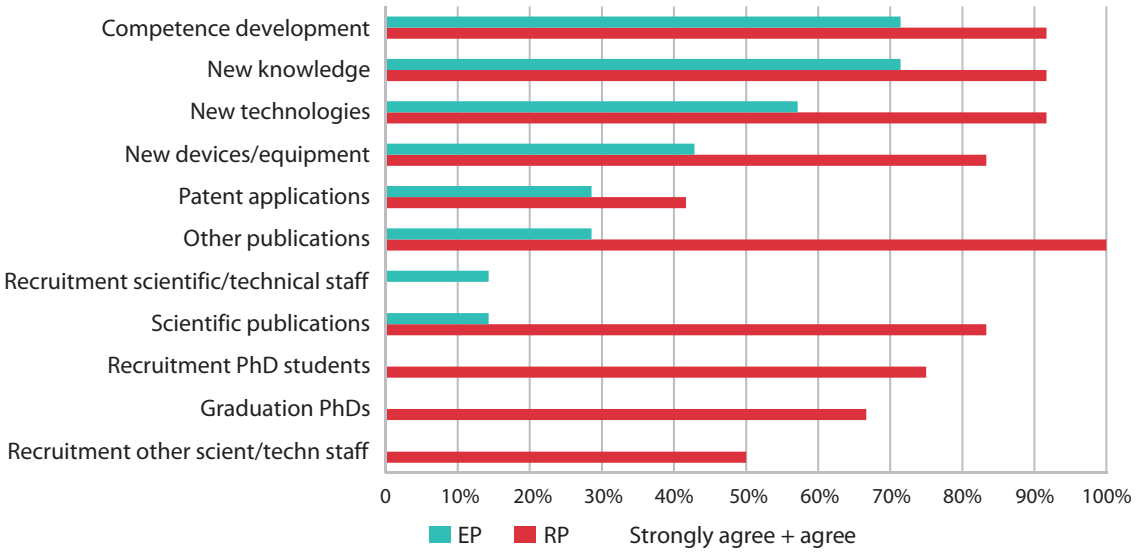
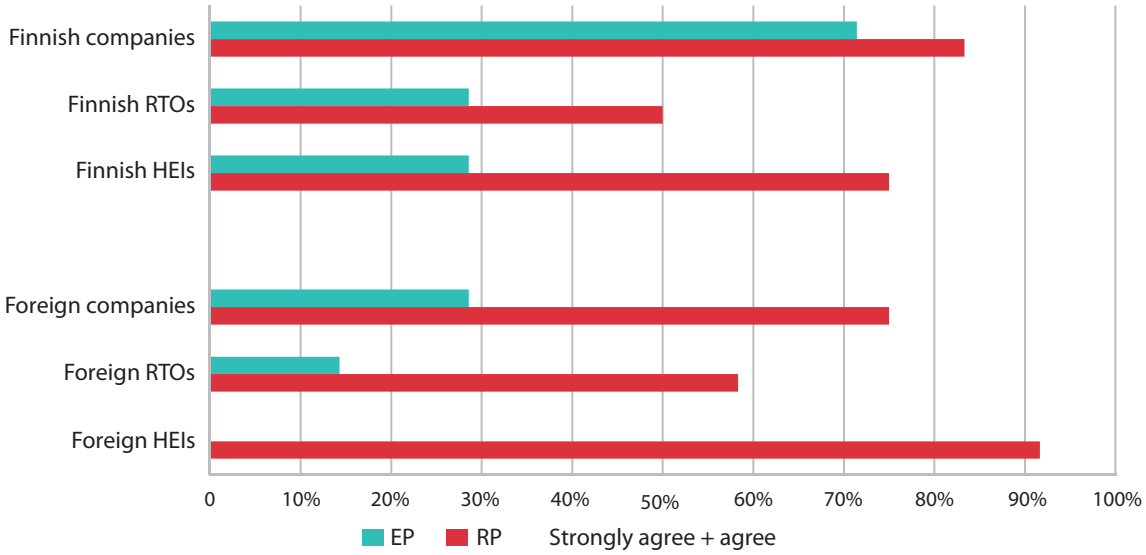


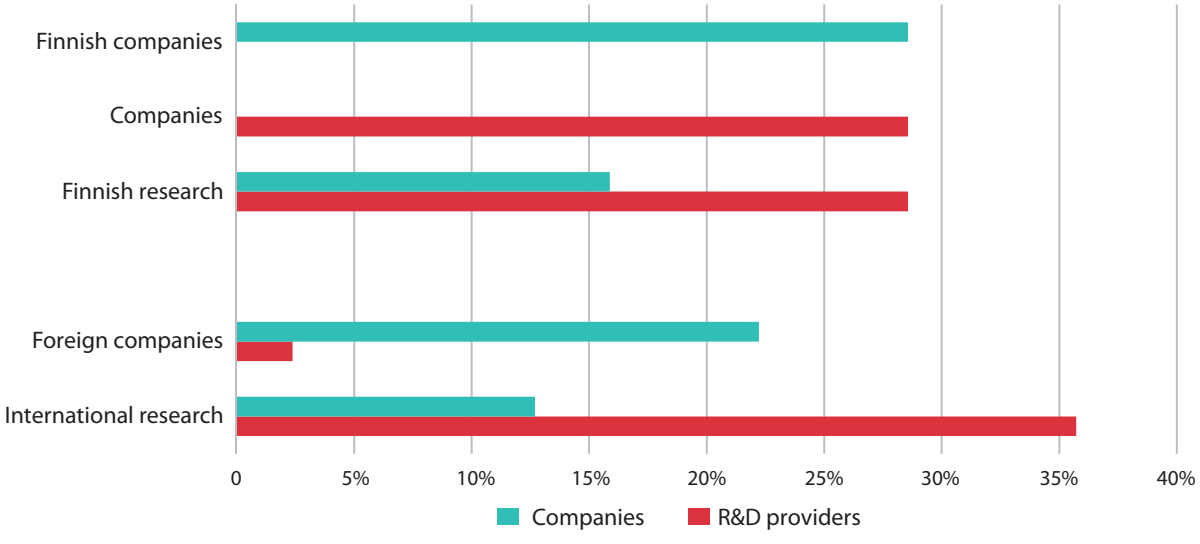
Figure 17. The extent to which projects in the Fuel Cell programme contributed to extended networks with other types of organisations. EP: n=7, RP: n=12.



The survey shows that participants of enterprise projects have significantly extended their networks with Finnish companies, but to some extent also with Finnish R&D providers and foreign companies, see Figure 17. However, the effect on the networks of participants of R&D projects is much more pronounced, and quite a bit more international in nature. Nearly all participants of R&D projects have experienced extended networks with foreign HEIs, and nearly as many with Finnish and foreign companies and Finnish HEIs. The networks with foreign and Finnish RTOs have also been extended significantly. Obviously, the programme has been most successful in extending the international networks of participants of R&D projects, dominated by RTOs and HEIs, which is also confirmed by interviewees who emphasise the establishment of international networks as very important and successful. Company representatives also mention the positive effects on the collaboration networks, and explain how this has been important for participation in international projects.

Comparing with Tekes' monitoring data, see Figure 18, we once again note much lower percentages but also similar trends between the datasets. We still believe that the differences mainly lie in a combination of respondents having come to appreciate networking effects more with time (in this case the difference in the average age of the datasets ought to be close to five years) and the way in which the survey questions were asked.

Figure 18. The extent to which participants in the Fuel Cell programme agree to increased connections. Companies: n=63, R&D providers: n=42. Source: 4FRONT analysis of Tekes' monitoring survey data.



3.2.2 Impact

Figure 19 shows that the impact of the Fuel Cell programme's enterprise projects is not very pronounced when compared to the Safety and Security programme (cf. Figure 13). While the top three alternatives, new products/services/processes, new pilots/demonstrators and improved R&D&I capability are the same (albeit in different order), the level of agreement is much lower for the Fuel Cell programme, thus suggesting that the time scales to impact in fuel cell development are considerably longer than in safety and security. Interviewees mainly emphasise new products and pilots, but explain that although companies have advanced significantly on the technology readiness level (TRL) ladder, much work remains before their fuel cell technologies are integrated into market-ready products. They argue that market acceptance also would require market-introduction programmes, such as have been used in Japan, USA and Germany (see case study of the German NIP programme in Appendix C). It is nevertheless noteworthy that according to the survey, two companies (representing 29%) have experienced increased turnover, improved profitability and increased employment (in Finland). A survey respondent from a R&D project notes that 'skilled fuel cell researchers from Tekes projects have found jobs in world-class fuel cell companies after the programme'. A company representative relates how the project led to recruitment and to the development of a new business plan allowing the company to take place in international value chains.

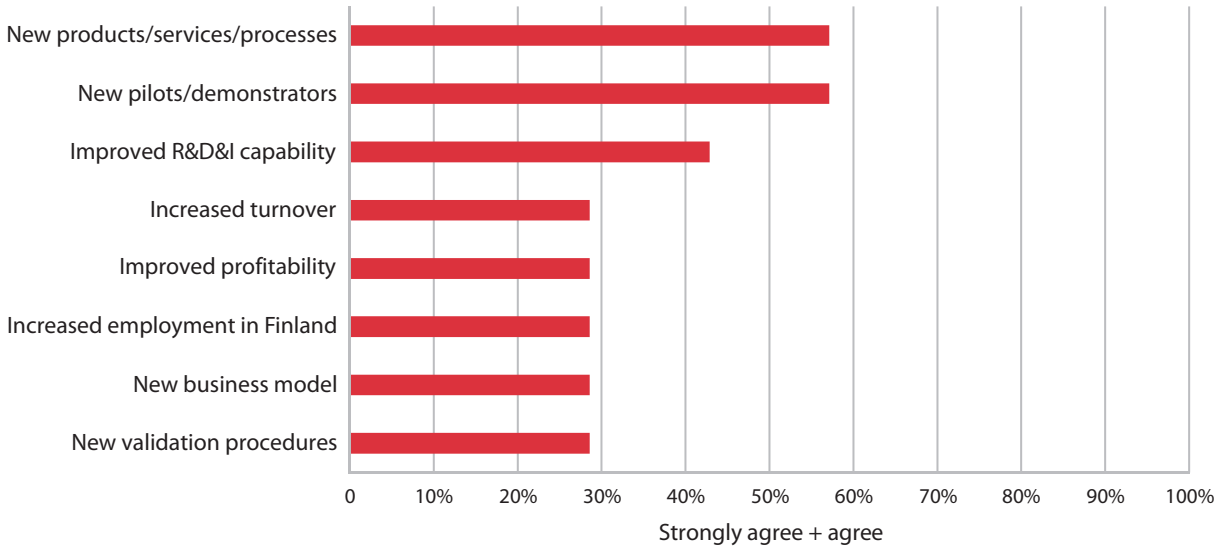
Interviewees explain that in 2007, Finland did not have very many companies active in fuel cells. The Fuel Cell programme has facilitated collaboration between industry and RTOs, which has increased the competitiveness of companies and it has also helped to get additional companies involved in fuel cells. Examples from interviews include:

- Elcogen, a micro-SOFC company, has expanded
- Convion, a provider of larger stationary SOFC systems, has increased its employment and product exports are being planned
- Woikoski, a supplier of hydrogen refuelling stations, has increased its employment

On the other hand, during the course of the programme, the largest company active in fuel cells when the programme started (Wärtsilä), which was an important driver for the creation of the programme, spun off its fuel cell development into Convion, and eventually withdrew entirely from fuel cells. Two R&D project participants (both from RTOs) also agree to spin-off companies having been established in Finland, and one to a spin-off company having been established in another country (one of the same two that agreed to a Finnish spin-off).

Figure 20 reveals that participants of R&D projects experience impact to a considerably greater extent than participants of enterprise projects. While most of the highest rated alternatives are the same as for the Safety and Security programme, it is noteworthy that increased competitiveness internationally is much higher rated by participants in the Fuel Cell programme. This is consistent with the networking effects reported in Figure 17, wherein the degree of internationalisation is pronounced (but only for participants of R&D projects). Clearly, respondents experience significant advances from both engineering and

Figure 19. The extent to which enterprise projects in the Fuel Cell programme contributed to impact for the participating organisation. n=7.



scientific points of view. Interviewees explain that for all but the largest R&D providers, the Tekes programme was critical to get active in fuel cell R&D. Survey results also reveal that two respondents out of three have received additional Finnish R&D funding, and that more than half have received additional foreign funding, thus indicating a possibly sustainable development.

The data from Tekes' monitoring survey in Figure 21 (companies and R&D providers combined) makes for an interesting comparison. As mentioned above, on average the monitoring survey data ought to be close to five years older than the web survey data. Five years ago, the dominating types of impact were with one exception intermediate ones such as competence, skills and technology. By 2016 the previous third-rated impact (new product) had risen to become the top impact (cf. Figure 19), while at the same time the magnitudes had increased notably (just as for the Safety and Security programme), thus reinforcing the well-established insight that it takes many years for impact to become observable.

Figure 20. The extent to which R&D projects in the Fuel Cell programme contributed to impact for the participating organisation. n=12.

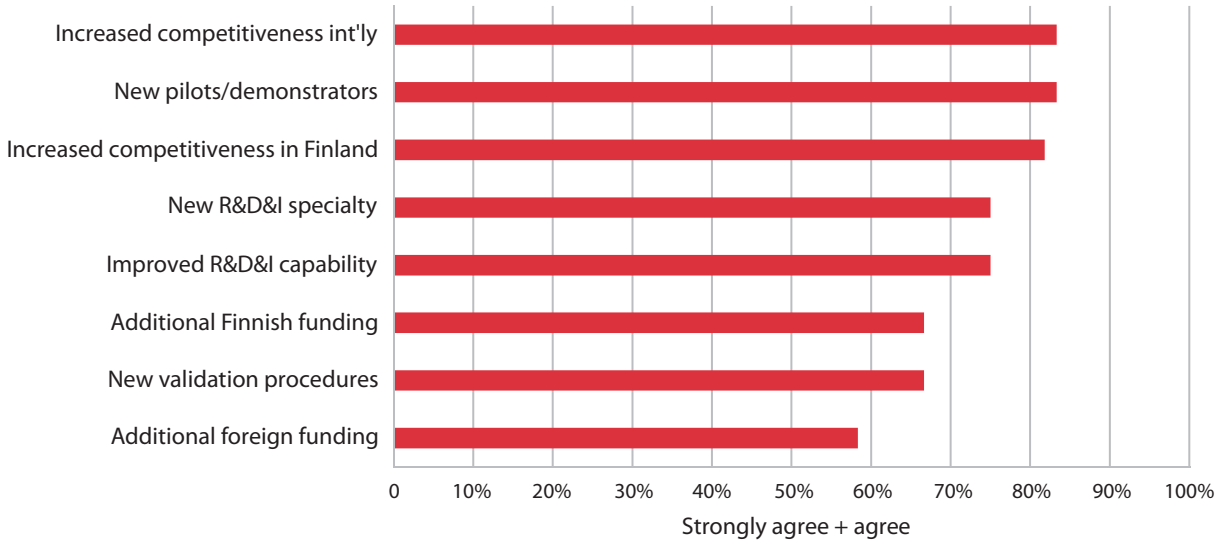
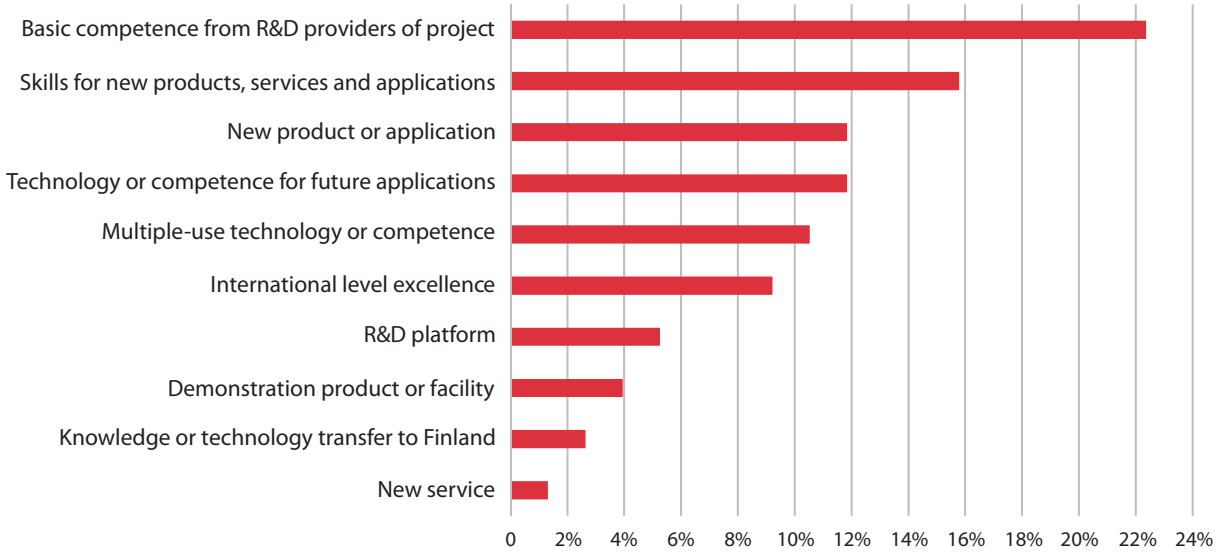


Figure 21. The extent to which participants in the Fuel Cell programme agree to impact. n=76. Source: 4FRONT analysis of Tekes' monitoring survey data.



3.2.3 Expectations and added value of the programme

Survey results reveal that six out of seven participants in enterprise projects (86%) believe that their project lived up to their organisation's expectations, and only one participant that it did not. Six out of twelve participants in R&D projects (50%) judge that their project exceeded expectations, another five that it fulfilled expectations (42%), and only one participant that it did not. It is thus clear that the vast majority of programme participants are quite satisfied with their projects.

In the survey, six out of seven respondents of enterprise projects (86%) state that the project would not have been conducted at all without Tekes funding. The remaining company says that the project would have been conducted with reduced scope, with fewer partners and over a longer timeframe. Out of the companies interviewed, two say that they would not have ventured into fuel cells at all without Tekes funding, and another four that their work would have been conducted with reduced scope and/or longer timeframe. Three out of four survey respondents of R&D projects (75%) state that the project would not have been conducted at all (same proportion as for the Safety and Security programme). None of the R&D providers interviewed say that they would have carried out their project without Tekes funding. Furthermore, interviewees of all kinds argue that Tekes funding was crucial for most participants, and only the companies that since long were strategically active in fuel cells and the largest R&D providers were not completely dependent on Tekes funding.

In conclusion, most of the results and impact presented in this section would probably not have been realised without the Fuel Cell programme. Most of the R&D providers would probably not have carried out any of the R&D, while a minority perhaps would have conducted less ambitious R&D projects in the same field. Survey results and interview statements suggest that very little of the company R&D that has been conducted would have been realised without Tekes funding. However, several interviewees argue that there is a dire need for additional public support to facilitate market preparation and commercialisation of fuel cells. The Fuel Cell programme has co-funded important technological advances, but the final step is missing, meaning that the advances made may be commercialised by others and in other countries than Finland. A participant of an R&D project reasons:

> *It is better not to give a funding at all, if funding cannot be given to bring the project to the goal. It is a waste of taxpayers' money if the results are only scientific papers and dissertations, but do not lead to commercial products for involved companies.*

In terms of added value, we note that two companies say that they have experienced increased turnover, improved profitability and increased employment (in Finland). Furthermore, the programme has strongly contributed to increased international competitiveness for R&D providers, thus suggesting that innovations resulting from the programme may lead to additional added value in the future. Moreover, there may be up to three new spin-off companies in Finland (and one in another country).

3.3 Participation in the Framework programme

We commence our treatise of the internationalisation aspects of the two Tekes programmes by studying Finnish participation in the security and fuel cell parts of FP7 and Horizon 2020 (H2020). We then compare FP funding to Finnish organisations between FP7 Coordination themes and joint undertakings (JUs). Following that, we deliberate to what extent Finnish participation in the safety and security and fuel cell parts of the FPs can be attributed to the two Tekes programmes, and finish the section by assessing the impact experienced by Finnish participants in FP projects.

3.3.1 Overall Finnish FP participation in security and fuel cells

Based on E-Corda data received from EUTI, we have summarised the Finnish participation in FP7 Security and H2020 Secure Societies (including funding decisions registered by February 2016), see Table 5. The reason for the number of Finnish participations being much larger than the number of projects is that many projects have (had) more than one Finnish participant.

So far, Finnish participants in security projects have received €43m from the FPs (37% to VTT), of which €30m has gone to organisations that participated in Tekes Safety and Security (SS) programme. VTT has coordinated four projects in FP7 and coordinates one in H2020; Laurea University of Applied Sciences also coordinates one project in H2020. In addition, University of Jyväskylä (JYU) has coordinated two projects in FP7 and the Crisis Management Initiative (CMI) one, but neither them participated in the Tekes programme. Studying projects coordinated by Finnish organisations that participated in the Tekes programme, it looks as if VTT has brought 11 companies and numerous other organisations into FP projects, and that Laurea similarly has brought one company and many other organisations into projects.

Table 6 provides the equivalent summary of Finnish participation in FCH JU (under FP7) and FCH2 JU (under H2020) by February 2016. Finnish participants have received €16m from the FPs (46% to VTT), of which €15m has gone to organisations that participated in Tekes Fuel Cell (FC) programme. (There are only three participations of organisations that did not participate in the Tekes programme.) VTT

Table 5. Summary of Finnish participation in FP7 Security and H2020 Secure Societies by February 2016. Funding amounts, in million euro, refer to FP funding. Source: Technopolis analysis of E-Corda data.

	Number of Finnish			Funding	Funding to Tekes SS participants		
	participations	projects	coordinators	to Finland	Total	EP	RP
FP7 Security	113	74	8	36.5	26.6	4.8	21.8
H2020 Secure societies	17	6	2	6.8	3.5	0.7	2.8
Total	**130**	**80**	**9**	**43.3**	**30.1**	**5.5**	**24.6**

Table 6. Summary of Finnish participation in FCH JU and FCH2 JU by February 2016. Funding amounts, in million euro, refer to FP funding. Source: Technopolis analysis of E-Corda data.

	Number of Finnish			Funding	Funding to Tekes FC participants		
	participations	projects	coordinators	to Finland	Total	EP	RP
FCH JU	33	22	6	9.6	8.7	1.5	7.2
FCH2 JU	5	2	1	5.9	5.9	4.9	1.0
Total	**38**	**24**	**7**	**15.5**	**14.6**	**6.4**	**8.1**

has coordinated five projects in FCH JU and coordinates one in FCH2 JU, and Aalto University coordinated one in FCH JU. It looks as if VTT has brought four companies (incl. two that did not participate in the Tekes programme) and two HEIs into FP projects, and that Aalto University has brought three companies into projects.

3.3.2 Comparison of Finnish participation in FP7 Cooperation themes and JUs

Evaluation question 13 asks how Finnish funding obtained from FP7 Security and FCH JU compares to other FP7 themes and JUs. For this analysis, we have not received any data from EUTI and have had to rely on the publicly available E-Corda data available on the European Union Open Data Portal.[60] In this dataset, funding for all ICT projects has been hidden, and all projects in ENIAC JU and IMI JU have been omitted. (Neither dataset contains funding information for GMES JU, which is administered by the European Space Agency (ESA).) We also note that several Security projects in the public dataset lack funding information (12% of the total Finnish funding is missing compared to the dataset received from EUTI). The comparisons between FP7 Cooperation themes and JUs are summarised in Table 7.

Figure 22 shows that the level of funding per Finnish participation in the FP7 Security theme is among the high-

Table 7. Summary of Finnish participation in FP7 Cooperation themes and JUs.[61] Funding amounts refer to FP funding. .. = Data not available. Source: Technopolis analysis of public E-Corda data.

	Participations	Coordinators	Funding (€ million)	Funding/participation (€*1 000)	Coordinators/ participations
ENERGY	95	8	12	121	8%
ENVIRONMENT	117	7	28	236	6%
HEALTH	214	15	62	292	7%
ICT	435	47	..	..	11%
KBBE	178	13	41	230	7%
NMP	312	29	89	284	9%
SECURITY	118	7	32	271	6%
SPACE	73	9	19	260	12%
SSH	62	9	17	273	15%
TRANSPORT	124	9	18	146	7%
ARTEMIS JU	95	5	10	107	5%
Clean Sky JU	1	0	0.03	33	0%
FCH JU	40	6	10	245	15%

60 open-data.europa.eu/en/data/dataset/cordisfp7projects, accessed 17 May 2016.

61 ICT = Information and Communication Technologies; NMP = Nanosciences, Nanotechnologies, Materials and new Production Technologies; KBBE = Food, Agriculture and Fisheries, Biotechnology; SSH = Socio-economic Sciences and Humanities; ARTEMIS JU deals with embedded computing technologies; Clean Sky JU deals with aeronautical research.

est in the Cooperation programme, and the level of funding in the FCH JU is far higher than for ARTEMIS. Interestingly, Figure 23 reveals that while the prevalence of Finnish coordinators in FCH JU projects is very high (one in seven projects with Finnish participants has been coordinated by a Finnish organisation), there are remarkably few Finnish coordinators in FP7 Security projects (every 17th project). However, we do not believe that these comparisons tell us anything about the effectiveness of the two Tekes programmes in stimulating FP participation.

Figure 22. Funding per Finnish participation in different FP7 Cooperation themes and JUs. Funding amounts refer to FP funding. Source: Technopolis analysis of public E-Corda data.

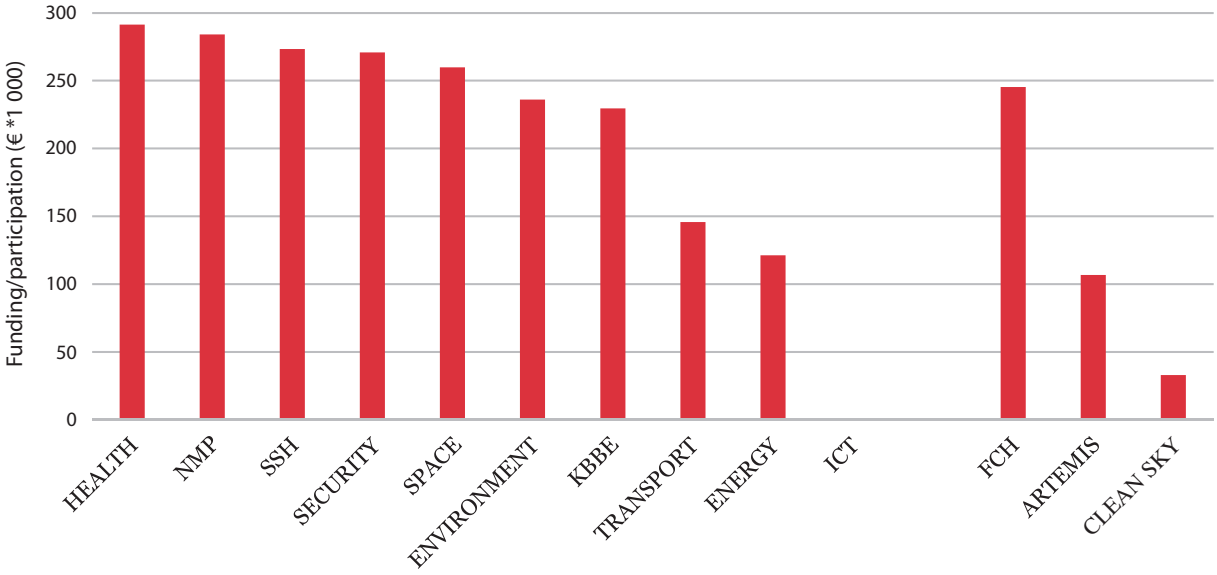
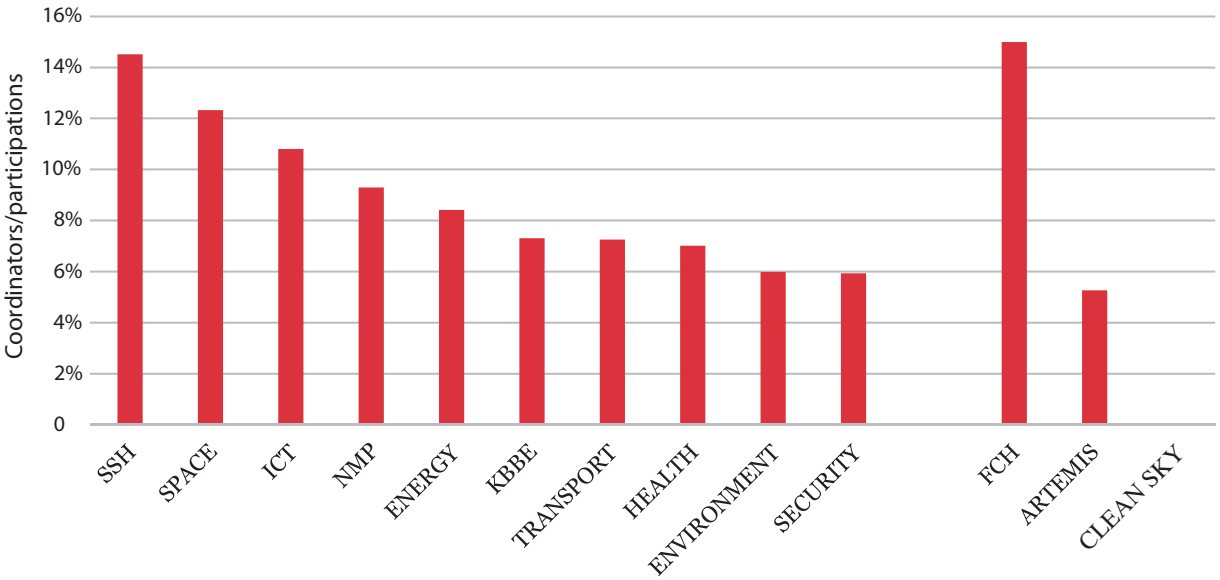


Figure 23. Ratio of Finnish coordinators and Finnish participations in different FP7 Cooperation themes and JUs. Source: Technopolis analysis of public E-Corda data.



3.3.3 FP participation by participants in Tekes programmes

We now go on to analyse how the participants in the two Tekes programmes have succeeded in FP7 Security and H2020 Secure Societies, and FCH JU and FCH2 JU (in all cases including funding decisions taken by February 2016). Figure 24 shows Tekes' funding to all enterprise projects in the Safety and Security programme (red curve), the share of the Tekes funding that went to organisations that have participated in the FPs (turquoise curve), and the total funding from the FPs to the same organisations that participated in the Tekes programme (black curve). First, we observe that very few of the enterprise project participants have participated at all in the FPs, as indicated by the turquoise curve being so much lower than the red one. Then we note that the amount of FP funding (area below the black curve) seems to be about the same as the funding these organisations received from the Tekes programme (area below the turquoise curve); we will soon get back to a more thorough analysis of the ratio of FP funding to Tekes funding.

Figure 25 shows the equivalent funding information for the R&D projects in the Safety and Security programme. We note that FP participation has been significantly more widespread among participants of R&D projects than among enterprise project participants. We also note that

Figure 24. Funding to enterprise projects in the Safety and Security programme, and FP funding to participants in the Tekes programme. Source: Technopolis analysis of Tekes and E-Corda data.

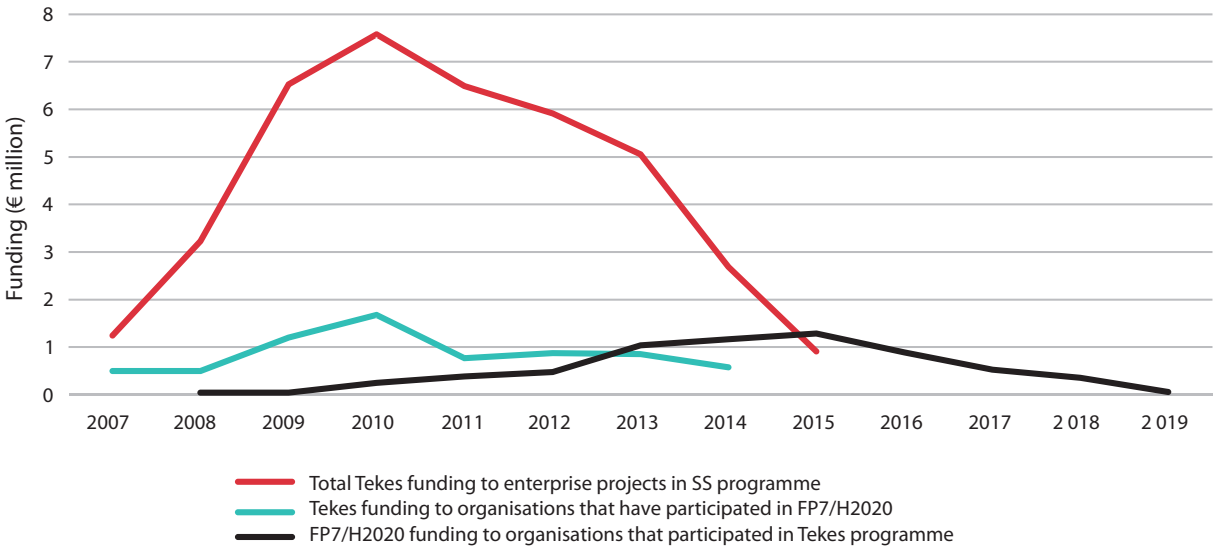
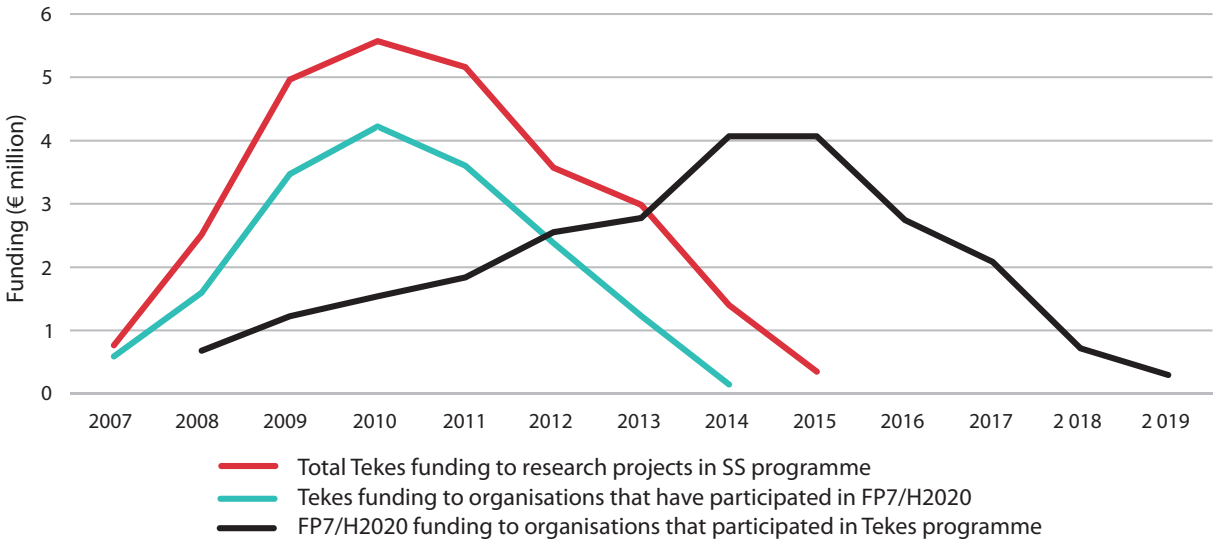


Figure 25. Funding to R&D projects in the Safety and Security programme, and FP funding to participants in the Tekes programme. Source: Technopolis analysis of Tekes and E-Corda data.



participants of R&D projects seem to have been quite successful in the FPs.

Figure 26 and Figure 27 show the equivalent information for the Fuel Cell programme. Compared to the Safety and Security programme, participants of the Fuel Cell programme seem to have participated in FP projects to a greater extent. However, the companies were collectively not very successful until the onset of FCH2 JU, which started in 2015. The sharp increase in FCH JU funding is almost entirely the result of two companies that have received three large projects. These are Convion (two projects) and Elcogen (one project).

We are aware of the fact that some Finnish companies active in fuel cells have received substantial funding from EU programmes in addition to that shown in Figure 26, for example from FP6 and more recently from the Trans-European Transport Network (TEN-T) programme.[62] Such funding is beyond the scope of this evaluation, but the reader should nevertheless be aware that the black line in Figure

Figure 26. Funding to enterprise projects in the Fuel Cell programme, and FP funding to participants in the Tekes programme.
Source: Technopolis analysis of Tekes and E-Corda data.

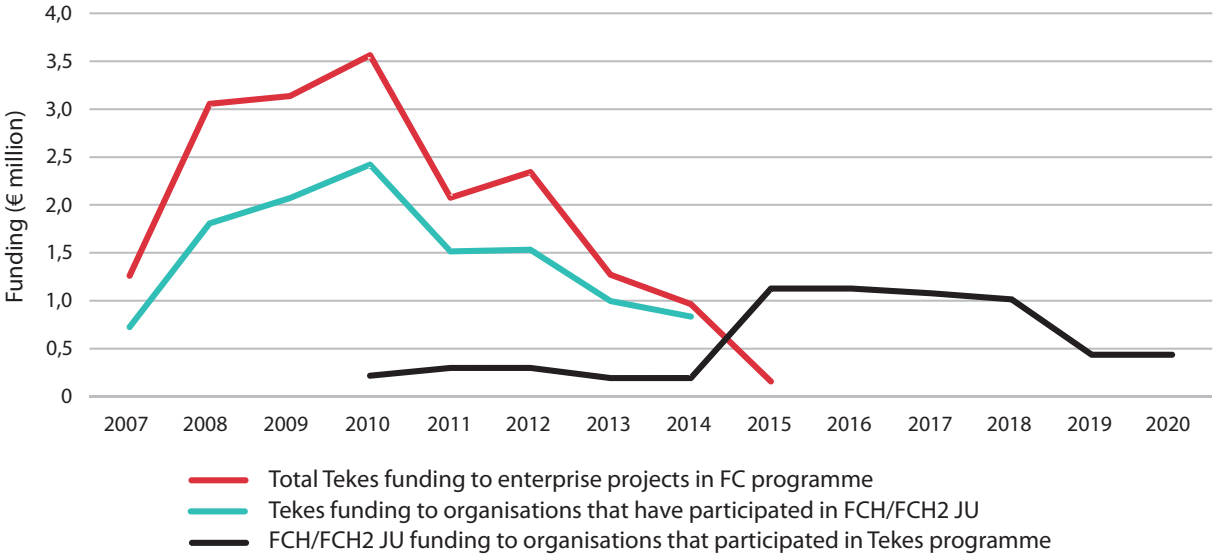
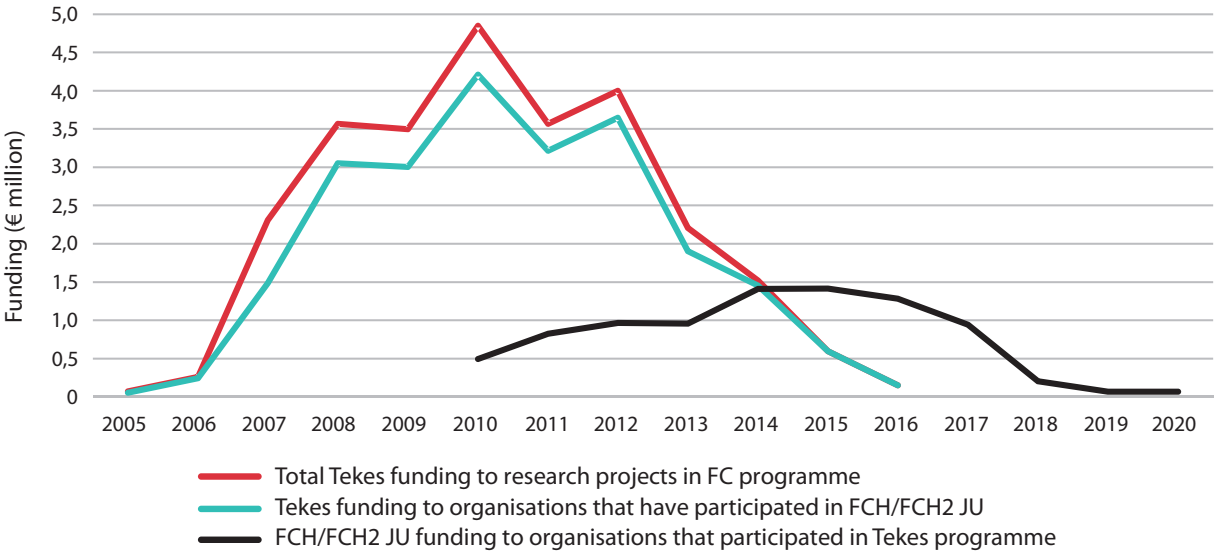


Figure 27. Funding to R&D projects in the Fuel Cell programme, and FP funding to participants in the Tekes programme.
Source: Technopolis analysis of Tekes and E-Corda data.



62 Finnish organisations participated in five FP6 projects and one LIFE project related to fuel cells with total budget of €53m (meaning that the FP funding was considerably lower, probably on the order of half as much). Source: Fuel Cells and Hydrogen in Finland – Finnish Fuel Cell Programme 2007-2013, Review 301/2013, Tekes.

Table 8. 'Payback' on Tekes funding by February 2016. Source: Technopolis analysis of Tekes and E-Corda data.

	Enterprise projects	R&D projects
FP funding/Total Tekes funding		
Safety and security participants	16%	90%
Fuel cell participants	36%	32%
FP funding/Tekes funding to FP participants		
Safety and security participants	94%	143%
Fuel cell participants	54%	37%

26 (and in the other three figures, for that matter) does not include all funding from all EU programmes.

Table 8 shows two possible ways to summarise FP funding received in relation to Tekes funding. In the uppermost half of the table, we have divided FP funding to participants in the Tekes programmes (by February 2016) by the total Tekes programme funding (the area under the black curve divided by the area under the red curve). In the lower half of the table, we have divided FP funding to participants in the Tekes programmes (by February 2016) by Tekes funding to the very same organisations (the area under the black curve divided by the area under the turquoise curve). Which of the ratios that is the most relevant is a matter of preference. Nevertheless, in subsequent chapters of this report, we focus on the ratio of FP funding and total Tekes funding.

3.3.4 To what extent can the FP participation be attributed to the Tekes programmes?

We have to rely on circumstantial evidence to answer this question. First, we refresh our memory as regards to what extent the Tekes projects contributed to extended international networks, according to survey respondents. We have already presented this information in Figure 11 and Figure 17, but in Figure 28 we have merged answers from enterprise and R&D projects, and exercise the opportunity of comparing the two programmes. We see that around half of respondents are of the opinion that their Tekes projects have expanded their networks with foreign companies and universities, but also that networks with foreign RTOs have benefited notably. Participants in the Fuel Cell programme seem to have benefited the most.

In the survey, we asked respondents that stated that they had participated in at least one FP proposal (in security or fuel cells) to assess the importance of their Tekes project in facilitating the participation in the FP proposal. Figure 29 shows that respondents, particularly those of the Fuel Cell programme, are of the opinion that the Tekes project made quite an important contribution in several respects. Almost two out three Fuel Cell programme participants and almost every other Safety and Security programme participant state that the Tekes project meant that they were invited to join a consortium.

Interviewees explain that the fact that they had already acquired knowledge and experience in the Tekes project meant that they were more attractive as partners in the

Figure 28. The extent to which projects in the Safety and Security (SS) and Fuel Cell (FC) programmes contributed to extended networks with foreign organisations. SS: n=41, FC: n=19.

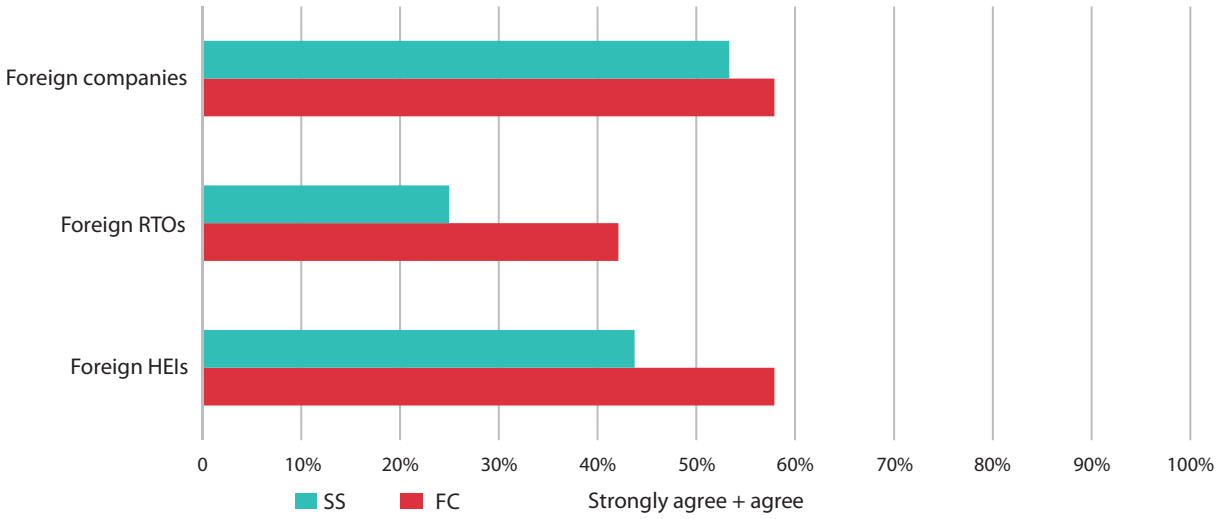
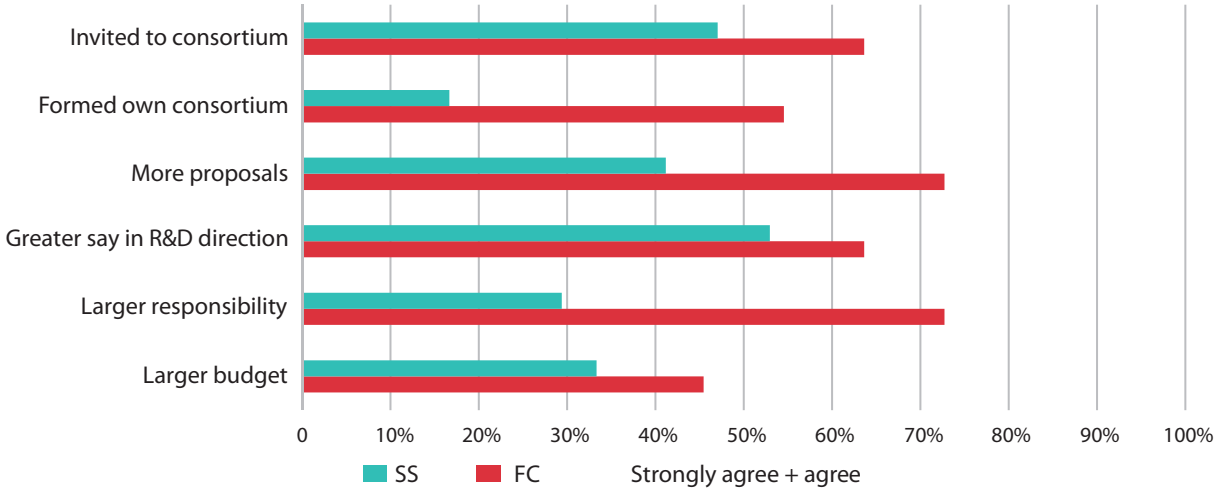


Figure 29. The extent to which projects in the Safety and Security (SS) and Fuel Cell (FC) programmes facilitated participation in FP proposals. SS: n=17, FC: n=11.



FP proposal. More than half of Fuel Cell programme participants also formed their own consortia. Having gained knowledge and experience 'at home' also resulted in participation in far more proposals and larger shares of proposal budgets, but perhaps the most important is that participants were given – or had the confidence to take on – larger responsibilities in the consortia and had a greater say in the R&D direction of the proposals. When considering these survey results, it is important to realise that (according to survey respondents) Safety and Security programme participants had a proposal success rate of 72 percent, and Fuel Cell programme participants a success rate of 91 percent. These are exceptionally high success rates for FP proposals, which is encouraging, but they also suggest that the survey respondents are a positive selection of very successful proposers, so these results should be taken with a grain of salt.

The survey results are further corroborated by interviews and free-text responses in the surveys. Several interviewees say that their Tekes projects were of importance for participating in FP proposals. Company representatives explain that their Tekes projects improved their competence and readiness for participating in FP projects, and provided case studies from Finland that could be used in FP7 projects. A survey respondent from the Safety and Security programme states that:

> *The project laid forth the groundwork for a successful FP7 project. Contacts made during the research exchange were directly used in the FP7 application.*

Two similar statements from the Fuel Cell programme:

> *Without Tekes' Fuel Cell programme, Finnish fuel cell research would not have been considered a serious effort in the European roundtable where EU money is distributed.*

> *Our Tekes project created the basis for participation in FCH JU proposals. Without the Fuel Cell programme, it would have been more difficult to participate.*

Figure 30 shows Tekes and FP funding to a company that participated in enterprise projects in the Safety and Security programme. This is a fairly typical funding scenario that (if one ignores the scale on the vertical axis) could apply to almost any organisation in either of the two Tekes programmes. For all ten enterprise and eleven R&D project participants in both the Safety and Security programme and in the FPs there is a 1–5 year overlap between Tekes and FP funding; typically it is 1–3 years. Similarly, for most of the six enterprise and four R&D project participants in both the Fuel Cell programme and in the FPs there is a 1–3 year overlap between Tekes and FP projects.

So why is this relevant? Well, for a Tekes project to facilitate FP participation there must be a time lag. It takes at least a year, and often longer, to form an FP consortium, to write a proposal, to get it approved, and to negotiate and sign a contract. If we look at this company's individual projects, see Figure 31, we can for example probably rule out that 'Tekes project 2' should have had any influence at all on 'FP7 project 1'. On the other hand, 'Tekes project 2' could very well have facilitated the company's participation in at least 'FP7 project 2' and 'FP7 project 3', and 'Tekes project 1' could certainly have influenced participation in all three FP7 projects. Whether there actually was any such facilitation is of course unknown to us, and we do not know whether the FP7 projects had any topical relation to the Tekes projects, but it is possible. Several interviewees explain that their Tekes projects indeed were topically related to subsequent FP projects, and that their Tekes projects facilitated or, for some organisations, were critical to their FP participation. However, it should also be noted that an interviewee rep-

Figure 30. Tekes funding and FP funding to a company that participated in enterprise projects in the Safety and Security programme. Source: Technopolis analysis of Tekes and E-Corda data.

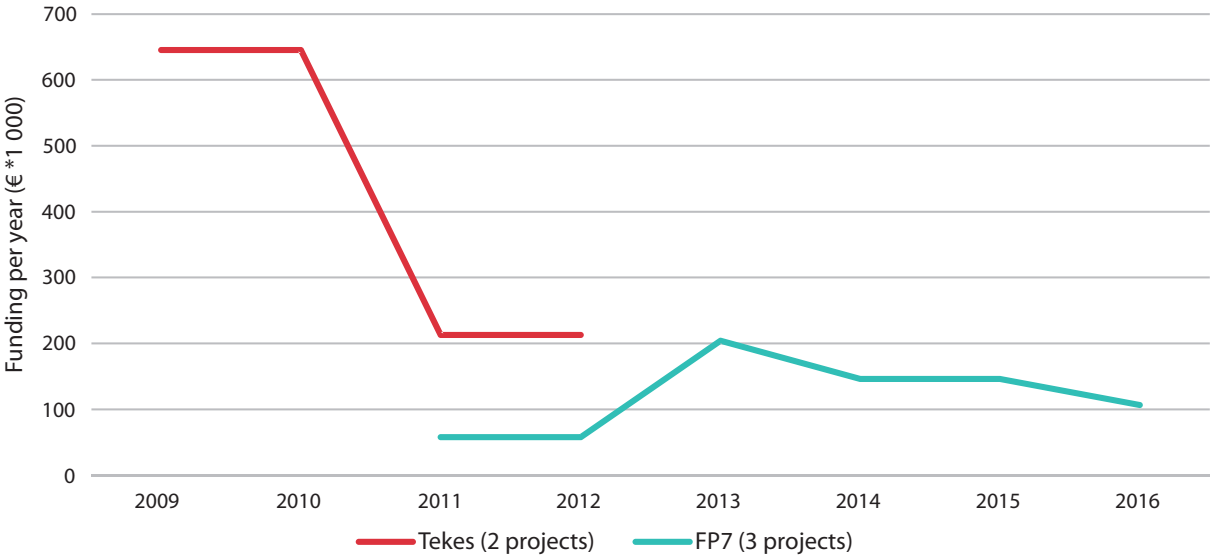


Figure 31. Funding to the five individual projects of previous figure. Source: Technopolis analysis of Tekes and E-Corda data.

resenting a large organisation states that there was no relation whatsoever between the organisation's Tekes and FP projects, so the picture is blurred. We save our answer to the question of the title of this section for next chapter.

3.3.5 Impact of FP project participation

In both surveys and interviews, we asked about the impact of participation in FP projects. However, considering the low number of survey responses in the first place and among them a very low occurrence of FP participation, we only received five FP participation-related survey responses from participants in enterprise projects and 18 from R&D projects. We therefore cannot rely on the responses from enterprise project participants, and must be very, very careful in interpreting responses from R&D projects.

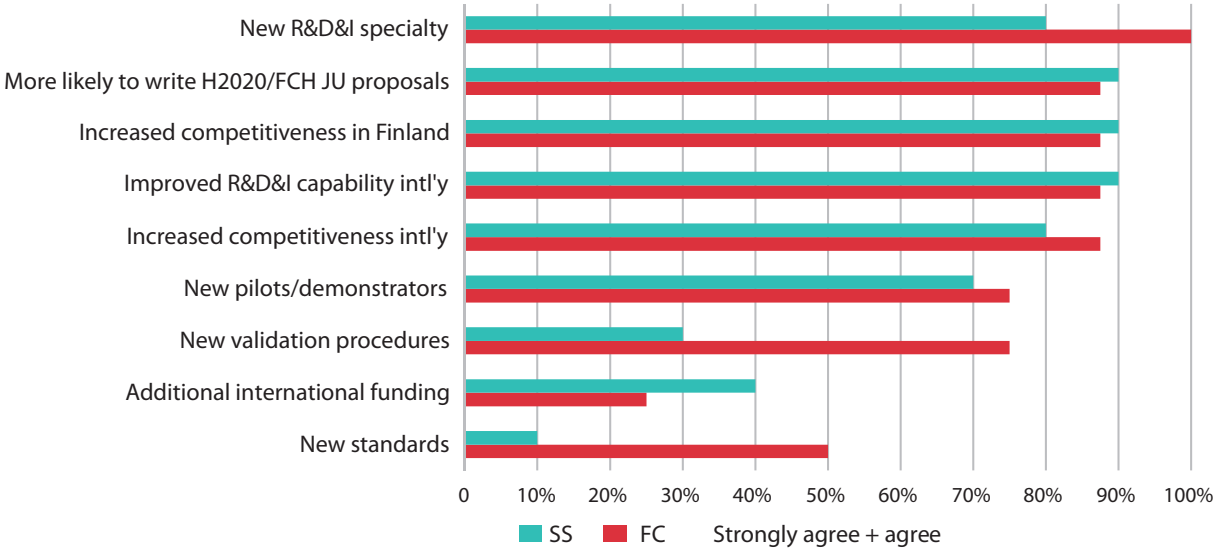
Keeping this scepticism in mind, Figure 32 nevertheless suggests that substantial impact has arisen for former participants of Tekes R&D projects. Given the low number of respondents, we suggest that the reader ignores the percentages *per se*. Possibly the only conclusion that can reasonably be drawn from this figure is that a handful of R&D providers have experienced very notable impact, but we cannot be sure that the responses are representative. However, an analysis of what organisations the survey respondents come from and what share of the FP funding they have received

offers some clues. Looking at the respondents from R&D projects in the Fuel Cell programme, we find that 88 percent (7 of 8) come from VTT, and VTT has received 88 percent of the FP funding that has gone to participants in R&D projects of the Fuel Cell programme. The equivalent percentages for the Safety and Security programmes are 80 percent (8 of 10 respondents) and 65 percent (of FP funding to participants in R&D projects in the Tekes programme). This is not to say that the survey results suddenly are to be taken at face value, only that there are some indications that they after all may be reasonably representative – at least as far as Finland's by far largest FP participant is concerned.

The interviewees are not very concrete on the impact of their FP projects, in some cases because projects are still ongoing. In the survey, representatives of R&D providers say that their FP projects have resulted in 'very good European networks' and 'a strong international reputation outside Europe'. One of them emphasises that projects have 'improved networks also for Finnish companies'. All interviewees talk of increased ability and capability to collaborate in international R&D&I projects (as do all five survey respondents from Tekes enterprise projects). Several company representatives describe that they have established important relationships that may lead to business opportunities, but the interviews provide scant reports of such already having been realised. One company representative relates that some of the organisation's FP projects have been quite successful in leading to technological advances, whereas other projects have not been successful. A couple of interviewees that have experience of being part of large consortia are uncertain of whether there was any impact at all, and one interviewee is downright negative of the benefits of participating in FP projects.

In balance, survey and interview data indicate substantial impact of FP participation for R&D providers, but for companies the impact seems quite a bit more limited, and more in the form of future potential. Moreover, while it seems like most R&D providers plan to participate in additional proposals to the FPs, a far lower proportion of companies appear similarly inclined.

Figure 32. The extent to which FP projects have contributed to impact for participants of R&D projects in the Safety and Security (SS) and Fuel Cell (FC) programmes. SS: n=10, FC: n=8.



4 Programme strategy and efficiency

In this chapter, we first assess whether the programmes were appropriately designed to facilitate and increase Finnish participation in FP projects. We largely base our treatise on the information in Sections 3.3.3 and 3.3.4. We then go on to examine how well the programmes, its services and administration met the needs and fulfilled the expectations of participants of the two programmes.

4.1 Programme strategies

Survey results and anecdotal evidence from interviews and survey free-text responses clearly show that the Tekes programmes have been quite important for *some* organisations' FP participation. Registry analyses reveal that for most of these organisations, there has been a sufficient time lag between Tekes and FP projects, meaning that it is *possible* that the FP participation was facilitated by the Tekes programmes. We specifically note that the Tekes programmes have had a substantial positive influence on participants' international networks (cf. Figure 28) and a distinctly positive influence on their FP proposal production (cf. Figure 29). The questions are whether the successful cases are the norm or an exception, and to what extent the programmes can be given credit for any increase in Finnish FP participation.

Table 9 summarises the number of unique participants in the two Tekes programmes (second column) and how many of them that have also participated in the security and fuel cell parts of the FPs (third column). The fourth column illustrates that 186 of Tekes programme participants (86%) have *not* participated in the FPs, thus suggesting that the programme strategies have not been very successful in stimulating widespread FP participation.[63] Having said that, the final column shows that the Tekes programme participants that after all have participated in the FPs dominated the Tekes programmes in terms of funding received, with the notable exception of enterprise projects in the Safety and Security programme.

Returning to Table 8 and comparing it with Table 9, we may conclude that:

- The enterprise projects of the Safety and Security programme have not been very successful in facilitating FP participation. Only 6 percent of Tekes participants have participated in FP7/H2020, and the payback has been quite low in relation to the total Tekes funding
- In contrast, the R&D projects of the Safety and Security programme have been quite successful in facilitating FP participation. Although not even half of Tekes participants have participated in the FPs, payback has been remarkably high
- The Fuel Cell programme lies in-between these two extremes. A third of Tekes programme participants have participated in the FPs, and payback has been rather modest

Table 9. Number of Safety and Security (SS) and Fuel Cell (FC) programme participants that have, and have not, participated in security and fuel cell parts of the FPs. Source: Technopolis analysis of Tekes and E-Corda data.

	Number of			Share of Tekes programme funding to FP participants
	Tekes programme participants	FP participants that participated in Tekes programmes	Tekes programme participants that have *not* participated in the FPs	
SS EP	163	10	153	23%
SS RP	24	11	13	75%
FC EP	16	6	10	67%
FC RP	14	4	10	82%
Total	**217**	**31**	**186**	**57%**

[63] However, we do not have information on rejected FP proposals, and it is likely that some of the 186 organisations in the fourth column have tried, but failed, to get FP funding. They may also have tried (and possibly succeeded) in getting funding from other parts of the FPs.

Moreover, survey results reveal that not a single one of the 29 the respondents (of both programmes) that have participated in FP proposals in security and fuel cells say that they had no prior experience of FP projects when the Tekes programmes started. This means that at least for these 29 respondents (24 of which from R&D projects), the programmes did not result in any obvious behavioural additionality, although Figure 28 nevertheless suggests that the programmes have increased the likelihood of additional FP proposals. However, we have a couple of accounts from interviews that the Tekes programmes had such an effect (these interviewees had no prior FP experience), but it seems as if this is unusual. We thus conclude that for the most part, the Tekes programmes have not been very effective in getting additional organisations to participate in the FPs, since most FP proposers are already 'in'. The programmes nevertheless seem to have increased the FP participation of these already experienced participants by making them more competent and thus attractive as partners. Moreover, there is no doubt that the programmes have been very important for a few organisations' FP participation, perhaps most obviously for a few companies active in fuel cells.

It is well known that Finnish R&D performers are heavily dominated by VTT, which is since long a frequent and very capable FP participant, meaning that the impact of the Tekes programmes on VTT's FP participation is difficult to assess. However, building knowledge and experience 'at home' before venturing into the European Research Area is no doubt advantageous also for an organisation as experienced as VTT. The same reasoning ought to apply to universities. However, it is noteworthy that several universities that participated extensively in the Tekes programmes have not participated at all in the security and fuel cell parts of the FPs, and some that after all have, have done remarkably poorly in the FPs. Aalto University stands out in this respect. Despite 16 projects in the Safety and Security programme, it has only participated in one FP project in security. In the Fuel Cell programme, the university had 22 projects, but it has only participated in two FCH JU projects (it coordinated one of them). Such observations suggest that some organisations preferred to apply for Tekes funding rather than to apply for FP funding, which involves lower success rates and more bureaucracy. We cannot prove that the Tekes programmes led to reduced FP participation for some organisations, but it is likely.

A recurring theme to anyone who has participated in FP proposals and projects is the bureaucracy. Forming a consortium and writing a proposal is complicated, costly and takes a long time, and success rates are often low. When a project is won, technical and financial reporting is challenging and time-consuming, in some cases requiring dedicated administrative resources. Coordinating an FP project has become a major endeavour that often also requires dedicated administrative resources. Moreover, the long time frames required to develop a proposal, to negotiate a contract and to conduct a multi-year project is unattractive to many companies, particularly SMEs. One interviewee explains that this can lead to a project idea no longer being relevant, because the market for the intended product had changed. Such deterring aspects of FP participation, most of which are quite correct but often exaggerated, of course cannot be alleviated by national parallel programmes such as these.

With the empirical data at hand, we of course cannot say how much of the €46m from the FPs that (so far) has gone to participants of the two Tekes programmes that can be attributed to these programmes. However, despite our reservations above, we conclude that the evidence suggests that a substantial share may be attributed to the Tekes programmes, since the Finnish organisations were attractive as FP project partners because they had something to contribute, and to a notable extent this had been developed through the Tekes programmes.

We now return to the impact logic model of Figure 2, which was developed in the beginning of the evaluation assignment and thus before data acquisition had commenced. We can see that the Tekes programmes had several objectives and priorities in common with FP7 Security and FCH JU (but of course not all). The agreement there was, was in part due to Finnish and European needs being aligned, in part because Finnish stakeholders actively participated in the drafting of the respective European agendas. Wärtsilä and VTT were for example involved in the establishment of FCH JU, as well as in the creation of the Tekes programme. Even though we can rule out that all of the €46m from the FPs mentioned above that have benefited Finnish organisations can be attributed to the Tekes programmes, a 'substantial share' of €46m is indeed still a considerable addition of resources for Finnish organisations. There is thus no doubt that the R&D&I activities of these Finnish organisations have increased, and hopefully their own output has increased in proportion. Moreover, given the fact that Finnish participants have gotten access to R&D&I carried out by partners in other countries, it seems reasonable to assume that the R&D&I results that through FP projects have become available to the Finnish organisations have increased more than the additional monetary resources would suggest. Still, when it comes to impact, the situation is a bit opaque and the empirical evidence of the evaluation is rather thin. It seems as if the R&D providers have experienced substantial impact from their FP projects, whereas companies are quite a bit more guarded and uncertain of the impact.

4.2 Programme efficiency

Figure 33 shows that, according to survey respondents, Tekes has performed pretty well in most respects. Participants are the most content with project reporting, and the least content with Tekes' support with results dissemination, followed by the transparency of the proposal assessment process. There are some differences between the programmes, and the participants of the Fuel Cell programme seem a bit more content. However, during the interpretation seminar, it was pointed out that both programmes had employed the same routines and tools, thus suggesting that the differences are more likely due to variations in participants' expectations than reflecting real differences.

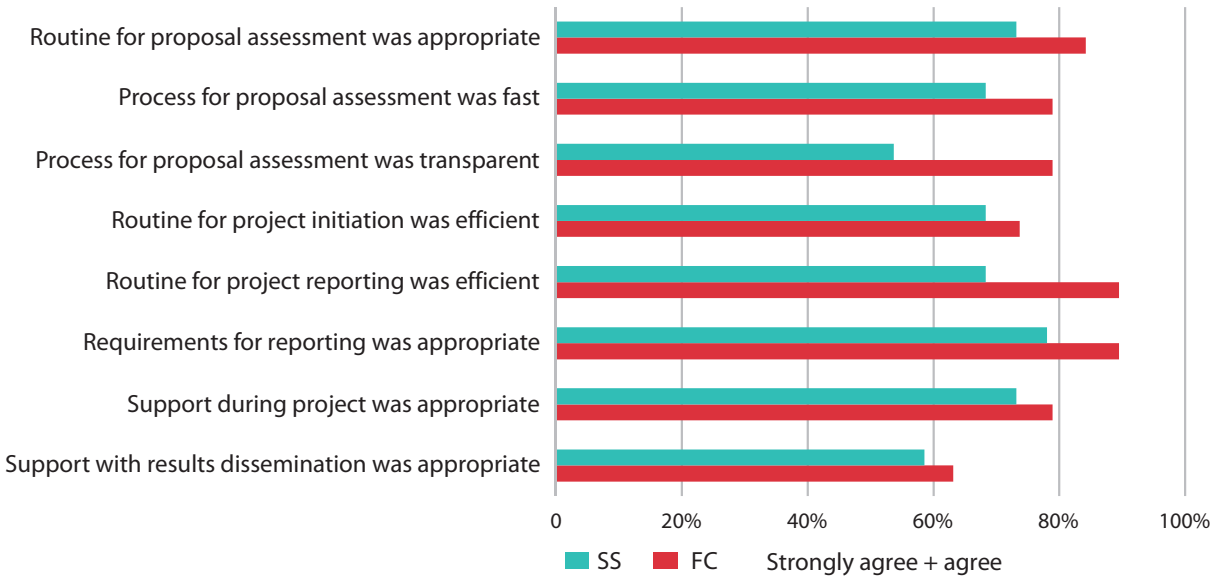
Interviewees are generally quite positive in their assessments, thus broadly supporting survey results, and they describe both programme managers and programme coordinators as skilled and devoted. One interviewee underlines that Tekes' programme officers really understand the areas that they manage, unlike some representatives of the European Commission, who at times have little or no topic expertise.

Many interviewees believe that the web-based system for proposal submission and reporting worked well, but a couple of interviewees are critical of the fact that they anyway had to submit parts of their proposals on paper. One interviewee is grateful for Tekes supporting fuel cell networks before the programme started, and another one for Tekes moderating the negotiation of an agreement between project partners. According to most interviewees, the reporting requirements were reasonable, i.e. not too extensive, and one praises the help hotline. A couple of interviewees bemoan what they believe was a lengthy proposal assessment process, which for one of them led to a company leaving the project team. Another interviewee argues for greater use of external evaluators that are independent from industry.

Interviewees describe that Tekes arranged many meetings and seminars, which some call excellent, whereas others refer to them as 'not meaningful'. One interviewee praises Tekes for organising meetings between companies with common interests. Several interviewees explain that they received support from Tekes in disseminating project results, but others argue that they did not need any help since they are quite competent to disseminate results themselves in for example scientific articles and at conferences. Some interviewees say that there was no need to disseminate the results externally, and that they preferred to keep the results to themselves.

Several interviewees raise the difference between applying for funding from Tekes and from other funding organisations. Some mean that it is easier to apply for funding from the Academy of Finland, while others are of the opposite opinion. On the positive side, they all agree that it is much easier to apply for funding from Tekes than from the European Commission.

Figure 33. The extent to which Tekes' programme administration fulfilled participants' expectations. SS: n=41, FC: n=21.



5
Fulfilment of programme objectives

This chapter assesses the extent to which the main objectives of the two programme have been fulfilled.

5.1 The Safety and Security programme

The creation of extended networks is an important result of the projects, as discussed in Section 3.1. However, we have only come across one instance of the creation of an internationally competitive Finnish Safety and Security cluster, namely the Finnish Information Security Cluster described in the case study on Cybersecurity in Appendix D.

The aforementioned networks mean that **Finnish safety and security technology actors networked**. However, although networks of participants in enterprise projects were extended, especially with foreign companies, the number of participants in enterprise projects was very large and on average they received rather small grants, thus suggesting a quite fragmented 'network'. Moreover, there is little evidence of project participants using **both domestic and foreign expertise in their activities**, since projects were predominantly domestic in nature.

The programme did generate some **new safety and security related business activities focusing on international markets, including research that can be utilised for this purpose**. From the survey of enterprise project participants and from interviews, we learn that projects resulted in new products, models and systems; increased market share internationally and in Finland; successfully commercialised products; and improved R&D&I capabilities. The empirical evidence indicates that there are examples of successes on international markets, and two companies that had commercial successes based on their Tekes projects have been sold to foreign companies, but the focus of business activities has mainly been on Finnish markets.

There are examples of development of new methods, technologies and products, thus possibly illustrating a certain contribution to the **development of safety and security related innovation chains**. However, with the very large number of participants in the enterprise projects and relatively small grants, the coherence of any innovation chains may be in doubt, but the situation may be more benign when it comes to participants in R&D projects. However, it is impossible to assess whether these innovation chains **are able quickly to respond to changes**.

Since these Tekes projects are not categorised in competency areas in the project lists received, it is difficult to say if the **competency areas that were identified in the preparation phase of FP7 Security** were developed in the Safety and Security programme. The following priority missions were identified in the Commission's Preparatory Action Plan:[64]

- Improving situation awareness
- Optimising security and protection of networked systems
- Protecting against terrorism (including bio-terrorism and incidents with biological, chemical and other substances)
- Enhancing crisis management (including evacuation, search and rescue operations, active agents control and remediation)
- Achieving interoperability and integrated systems for information and communication

Some of the seven application areas of the Tekes Safety and Security programme that are referred to in Section 2.1.3 are obviously consistent with the Commission's priority missions.

In the survey and in the interviews, some participants state that their Tekes project was important when applying for FP funding, which indicates that the **opportunities for Finnish participants to receive FP funding** improved to a certain extent. Registry analyses reveal that almost every other participant in R&D projects have participated in the FPs and that they have been remarkably successful in doing so. However, several universities have not participated at all in the FPs, and some that have, have done remarkably poorly, thus suggesting that the programmes actually may have reduced the FP participation of some organisations. In contrast, only a small minority of the participants in enterprise projects have participated in the FPs, thus showing that the programme has not been very successful in this case.

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64 Commission communication on the implementation of the Preparatory Action on the enhancement of the European industrial potential in the field of Security research, Towards a programme to advance European security through Research and Technology, Brussels, 3.2.2004 COM(2004) 72 final.

As already noted in Section 3.1.3, the programme objectives were very broad and general. We observe that the objectives are neither quantified nor set in time, which means that assessment of their fulfilment by necessity becomes bland. We nevertheless conclude that the Safety and Security programme only to a rather limited degree has fulfilled its objectives, and specifically note that no objective has been completely fulfilled.

5.2 The Fuel Cell programme

The Fuel Cell programme supported R&D in close collaboration between Finnish industry and R&D providers, which created an innovative development environment to build or improve the knowledge base in the field, as evidenced by the high degree of development of competence, new knowledge, new technologies and new devices/equipment (cf. Section 3.2.1).

This knowledge base in turn **improved the opportunities for the Finnish industry to generate breakthrough products in selected fuel cell product segments**, and a few companies developed new products/services/processes and new pilots/demonstrators (cf. Section 3.2.2). However, it should be noted that this part of 'Finnish industry' is a rather small club; only 16 companies participated in the programme.

The programme provided **national funding for demonstrators**, some of which have led to realisation of products. The development of fuel cell systems for stationary applications has started, and there are potential niche markets for several companies. However, the programme ended too soon **to realise commercialisation in niche market areas**, since product development has taken far longer than expected. The programme sought to **improve the adaptation of the fuel cell technology**, but market adaptation of the developed technologies has not yet been achieved. Success would require additional demonstrations and possibly some market-introduction support instrument, just as in all other emerging fuel cell markets around the world.

The programme has **generated commercial interest and new jobs in companies**. When the programme started, Finland did not have very many companies active in fuel cells, and the programme has helped additional companies to enter the field, as well as to increase the competitiveness of some incumbent companies. A few companies have increased their turnover and have recruited additional employees. On the other hand, the largest company active in fuel cells when the programme started spun off its fuel cell development activities into a separate company, and eventually withdrew entirely from the field.

The more efficient use of natural gas or biogas in SOFCs contribute to **improving energy security** and to significantly **decreasing CO_2-emissions**.

Interestingly, the programme did not have an explicit objective for FP participation, although the programme's planning document stated that international cooperation was considered necessary in order to fill the gaps in the value chain. Survey results and interviews indicate that the programme indeed significantly has improved the prospects for FP participation, but the impact is limited to a small number of organisations. Only ten participants of the Tekes programme (six of which are companies) have participated in FP projects, and although two companies have been very successful in winning FP projects, the overall Finnish payback so far is moderate at best.

Just as for the Safety and Security programme, assessment of objective fulfilment for the Fuel Cell programme becomes hesitant since also this programme's objectives lack quantification and indication of when they are to be met. A generous interpretation could conclude that most programme objectives have been fulfilled, but our more balanced and critical assessment is that the programme to a significant extent has fulfilled its objectives. This does not necessarily mean that the Fuel Cell programme has been more successful than the Safety and Security programme, but rather that the objectives of the Fuel Cell programme were formulated in a way that made them easier to reach, and that the programme addressed a much smaller group of stakeholders.

6 Conclusions, reflections and recommendations

In this final chapter, we summarise the evaluation's findings, reflect upon them and formulate our recommendations.

6.1 The two programmes and their objectives

The Safety and Security and Fuel Cell programmes ran in parallel with each other and with topically related FP subprogrammes, and both Tekes programmes aimed to facilitate Finnish participation in the FPs. Both programmes also sought to generate business opportunities for companies, but the programmes were more dissimilar than similar in most respects. The former programme was an innovation programme with an origin in a terrorist attack, and the latter a 'classical' technology programme whose creation was closely tied to the interests of one dominating company. The Safety and Security programme had a very wide-ranging scope and addressed a wide array of stakeholders, whereas the Fuel Cell programme focused on a specific technology field with a much smaller number of potential stakeholders.

To a significant extent, the Fuel Cell programme built on previous R&D efforts and achievements of a core group of Finnish actors, whose work in part had been funded through FP6. This meant that Finnish R&D in the field was already of international calibre, and that international networks already existed. In contrast, the Safety and Security programme sought to exploit a broad and quickly developing market that was less dependent on technology development. Moreover, despite some Finnish companies already being very successful (see Cybersecurity case study in Appendix D), the majority of programme participants were not as advanced and most probably had considerably less international R&D collaboration experience.

Both programmes were at the core of Tekes strategies, and the linkage to FP7 did not divert them from their aims. The programmes differed from many other Tekes programmes in that they were seven years long, whereas most Tekes programmes are five years in duration. During these seven years, programme objectives and thematic priorities were on several occasions adapted to changes in their operating environment (cf. Sections 2.1.3 and 2.2.3, respectively), thus illustrating sound resilience. There is consequently little doubt that the programme objectives were relevant to Finnish organisations' priorities, and our interviewees confirm that the objectives were relevant to their own organisations. However, the degree to which the objectives were challenging differs between programmes. Based on our own knowledge of the field and on the views of our interviewees, we conclude that the objectives of the Safety and Security programme were not particularly challenging. In contrast, we similarly conclude that the objectives of the Tekes Fuel Cell programme in general were very challenging, in part due to a lack of suppliers; witness the meagre commercial successes of participating companies to date, despite extensive R&D&I efforts over more than a decade.

FP7 Security and Tekes' Safety and Security programme had a lot in common since they both aimed to support the development of businesses and commercial solutions, as well as to promote R&D in the very broad security field. The two programmes had some priorities and areas in common, such as crisis management and cybersecurity, but there were also several differences. The Tekes programme encompassed both safety and security, while FP7 only covered security, meaning that the Tekes programme had a wider scope than FP7 Security. Many government agencies and even non-governmental organisations (NGOs) participated in FP7 Security and the programme focused on end users. Part of the aim of the FP7 Security objectives was 'to stimulate the cooperation of providers and users for civil security solutions'.[65] This was not the focus of the Tekes programme, although there were some participants from government agencies and other public organisations. Ultimately, the Tekes programme had a clear focus on commercialisation and improving business opportunities for Finnish companies and not on improving emergency management capabilities in society in general.

[65] Decision No 1982/2006/EC of the European Parliament and of the Council of 18 December 2006 concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007–13).

To a significant degree, Tekes' Fuel Cell programme focused on knowledge and capacity building. The programme also aimed to fund demonstration and commercialisation, but developments probably did not progress as far as originally envisioned. While FCH JU had a more pronounced focus on demonstration and commercialisation activities, it also funded more fundamental R&D. The Fuel Cell programme appears to have been well adapted to Finnish participants' needs, but less so with FCH JU priorities. The alignment between the Finnish and the EU programmes was nevertheless reasonably good, and the intentions of the Tekes programme creators to reap synergies between the two programmes was essentially well considered. In this context, it is worth noting that key Finnish stakeholders, notably Wärtsilä and VTT, were involved from the beginning in both the creation of the Fuel Cell programme and in the establishment of FCH JU in order to ensure that their interests were taken care of.

When assessing fulfilment of the programme objectives, it becomes obvious that they were not formulated with such an exercise in mind. The objectives are entirely qualitative and include no indication of when they are to be achieved, thus making any assessment of their fulfilment quite difficult and not very illuminating. Taking one of the Fuel Cell programme objectives as an example, is 'generate commercial interest and new jobs in companies' fulfilled when one company has shown an interest in fuel cells and one person each has been employed in two separate companies? Surely that was not the intention, but when should an objective such as this be considered fulfilled? Moving on to one of the Safety and Security programme objectives, how should one determine when 'innovation chains' have developed and when they are 'able quickly to respond to changes'? It is not necessarily a problem only to have qualitative objectives, but then one has to accept that any assessment of objective fulfilment will end up being indecisive. The absence of performance indicators does not make assessment any easier.

6.2 Results and impact of the two programmes

The two programmes provided €111m in Tekes funding to 335 projects. These projects resulted in development of competence, knowledge, technology and hardware. They also produced some patent applications, many scientific publications and some PhD degrees, and led to increased national and international networking. The impact of these results include new products/services/processes and new demonstrators, as well as improved capabilities for R&D&I. The impact is the most obvious for the Safety and Security programme, and less so for the Fuel Cell programme. Several companies report that their projects have contributed to increased turnover, improved profitability and increased employment in Finland, once again mainly for the Safety and Security programme. There are also some accounts of spin-off companies having been founded. R&D providers report impact in terms of improved R&D&I capabilities, increased competitiveness, new demonstrators, additional funding for R&D&I and new validation procedures. The vast majority of participants judge that their projects lived up to or exceeded their own expectations, and a majority argue that their projects would not have been conducted had they not received Tekes funding, meaning that most of the reported results and impact were made possible by the Tekes funding.

The clear minority of the participants in the Tekes programmes that have also participated in the FPs credit the Tekes projects with facilitating their FP participation. More than half of the aforementioned minority believe that their Tekes projects resulted in them being invited to join FP consortia, since the projects made them more attractive as partners, while others formed their own consortia. Having built knowledge and experience 'at home' also resulted in participation in far more proposals and larger shares of proposal budgets. However, arguably the most important is that participants were given larger responsibilities in the consortia and had larger influence on the R&D direction of proposals. Participants of the Tekes programmes have together secured €46m in FP funding, but how much of this that can be attributed to the Tekes programmes cannot be determined. Looking at the entire population of participants in the two Tekes programmes, we find that only 14 percent have participated in FP projects, with a particularly low turnout for participants of enterprise projects in the Safety and Security programme. Overall, the Tekes programmes therefore have not been very effective in facilitating widespread FP participation. Moreover, for some organisations, the programmes actually may have reduced FP participation since the programmes offered more easily accessible funding in Finland. Nonetheless, there is no doubt that the programmes have been very important for the FP participation of a limited number of organisations, perhaps most obvious for companies active in fuel cells, as well as for VTT in both programmes.

6.3 Exploiting the outcome of the two programmes

Several projects in the Safety and Security programme have generated a lot of new knowledge and new products. However, it is in general difficult to focus on business development in the safety and security area, since clients are often public authorities with a limited (perceived) need for new products. Especially the security area is governed by political decisions, rules and regulations, both in Finland and

in other countries, which makes it difficult to launch new business ideas and products commercially. When it comes to civil security, there is a question of whether demand is sufficient. A common misconception is that there are similar opportunities for business development and profits on the civilian security market as on the military market. There are nevertheless examples of companies that have developed new technologies and products through their projects, and the programme led to increased exports and increased job opportunities in Finland. However, we need to keep in mind that the empirical foundation as regards enterprise project in the Safety and Security programme is thin. R&D providers undoubtedly reinforced their knowledge and competence in the safety and security area, which likely makes them even more capable of participating in H2020, although there are certainly other factors than knowledge and skills that influence FP participation. Several interviewees regret that there is no longer a Finnish safety and security programme, since they argue that there is a continued need for R&D&I in the area, in part raised by the uncertain security situation in Europe.

The Fuel Cell programme funded development of fuel cell systems for stationary applications, and there are potential niche markets for several companies. However, the programme ended too soon for companies to fully to realise commercialisation, since product development has taken far longer than expected. Hydrogen and fuel cells will play an important role in renewable and distributed energy generation and in the transportation sector when aiming at complying with the very stringent greenhouse gas-reduction requirements, as well as when striving to fulfil zero-emission requirements in metropolitan areas. Finnish actors may elect to focus on selected hydrogen and fuel cell technologies and concepts that are not yet available and not the focus of major international development and try to advance these, as international competition may be less fierce. Finnish actors could more strongly pursue fuel cell integration and possibly focus on Scandinavia-specific (niche) applications like machinery (forestry, harbours, off-road, small generators). Finnish actors should also be prepared for an increasing share of renewable electricity feed-in by PtG/PtH2 (power to gas/hydrogen) concepts. Demonstration and market preparation for these technologies is essential.

Where Finnish companies already have succeeded in developing market-ready SOFC technology, they may need assistance in introducing them in real-life applications. Setting up local manufacturing requires a supply chain. With the competence and knowledge available, this would be possible if support for application-oriented demonstration were to be made available. Deficits in such supply chains have been a strong motivation for the German NIP programme to assist in closing this gap (see Appendix C). If this is not going to happen in Finland, Finnish companies will set up their manufacturing where conditions are more favourable and already from the beginning closer to customers. If this were to happen, the opportunity to position Finland and its industry with manufacturing sites inside the country, with local value and employment creation, would be lost. In order to advance hydrogen and fuel cells on a broader scale, it may be worthwhile to consider supporting regulatory measures to facilitate introduction of efficient zero-emission technologies such as fuel cells. This would also require the advancement of hydrogen as an intrinsically clean fuel, including supply, distribution and dispensing infrastructure, which would open additional business opportunities.

6.4 Reflections

It is natural for national policymakers and R&D&I funding agencies to want to increase the nation's payback from European programmes (and other international programmes, such as those administered by the European Space Agency (ESA)) that Member States co-finance. Several countries use this payback as an indicator of success, and for example the Norwegian government has set an explicit target that two percent of the competitive funds in H2020 shall go to Norwegian organisations.[66] However, looking *only* at payback probably is not sound, since more money is not necessarily better. It is the results and the impact of participation in European programmes that is important. Also, certain R&D&I needs will likely always be best addressed at national level, for example needs that are more or less uniquely national in nature and thus difficult or impossible to place in a European context, or ones that from a national perspective may be more sensible to tackle nationally (even if they are of European interest).

Moreover, some organisations will never look to European programmes to satisfy their needs, and they may then have to do without public co-funding if there is no national funding opportunity – which may mean that they entirely forego development to the detriment of their own long-term competitiveness. Particularly SMEs will never participate *en masse* in FP programmes regardless of the Commission's commendable attempts to speed up and simplify processes. Most SMEs' development needs tend to change far too rapidly to fit into multi-year planning perspectives, and their tolerance for time- and resource-consuming administrative processes is minimal. The vast majority of SMEs with development needs will thus continue requiring national funding opportunities. That small organisations may be better served by national projects, and that certain types of projects are likely always better

66 'Strategy for research and innovation cooperation with the EU', Norwegian Ministry of Education and Research, 2014.

conducted at national level are among the lessons learned from the Austrian KIRAS programme (cf. Appendix B). Furthermore, many national organisations would not stand a chance in the generally much higher competition in FP programmes. While competition in general fosters competitiveness, competition must be reasonable, meaning that national programmes are needed for those proposals and proposers that are good, but not quite good enough win in a European competition.

The point with this argument is that FP funding is no panacea in a situation with shrinking national resources. FP projects may fit the funding and collaboration needs of many organisations, but definitely not all. The issues are therefore arguably:

- how the organisations that after all could have their needs satisfied through European projects can be convinced to participate in the FPs to a greater extent (possibly with some national funding to encourage them to do so), and
- how to use the remaining resources to cater for the needs and organisations that for various reasons cannot be expected to have them solved through European projects.

Words are not enough

We have already argued that programmes such as the ones of this evaluation are not very effective, since they provide very weak incentives for writing FP proposals. Previous studies of programmes with similar intervention logics have yielded comparable experiences. The Swedish sectoral research programmes ('branschforskningsprogram') had a similar intervention logic and explicitly aimed to stimulate FP participation but (with some exceptions) the programmes' impact on Swedish FP participation (and in the Research Fund for Coal and Steel for the Steel programme) was very modest, since the programmes provided no direct incentives, only encouraging words and good intentions.[67] A recently evaluated decade-long Norwegian programme with FP ambitions similarly had very little effect on FP participation, in large part for the very same reasons (but also because natural gas-related R&D&I had no obvious 'home' in FP7).[68]

The exceptions among the Swedish sectoral research programmes were the Automotive, Aerospace and ICT programmes that had far greater impact on FP participation, arguably for two main reasons. On the one hand, the respective sectors are very powerful and influential at the European level; in practice, strong industry lobbying groups pretty much dictate the contents of FP work programmes, thus ensuring that the research priorities suit industry needs. On the other hand, a handful of Sweden-based companies are very active in these lobbying groups: Saab Group and GKN Aerospace Sweden (formerly Volvo Aero) in aerospace; AB Volvo, Scania and Volvo Car (and previously Saab Automobile) in automotive; and Ericsson in ICT.[69] Having strong 'national champions' active in core European industry sectors obviously helps, and Nokia certainly benefited from FP participation in the ICT parts of consecutive FPs (alongside Ericsson).

The Swedish and Norwegian experiences quoted above (as well as several similar ones from other countries) tell us that generous national funding does indeed reduce the appetite for applying to the FPs, which is also a conclusion of an evaluation of the FP7 Cooperation programme.[70] As discussed in Chapter 4, we suspect that the same thing has happened in the two Tekes programmes – at least for some organisations. The lesson here is that it is not sufficient to state that a programme should lead to increased FP participation, even if it is made very clear that the programme will not get a continuation (with the underlying logic that participants should use it to build FP experiences and skills while there is time). Proposers to any public programme (national or international) are rational creatures that first go for the lower-hanging fruit – even though it may be argued that they are rather short-sighted. It is possible that FP participation increases in the years after such a programme ends, and in that case it would be reasonable to assume that the projects the programme has funded has increased proposers' success rates and thus FP funding received. However, since we are not aware of any such study, this will have to remain an unverified hypothesis.

A cynical conclusion of this is that a reduction in national R&D&I funding will increase FP participation (which the Finnish government has already kindly ensured). There is no doubt that this is true, at least in the short term, but that of course would not be beneficial to the Finnish innovation system and its actors, since it would lead to an overall decrease in public funding for R&D for Finland, and a long-term decline in R&D expenditure.

What may be learnt from the Austrian and German case studies (Appendices B and C) when it comes to nation-

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67 T. Åström, P. Stern, T. Jansson and M. Terrell, 'Meta-evaluation of Swedish Sectoral Research Programmes', VINNOVA rapport VR 2012:05, VINNOVA, 2012.

68 T. Åström, M. Terrell, A. Karmhag Olsson, A. Håkansson, A. Swenning and I. Storsul Opdahl. 'Evaluation of the programme Maximizing Value Creation in the Natural Gas Chain (GASSMAKS)', Research Council of Norway, 2016.

69 T. Åström, P. Stern, T. Jansson and M. Terrell, 'Meta-evaluation of Swedish Sectoral Research Programmes', VINNOVA rapport VR 2012:05, VINNOVA, 2012.

70 V. Peter, 'Evaluation report of the FP7 COOPERATION Specific Programme', European Commission.

al funding possibly reducing incentives for FP participation? One lesson from the former is that programme continuity is important, since it gives stakeholders – in particular researchers – the peace of mind to engage in long-term developments where national funding can be used for some projects and FP funding for others. In such a context, there may be a greater complementarity between national and European programmes, and less of going for the lower-hanging fruit. In the much larger German NIP programme, the main participants are large companies that are quite capable of strategically using both NIP and FCH JU funding to achieve their long-term goals. In this case, organisational size and degree of strategic orientation are key, and once again that there is less risk of national funding deterring FP participation. The same can be said of the Swedish Automotive, Aerospace and ICT sectoral research programmes, where the dominating companies seem to have had little problem of combining national and FP funding. The Automotive and Aerospace programmes have existed since 1993 and are still on-going, thus reinforcing the Austrian continuity argument.

Option for increasing FP participation

Assuming that it is desirable for Finnish funding from the FPs to increase, there are alternative ways to achieve that.

A basic prerequisite for reasonable success in European programmes is that they reflect national needs and priorities, which requires that national representatives are active – and eloquent – in the fora where research agendas are developed and decided upon. Wärtsilä and VTT were members of the original Hydrogen and Fuel Cells (HFC) European Technology Platform and thus involved in the configuration and definition of the FCH JU. This means that they had an opportunity to ensure a suitable adoption of the FCH JU to Finnish – and their own – interests and needs. This is very likely one reason why VTT and Convion (which was spun off from Wärtsilä) have done very well in the FCH JU, alongside a few others. There is also the issue of alignment of national research policies with European ones, and this structuring effect is said to be significant.[71] We have no insights into strategic priorities of the Finnish government and Tekes in this respect[72], but the importance of being proactive in agenda setting probably cannot be overemphasised, and this is among the lessons of the Austrian and German case studies (cf. Appendices B and C).

We argued above that proposers are rational (from their point of view) and that words are not enough. Experiences from other countries indicate that the most powerful incentives are financial. Such incentives may be devised by distributing funding to R&D providers as top-up funding on FP funding already received, either on a project-by-project basis or by allowing past FP performance to influence government base funding. As an example, the Research Council of Norway (RCN) provides top-up funding to Norwegian RTOs participating in FCH JU projects. This measure has proved very effective in stimulating participation of RTOs, but the output additionality as measured in financial payback is quite modest, meaning that the measure is expensive.[73] Many countries have some form of mechanism where FP participation influences the size of the base funding to universities and RTOs, but this is often not a very powerful incentive since the extent of the reward is often low.[74] The Finnish university funding model includes objectives and incentives for winning international competitive research funding, with a three percent overall weight among all of the objectives. However, one may argue that having FP participation as one (of many) performance indicators still has an effect on behaviour. RTOs found it rather challenging to co-fund their participation already in FP7, and the H2020 cost models make participation even less attractive for RTOs. We understand that the Academy of Finland has a measure to compensate for this, and so does RCN. An interesting aspect of the latter is that Norwegian RTOs that bring with them Norwegian companies into FP projects receive a significant extra bonus.[75]

In addition to such financial 'carrots', it is possible that some element of 'stick' could be effective as a complement. By this, we mean making (some part of) the national funding conditional on FP funding (or perhaps on FP proposals, whether successful or not), but we realise that it would be a challenge to device such an incentive in a way that is seen as fair and reasonable. Either way, there is little doubt that sound financial incentives are key for increasing FP participation, but they can of course be designed in a multitude of different ways that need to be fine-tuned to the detailed context (country, type of organisation, topic etc.).

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71 Ibid.

72 To our knowledge, specific national priorities for EU FP participation have not been set, or at least not publicly stated. The closest to this may be the general objectives for international collaboration set by the Research and Innovation Council, most recently in its Review 2015–2020.

73 T. Åström, A. Håkansson, G. Melin, P. Stern, P. Boekholt and E. Arnold, 'Impact evaluation of the Research Council of Norway's support measures to increase participation in EU-funded research', Research Council of Norway, 2013.

74 T. Åström, T. Jansson, G. Melin, A. Håkansson, P. Boekholt and E. Arnold, 'On motives for participation in the Framework Programme', Norwegian Ministry for Education and Research, 2012.

75 T. Åström, A. Håkansson, G. Melin, P. Stern, P. Boekholt and E. Arnold, 'Impact evaluation of the Research Council of Norway's support measures to increase participation in EU-funded research', Research Council of Norway, 2013.

The threshold to FP participation is quite high for newcomers in general and for small organisations in specific, and providing assistance to proposers is a proven way to lower the threshold. Such assistance may be in the form of general (or even better, tailored) information on FP funding opportunities, helplines, proposal writing workshops etc., but the most effective assistance is when ambitious hands-on support with forming a consortium and writing a proposal is made available.[76] Such support may be made available through 'grants offices' that most large universities and RTOs around Europe have established. These usually only cater to internal needs, but if there is more than one participant from the same country, other types of organisations may benefit as well. Some RTOs receive public co-funding to assist companies. In addition to co-funding such grants offices, RCN has a complementary measure that mainly targets SMEs, who may receive a rather generous grant to write an FP proposal. The grant may be used to buy consulting services, if desired.[77] This measure ('Prosjektetableringsstøtte', PES) has proved to be remarkably effective in terms of output additionality (as measured in financial payback).[78]

The frequent references herein to RCN's various measures is due to the fact that the Council has tried a wide range of measures to reach the government's goal for FP participation, probably more than any other funding organisation. There may thus be good reason for Tekes to make the most of the Council's experiences.

6.5 Recommendations for making better use of the FPs

For research and innovation policy

The main policy implications are:

- Development of a comprehensive national strategy that addresses rationale, objectives, action plan and effective support measures would lead to better exploitation of the opportunities offered by the FPs
- Proactivity in fora where research agendas of European programmes are developed and decided upon is critical, and this is mainly a task for national public authorities and agencies
- National R&D&I programmes that are topically aligned with FP priorities improve the chances of success in the FPs, but they do not automatically foster extensive FP participation
- Too generous national R&D&I funding may reduce the incentives for FP participation
- Financial incentives are the most effective means to stimulate FP participation
- Some R&D&I needs will always be best addressed at national level
- For most organisations, the FPs will remain a marginal funding source
- Some organisations, notably the majority of SMEs, will probably never participate in the FPs
- In many cases, there is a need for national public co-funding of demonstrators, and in some cases probably a need for regulatory measures, to facilitate market introduction of new technologies

For Tekes

To improve programmes and programme services, Tekes may want to consider:

- Setting programme objectives that are amenable to monitoring and evaluation, including time for fulfilment and matching indicators (whenever possible)
- Ensuring that there is funding available for activities to exploit programme outcome after programmes have been concluded, e.g. for demonstrators

To stimulate increased FP participation, Tekes may want to consider:

- Being explicit on the possibilities (or restrictions) of combining Tekes and FP funding
- Devising financial incentives that explicitly reward FP participation, preferably ones that stimulate R&D providers to bring companies into consortia
- Developing hands-on support functions for FP proposers, or co-funding other organisations to do so
- Ensuring that all project advisors that have client contacts are knowledgeable of FP opportunities and challenges
- Following up Finnish FP proposers to determine whether they have previously received Finnish public funding, and if this is the case, poll them to find out if they believe that there is any connection between the Finnish funding and the proposal. Developing an indicator to follow up such a dependence would be a valuable tool in determining the effectiveness of programmes and measures to stimulate FP participation

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76 T. Åström, T. Jansson, G. Melin, A. Håkansson, P. Boekholt and E. Arnold, 'On motives for participation in the Framework Programme', Norwegian Ministry for Education and Research, 2012.

77 www.forskningsradet.no/en/Funding/PES2020/1253991614799.

78 T. Åström, T. Jansson, G. Melin, A. Håkansson, P. Boekholt and E. Arnold, 'On motives for participation in the Framework Programme', Norwegian Ministry for Education and Research, 2012.

For the R&D and innovation activities of Finnish players

FP participation can be highly rewarding to address broader issues than national programmes permit and to build valuable international networks, but it can also be immensely frustrating:

- Only join a consortium whose project is really in line with your own strategic needs, and choose your partners carefully (preferably based on own experience, or at least on recommendation)
- The learning curve for writing a successful FP proposal is steep, and project administration and reporting is challenging as well. If you do not have the time or the patience, partner with an experienced FP participant, or seek knowledgeable advice from a consultancy
- Arguably the best way to hone one's skills to write competitive FP proposals is to volunteer to be 'expert evaluator' for the Commission (i.e. to assess proposals submitted to the FPs on behalf of the Commission). This is poorly paid work, but it is an excellent way to understand what it takes to increase a proposal's chance of success

Appendix A. Interviewees and attendees of interpretation seminar

A.1 Interviewees

Henri Andell	Safera Oy
Mikael Bergelin	Åbo Akademi University
Erkko Fontell	Convion Oy (previously Wärtsilä Finland Oy)
Michael Gasik	Aalto University
Sami Herrala	9Solutions Oy
Olli Himanen	VTT
Juhani Huovelin	University of Helsinki
Mikko Huttunen	Skysweep Technologies Oy
Outi Kauppinen	EUTI/Tekes
Riitta Keiski	University of Oulu
Jari Kiviaho	VTT
Mikko Kolehmainen	Lappeenranta University of Technology
Martti Korkiakoski	Tekes
Jaana Kuula	University of Jyväskylä
Arttu Luukanen	Asqella Oy
Mikko Moisio	Dekati Ltd. (previously Tekes)
Matti Noponen	Elcogen OY
Anneli Ojapalo	Oy Woikoski Ab
Jyri Rajamäki	Laurea University of Applied Sciences
Kimmo Rauma	Visedo Oy
Tuomo Räihä	Suoja-Expert Oy
Jaakko Saijonmaa	Airbus Defence and Space Oy
Heikki Salonen	Cargotec/Kalmar
Kimmo Solehmainen	VTT
Suvi Sundquist	Tekes
Timo Sukuvaara	Finnish Meteorological Institute
Anja Talo	Enfucell Oy
Sirra Toivonen	VTT
Teppo Tuomikoski	EUTI/Tekes

A.2 Attendees of interpretation seminar (26 April 2016)

Hannu Juuso	Tekes
Jonna Lehtinen-Salo	Ministry of Employment and the Economy
Anneli Ojapalo	A.Ojapalo Consulting
Christopher Palmberg	Tekes
Pekka Pesonen	Tekes
Jaakko Saijonmaa	Airbus Defence and Space
Eero Silvennoinen	Tekes
Suvi Sundquist	Tekes
Johanna Enberg	*Technopolis Group*
Kimmo Halme	*4FRONT*
Timo Kotilainen	*Kasin Consulting*
Helka Lamminkoski	*4FRONT*
Tomas Åström	*Technopolis Group*

A.3 Evaluation steering group

Raine Hermans	Tekes
Christopher Palmberg	Tekes
Pekka Pesonen	Tekes

Appendix B. Austrian National Research Programme for Security – KIRAS

B.1 Background

The purpose of this case study is to describe the Austrian national research programme for security, KIRAS, and the efforts to encourage and stimulate Austrian participation in FP7 Security and Horizon 2020. More specifically, the case study outlines what synergies that can be achieved by having a national programme in parallel to an EU programme and what kind of successes and failures that may be observed. Furthermore, the case study aims at highlighting experiences that Finnish stakeholders may learn from in stimulating participation in Horizon 2020.

The Austrian national security research programme 'Das Österreichische Förderungsprogramm für Sicherheitsforschung – KIRAS' started in 2005 and it was at the time the first national security programme in Europe. The background to the KIRAS programme was the changed security situation in light of the terrorist attacks in the USA on 11 September 2001 and in Madrid on 11 March 2004, as well as the initiative from the European Commission to start the Security Research Programme in FP7.[79]

The present Austrian Security Strategy and was adopted by parliament in 2013.[80] The Austrian Cybersecurity Strategy was adopted in 2013, and was developed based on a Security Strategy from 2011 and the Austrian Programme for Critical Infrastructure Protection.[81]

B.2 The KIRAS programme

The Federal Ministry for Transport, Innovation and Technology (bvmit) is responsible for KIRAS, and the Austrian Research Promotion Agency (FFG) manages the projects funded by the programme. The general aim of the programme is to promote national security research in order to increase security in the Austrian society.

KIRAS supports national R&D projects that correspond to the strategic objectives of the programme:[82]

- To improve the subjective perception and objective level of security of Austrian citizens
- To support the generation of knowledge needed for security policy
- To promote security related technology leaps
- To support the growth of the Austrian security industry
- To achieve excellence in security research and
- To integrate relevant societal questions in every project

The programme also includes the humanities, social and cultural (HSC) aspects of security research and participation of a stakeholder representing these aspects are mandatory in each project. Moreover, the programme emphasizes end users, which also must be represented in projects. Another important factor is that projects funded through KIRAS shall contribute to creating skilled jobs in Austria. Furthermore, the programme encompasses civil security and not military security, while nevertheless allowing dual-use research. Safety aspects are not included in the programme.

One important purpose of the programme was to stimulate Austrian stakeholders' participation in FP7 Security, and presently to stimulate participation in Horizon 2020 Secure societies. The impact logic of the programme is shown in Figure 34. Note that the programme is to contribute to Austria being at the forefront of European security research ('Vanguard in EU-Security Research').

The thematic focus of the programme is the protection of critical infrastructure, covering areas such as energy, water, food, health care, finance, transport, and communication and information infrastructure.[83] The programme invites participants from the following stakeholder groups:[84]

- Industrial and service companies with business location or research institution in Austria
- Research organisations and researchers from higher education institutions
- Austrian public and private (but publicly regulated) end users

79 www.kiras.at/das-programm/grundlagen-von-kiras/.

80 The Federal Chancellery of the Republic of Austria, Austrian Security Strategy Security in a new decade – Shaping security, Vienna 2013.

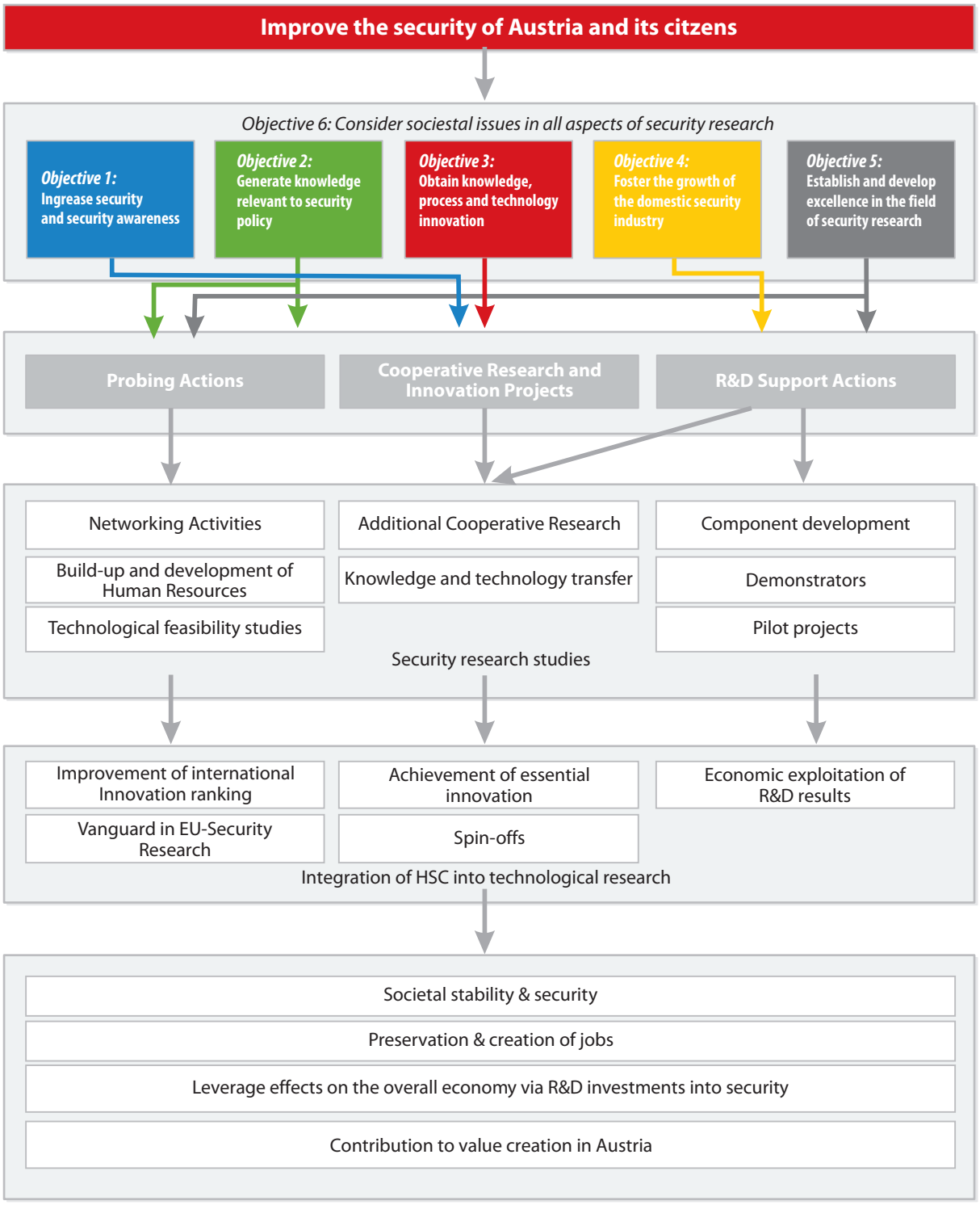
81 Federal Chancellery of the Republic of Austria, Austrian Cybersecurity Strategy, Vienna 2013.

82 www.bmvit.gv.at/en/innovation/security_research.html.

83 http://www.kiras.at/das-programm/thematischer-schwerpunkt/?L=0.

84 Bundesministerium für Verkehr, Innovation und Technologie, Das Österreichische Förderungsprogramm für Sicherheitsforschung KIRAS, Programmdokument, Wien, April 2015.

Figure 34. Impact logic of the KIRAS programme. Source: Personal communication with bvmit.



At present, KIRAS has two promotion and funding instruments.[85] There are different requirements for the types of participants that must be included in projects, but the basic idea is that there is to be a consortium encompassing several different types of stakeholders in each project.

- **Cooperative research and innovation (R&I) projects** focus on industrial research and projects are to result in demonstration and application activities. Projects must include one participant each from public or private end users, research organisations and industry, and in addition one participant representing HSC aspects
- **R&D support actions** fund studies and concepts that focus on end user needs. Project participants must be located in Austria. This instrument allows for security related HSC research

The instruments have no explicit co-funding requirements, but the level of funding varies depending on instrument and participants.

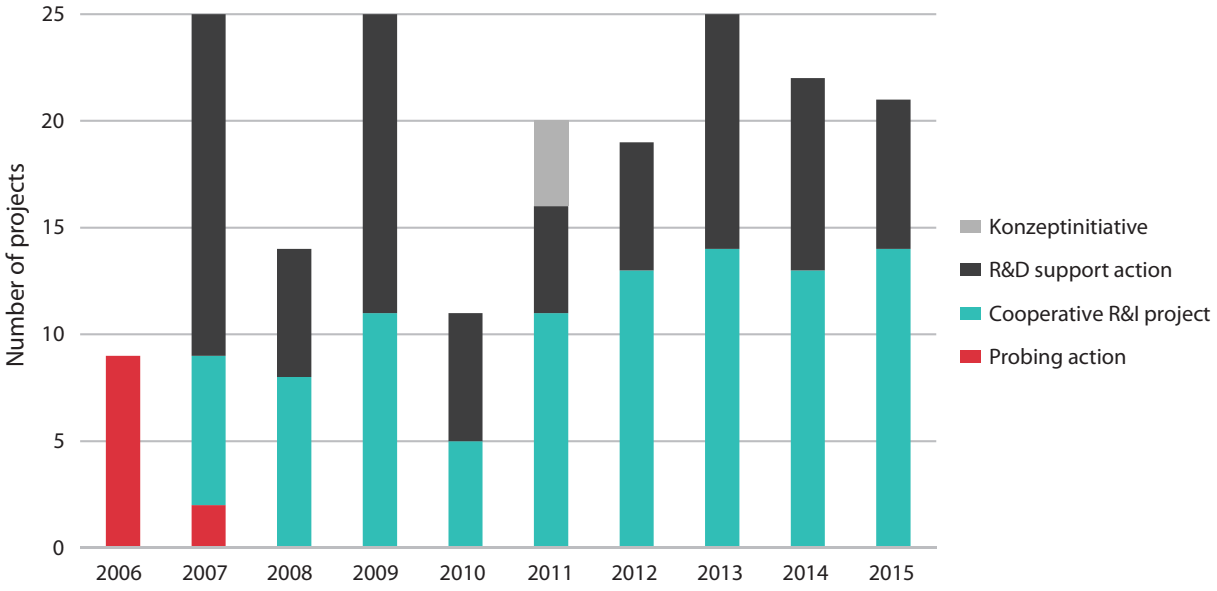
Between 2006 and 2015, there were 24 calls for proposals with different priorities. The present programme period lasts from 2014 until 2020.[86] During the 2006–2015 period, 191 projects received financial support and the distribution of projects by year and by promotion and financial instruments are presented Figure 35. The typical project duration has been about two years. The 'Probing action' instrument, used in 2006 and 2007 only, aimed to assess innovative high-risk project ideas on their feasibility and implementation potential. The pilot 'Konzeptinitiative' instrument, used in 2011 only, was an SME instrument. In 2013 and 2015, KIRAS and the German security research programme 'Research for civil security' had joint calls for proposals to promote bilateral projects. In 2013, five Austrian-German projects were funded.

The most common participant category by number of participations has been public organisations (31%), followed by companies (27%), research institutes (24%) and universities (18%).[87] The total funding in the 2005–2014 period was €64.5m, and the total project budget €93m.

An important requirement on projects is that they are to contribute to the creation of jobs. A 2014 follow-up of the programme estimated that the programme had contributed to the creation or keeping of 2,000 jobs in Austria, as well as to an added value of €116m (in Austria).[88]

The KIRAS programme has been evaluated three times. Interim evaluations were carried out in 2010 and in 2012, and an ex-post evaluation of the 2005–2013 period in 2014. The aim of the ex-post evaluation was to evaluate the projects' contribution to the programme's strategic objectives, as well as which of the programme's framework conditions that constituted positive or negative factors for project participants in achieving project success. The evaluation

Figure 35. KIRAS projects by year and instrument.



85 www.kiras.at/instrumente/?L=1.

86 Bundesministerium für Verkehr, Innovation und Technologie, Das Österreichische Förderungsprogramm für Sicherheitsforschung KIRAS, Programmdokument, Wien, April 2015.

87 Bundesministerium für Verkehr, Innovation und Technologie, Sicherheitsforschungsprogramm KIRAS, 7/2015.

88 Bundesministerium für Verkehr, Innovation und Technologie, Sicherheitsforschungsprogramm KIRAS, 7/2015.

showed that the strategic objectives had been achieved, that the programme had been well implemented and that there was little room for improvement.[89]

Since KIRAS has existed for quite some time, experience shows that projects relating to some critical infrastructure areas have been more successful than others. Examples of successful areas are border security, cybersecurity and big events. In order to attract the right stakeholders and achieve the intended outcome, it has proved important that the programme suits stakeholders and supports the idea that projects should be carried out by consortia including different stakeholder types.

B.3 Results and impact in terms of FP7/H2020 participation

In some cases, there is a direct link between KIRAS and FP7 Security projects. One example is a KIRAS project on airport screening techniques 'FBC – Grenzkontrolle der Zukunft', which was developed to the 'FastPass' project in FP7 Security.[90] However, there has been no comprehensive monitoring of whether KIRAS has enhanced participation in FP7 Security or Horizon 2020 Secure Societies.

Experience shows that there may be an advantage in starting up certain types of projects at a national level, and thus in a less complex context. Meanwhile, there are also several examples of projects that have been launched directly at EU level. Important results of FP participation is networking with stakeholders in other countries and access to research networks that do not exist in Austria.

FFG has put substantial work into stimulating Austrian participation in FP7 Security and Horizon 2020 Secure Societies. FFG advices individual proposers, provides training courses on how to apply and report to the Commission, and assists in locating partners in other EU countries.[91] However, there is no financial support to proposers.

In FP7 Security, Austrian organisations participated in 79 out of 307 projects, and Austrian organisations coordinated 13 projects. In a follow-up by the Ministry of the Interior (BM.I), the added value of the Austrian FP7 Security participation was estimated to around €81.3m (in Austria).[92] So far, Austrian organisations participate in 28 projects in Horizon 2020 Secure Societies, and three projects are coordinated by Austrian organisations.[93]

B.4 Lessons learned

So what may Tekes and Finnish stakeholders learn from KIRAS? Experience suggests that actively seeking to influence EU agendas of relevance to security research to consider a nation's priorities paves the way for enhanced FP participation of that nation's organisations, and Austria has participated in a group of six countries that has strived to influence security priorities in both FP7 and Horizon 2020. On several occasions, the group (Austria, Germany, France, the Netherlands, France and the United Kingdom) has formulated common standpoints prior to programme committee meetings.[94]

Austrian experiences also suggest that small organisations may be better served by national projects, whereas larger organisations may be more able to participate in and benefit from FP projects. On the other hand, certain types of projects are likely always better conducted at national level, regardless of size of participants.

Finally, it is seen as most valuable that the KIRAS programme has been running continuously for such a long time, thus giving constant attention to security-related matters in both Austria and the EU. However, although there is a general feeling – and indeed assumption – that KIRAS has stimulated Austrian FP participation, there is no hard evidence of the programme having had this effect since it has not been monitored.

89 Joanneum Research Forschungsgesellschaft mbH, Prognos AG und Institut für empirische Sozialforschung GmbH, Evaluierung des österreichischen Sicherheitsforschungsprogramms KIRAS, Ex Post-Evaluation 2014, September 2014.

90 Technopolis Group, Final Evaluation of Security Research under the Seventh Framework Programme for Research, Technological Development and Demonstration, September 2015.

91 www.ffg.at/en/content/our-services.

92 Bundesministerium für Verkehr, Innovation und Technologie, Sicherheitsforschungsprogramm KIRAS, 7/2015.

93 Bundesministerium für Verkehr, Innovation und Technologie, Sicherheitsforschungsprogramm KIRAS, 7/2015.

94 Technopolis Group, Final Evaluation of Security Research under the Seventh Framework Programme for Research, Technological Development and Demonstration, September 2015.

Appendix C. Germany National Innovation Programme (NIP) for hydrogen and fuel cell technology

C.1 Background

Germany is among the leading technology developers in hydrogen and fuel cells worldwide, together with countries such as Japan and the USA. With respect to transportation and stationary applications, South Korea also belongs to this group. After Japan, the USA and South Korea, Germany has recently established market introduction programmes for stationary fuel cells. German companies are leaders in component development, systems integration and manufacturing technologies. Research and innovation projects funded through the National Innovation Programme (NIP) for hydrogen and fuel cell technology have contributed substantially to the development or improvement of the supply chain. These projects have further enhanced and accelerated technology development in the fuel cell and hydrogen area. NIP funding has thus played an important role in the development of hydrogen and fuel cell technologies in Germany.

Nonetheless, industrial development in Germany needs to be broadened to ensure robust commercialisation. Alternative offers are partly missing and there are certain gaps in the supply chain. So far, competitive low-temperature proton-exchange membrane fuel cells (PEMFC) stack development and manufacturing neither exists for transport nor for stationary applications. Patent applications are comparable in number to those of South Korea, but substantially below those of Japan and the USA. The interlinkage of institutional research with industrial development has potential for further expansion with NIP-funded projects, which have a high R&D content and thus may foster innovation.

Although NIP has focused on market preparation over a broad range of topics, certain technologies and applications still require technological advances in order to proceed towards market introduction. The majority of NIP-funded projects have primarily focused on technology development and innovation, and have put a secondary focus only on economic goals and cost reduction.

National needs notably include the build-up of a broad supply chain in the hydrogen and fuel cell sector, the closing of existing gaps compared to international competitors and the acceleration of technology development and market preparation. The aspired continuous improvement of Germany's competitive position requires both improved collaboration between institutional research and industry with increasing intellectual property generation and focused commercialisation of products.

C.2 The NIP programme

NOW GmbH (National Organisation Hydrogen and Fuel Cell Technology), a subsidiary of the German Federal Ministry of Transport and Digital Infrastructure (BMVI), is responsible for the coordination and management of the NIP programme. In the 2008–2016 period, the programme has had a total budget of €1.4 billion. BMVI contributed €500m and the Federal Ministry for Economic Affairs and Energy (BMWi) €200m, while participating industry contributed the balance (€700m). The extension of the programme (NIP 2.0) from 2016 to 2025 is currently under preparation. A first 'bridge funding' of €162m has already been approved for the next two years.

The focus of NIP is development and market activation of internationally competitive hydrogen and fuel cell products. The Federal Ministry of Education and Research (BMBF) provides additional funding for basic research on hydrogen and fuel cells. Within the programme, the National Development Plan (NEP) defines the topics to be funded, and provides the funding guidelines, as well as the basis for awarding grants. The funding rules of NIP remain valid until 31 December 2016; the rules for NIP 2.0 programme are under preparation.

NIP was established to be complementary to and well-coordinated with the FCH JU in order to enable German companies and organisations to receive national as well as European funding. Structurally, NIP has focused on being complementary to the FCH JU by providing funding to projects beyond the scope of the FCH JU, without excluding co-funding from both programmes up to the maximum permissible funding rate. Funding programmes of several German federal states have further complemented the funding landscape by providing both individual funding or funding complementary to FCH JU funding.

Both, both NIP and the FCH JU are public private partnerships (PPP) incorporating large German companies and organisations such as BMW, Bosch, Daimler, DLR, EnBW, E.On, Fraunhofer, Forschungszentrum Jülich, Karlsruhe Institute of Technology, Linde, Siemens, TÜV SÜD, Vaillant, VW and ZSW.

The German federal government supports the development and adoption of hydrogen and fuel cell technologies through NIP with the aim of achieving market maturity over the program duration. Industrial value chains shall be established, and value-added activities shall contribute both to economic as well as to energy and climate policy objectives of the federal government. Besides large-scale

demonstration projects, NIP also focuses on R&D projects. The demonstration projects are grouped into comprehensive lighthouse projects taking place under real-world conditions. This allows project partners to jointly tackle and solve challenges in an effective and synergetic manner.

NIP is subdivided into four programme areas, in order to advance on different hydrogen and fuel cell technology product and application options in parallel, and to be able to address in a targeted way the application-specific challenges of market introduction. The four programme areas are:

- Transport and Hydrogen Infrastructure
- Hydrogen Provision
- Stationary Energy Supply
- Special Markets

With an eye on series production of components, the explicit focus in all programme areas is on strengthening of the supply industry.

The goals of NIP are:

- To accelerate market development through targeted support and promotion of hydrogen and fuel cell sectors in mobile, stationary and portable areas
- To strengthen value chains and added value in Germany
- To secure technological leadership and implementing the technology in Germany

Commercial companies, universities and other research institutions are eligible for funding. In exceptional cases, projects by local authorities and other incorporated public bodies can be supported. In particular, SMEs are encouraged to submit applications. Both individual applicants and consortia can submit applications and receive funding.

A two-step application process has been applied. A short project outline has been evaluated according to predefined criteria leading to the second phase of the application process, which starts with a proposal initiation meeting with NOW. Subsequently, the applicant submits a full proposal in the web-based proposal portal. If the review of the proposal is positive, a grant is issued to the proposer. The ratio of grant to total project costs and the maximum funding rates are in line with the Commission's Framework for State aid for research and development and innovation.

Project funding is awarded as a non-repayable grant, which is limited to a maximum amount through the grant agreement. The funding rate depends on how application-oriented the project is, and can reach a maximum of 50%. Depending on the type of action (study, development contract, small or large-scale demonstration activity) the contract durations vary between less than a year and several years (typically 3–5).

Co-funding through programmes at national and EU level is in principle possible, in compliance with overall funding limits as defined by the Commission's Framework. However, NIP does not aim at co-fund FCH JU projects (or vice versa), but rather aims at supporting complementary projects, which do not receive FCH JU funding. Figure 36 presents the NIP complementarity approach to FCH JU funding to the right: two complementary projects are defined, one applying for FCH JU funding, the other applying for NIP funding. The funding rates depend on the specific funding rules of the two programmes. The alternative approach, which is possible but not strongly encouraged through the NIP, is shown to the left. A project applies for funding from both NIP and the FCH JU. Again, the maximum funding rate is limited by the Commission's Framework.

Figure 36. Complementarity between NIP and the FCH JU.

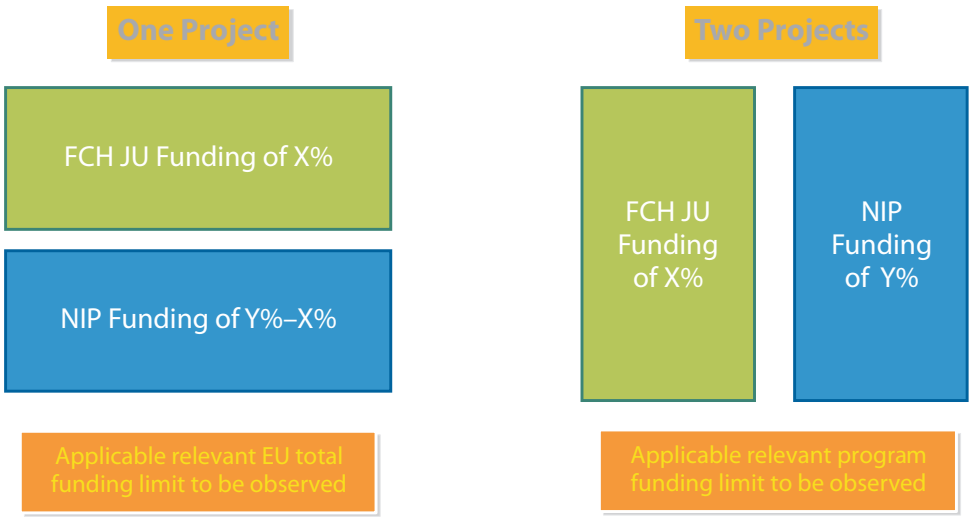


Figure 37. Impact logic of the NIP programme.

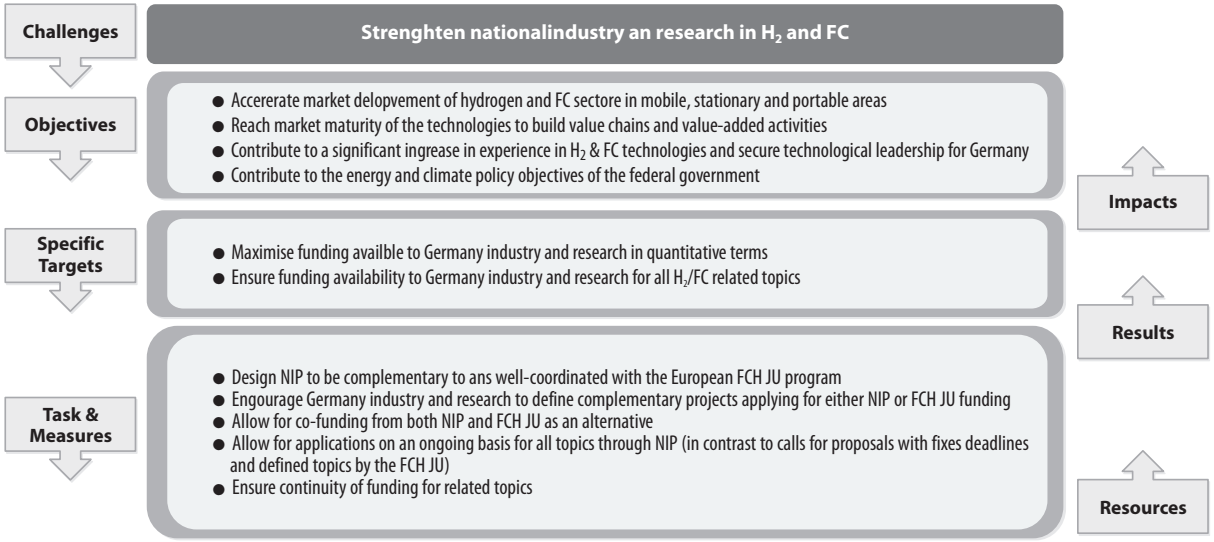


Figure 37 illustrates the impact logic of NIP, summarising the programme's objectives, expected effects and measures related to FP7/FCH JU participation of German stakeholders.

C.3 Results and impact in terms of FCH JU/ H2020 participation

The participation of key German organisations in FCH JU projects is generally high. Complementing this, NIP has provided funding to a number of projects and organisations that have not received FCH JU funding, either because their proposals were rejected or because they were not eligible for FCH JU funding. An important reason for the latter is the fact that individual organisations may apply for NIP funding, in contrast to a minimum of three organisations from three different Member States in the FCH JU.

NIP has funded a number of lighthouse projects such as the Clean Energy Partnership (CEP) demonstrating fuel cell vehicles and the related hydrogen-refuelling infrastructure over many years. Subsequently, NIP beneficiaries have participated in complementary FCH JU projects. This combination has allowed German industry to prepare the grounds for the German H2Mobility initiative, which has started the rollout of a Germany-wide hydrogen-refuelling infrastructure.

The early start of the CEP cluster network in 2002 and its later support by the NIP, allowed German stakeholders to build the largest such demonstration in Europe and to act on a comparable level as the USA or Japan. A similar, though not as powerful, effect has been achieved in the field of stationary combined heat and power (CHP) fuel cell systems (CALLUX) and larger distributed industrial fuel cell-based power generation with SOFC and high-temperature polymer electrolyte membrane fuel cells (HT-PEMFC) and maritime applications (e4ships). Furthermore, hydrogen production via electrolysis was another key area for research and demonstration. Achievements in this area certainly have facilitated German participation in larger and complex demonstration projects funded by the FCH JU. The chain from the German CALLUX field test of residential fuel cell CHP systems over the FCH JU-funded ene.field project[95], to the current market introduction in several EU countries supported by national commercialisation programmes, is certainly a success story for the German industry. Nonetheless, it must be cautioned that market penetration has only started and may still encounter difficulties.

International networking was significantly enhanced through the NIP programme. It helped Germany to maintain or even improve its leading position in several hydrogen and fuel cell areas in a global perspective. A small series of hydrogen infrastructure workshops held since 2013 between DOE, NEDO and NOW (with some participation also from the SHHP[96]) is one of those examples. Strong participation by German stakeholders in FCEV & HRS demonstration as well as stationary FC system development and field demonstration in Germany and Europe are other examples.

The opportunity to get similar areas and technology developments funded through two programmes running in

[95] The FCH JU ene.field project will deploy and monitor 1,000 new installations of residential fuel cell CHP across 11 key European countries. Link: enefield.eu/.

[96] Scandinavian Hydrogen Highway Partnership (with Danish, Swedish and Norwegian partners).

parallel, also allowing complementary funding approaches, has allowed achieving critical mass for industry to justify efforts and to more effectively achieve goals in technology development and commercialisation.

Both NIP and FCH JU have played major roles in developing hydrogen and fuel cell technologies and products in Europe. However, the ambitious commercialisation goals of both programmes have not yet been met. The next few years will show whether the mass-market introduction of hydrogen and fuel cell products will be successful in Europe, and at what rate. In the positive case, NIP will have contributed significantly to value added in Germany.

Few SMEs have participated in NIP as direct beneficiaries. However, SMEs have served as suppliers to NIP beneficiaries and have thus contributed their products on a commercial basis, while beneficiaries only received funding up to the maximum funding rate. On the same note, few research organisations have participated in NIP, while their participation the FCH JU has been extensive.

No evaluation has been carried out to analyse the effects of NIP funding on FCH JU participation. However, the hydrogen- and fuel cell-focused NIP funding (that did not exist in Germany prior to NIP) has certainly improved the ability of German industry and research organisations to participate at a much more focused and prominent level in R&D and early fleet/field demonstration activities in Europe. In general, NIP beneficiaries improve their capabilities for FCH JU participation through their participation in NIP projects. As an example, PEMFC stack and component projects funded through NIP enhanced the beneficiaries' capability to participate in FCH JU fuel cell stack development projects (such as Autostack), which were quite successful. These FCH JU projects laid the foundation for the capability to prepare and enter into a European and German stack manufacturing undertakings for mass-produced and cost-competitive automotive stacks. Another example is the demonstration and deployment of micro-CHP systems. Complementing the NIP-funded CALLUX project, new German fuel cell companies, such as Elcore have received FP funding through the ene.field project.

C.4 Lessons learned

Hydrogen and fuel cells will play an important role in renewable and distributed energy generation and in the transportation sector when aiming at complying with the very stringent greenhouse gas-reduction requirements, as well as when striving to fulfil zero-emission requirements in metropolitan areas.

The German NIP programme is strategically matched to the FCH JU, so as to provide complementary funding opportunities. This enables German companies and research organisations to develop, demonstrate and deploy fuel cell technologies in German 'lighthouse projects' such as the CEP (automotive), CALLUX (stationary) and maritime applications (e4ships), as well as in complementary European projects such as H2MovesScandinavia (automotive), HyFIVE, H2ME, H2ME II, CUTE, CHIC (buses), ene.field (stationary).

NIP-funded projects often provide the foundation for subsequent FCH JU-funded programmes and projects. This enables German companies and research organisations to maintain or even improve their leading position in several hydrogen and fuel cell areas in both European and global perspectives.

Finnish actors may elect to focus on selected hydrogen and fuel cell technologies and concepts that are not yet available and the focus of major international development and try to advance these, as international competition may be less fierce. Finnish actors could more strongly pursue fuel cell integration and possibly focus on Scandinavia-specific (niche) applications like machinery (forestry, harbours, off-road, small generators). Finnish actors should also be prepared for an increasing share of renewable electricity feed-in by PtG/PtH2 (power to gas/hydrogen) concepts. Demonstration and market preparation for these technologies is essential.

Where Finnish companies already have succeeded in developing market-ready SOFC technology they may need assistance in introducing them in real-life applications. Setting up local manufacturing requires a supply chain. With the competence and knowledge available, this is also possible in Finland, in case support for application-oriented demonstration is made available. Deficits in such supply chains have been a strong motivation for the NIP programme to assist in closing this gap. If this is not going to happen in Finland, Finnish companies will set up their manufacturing where conditions are more favourable and already from the beginning closer to customers. If this were to happen, the opportunity to position Finland and its industry with manufacturing sites inside the country, with local value and employment creation, would be lost.

Influencing the orientation of the R&D direction of the FCH JU is essential in order to have topics of national interest included in its Annual Work Programmes. The focus should be on areas where Finland is strong and can achieve an impact with its limited number of experts (small-country limitation).

In order to advance hydrogen and fuel cells on a broader scale, it may be worthwhile to consider supporting regulatory measures forcing the introduction of efficient zero emission technologies such as fuel cells. This will also require the advancement of hydrogen as an intrinsically clean fuel, including supply, distribution and dispensing infrastructure, which would open additional business opportunities.

Appendix D. Case study: Cybersecurity

D.1 Background and status of cybersecurity at start of the Safety and Security programme

D.1.1 Situation in 2005–2007

When Tekes' Safety and Security programme was on the drawing board, the world, and specifically the world, was very different. In the aftermath of September 11th, the nation-level safety and security issues, flight safety and counter terrorism were strongly on the agenda. However, in the digital domain, the risks and security issues where discussed under the titles of IT security and information security. Cybersecurity as a broader concept, where physical security and safety is compromised through the means of digital systems, became a doctrine only 5–7 years later.

In the era of IT and information security, Finland had a substantial and strong industry. Companies like SSH Communications, Stonesoft and F-Secure were well known and respected among industry specialists, not only in Finland but also globally. These companies were founded and run by persons who had a strong and deep understanding of the ICT protocols and fundamental IT technologies.

The clients where IT departments of large private companies and government offices, and the focus was primarily technical. The solutions were targeted to keep the networks clean of anomalies and 'computer viruses', and the adversaries where individual and unorganised hackers.

The technical foundations established have been very successful, and resulted in several technology start-ups and well-known industry experts. One indication of the success is that Finland has ranked well in many indices, such as ITU's Global Cybersecurity Index[97], EU Cybersecurity Dashboard[98] and Microsoft's Malware Infection Rate[99]. However, this has more to do with the prudence of the organisations applying the policies and technologies than with the uniqueness of Finnish products and services – although they clearly have contributed to this good position. The relatively extensive competence pool has also positively impacted on the early success of the information security industry.

D.1.2 Change of paradigm

In the beginning of the 2010s, the adversary profile changed from 'hactivists' to organised crime. The new group was very business-oriented, professional and well equipped. The losses caused by cybercrime rose to a level of US$400 billion 2013[100] and it is still rising.

Besides organised crime, the well-funded intelligent services became a risk for many less well-resourced countries. Internet became a cost-effective platform to conduct military intelligence, cyberespionage and hybrid warfare. Some governments that had invested hugely to counter terrorism, had created tools and practices that made them hostile actors and a new threat to not-so-well-prepared nations that found it very difficult to protect themselves. This was all made publicly known when Edward Snowden revealed the huge mechanisms built by USA's National Security Agency (NSA).

The Finnish Cybersecurity Strategy was published 2013[101], in the middle of this paradigm shift. Cybersecurity was a hot topic among IT technology providers, but among security specialists, it had become a recognised risk for national security and safety. The risks, adversaries and solutions were discussed among politicians, security authorities and industry specialists.

The global information security market had grown to a substantial size of €60 billion in 2010[102] and was growing with pace of 9–11 percent per annum. Today the global market is estimated to be €90–100 billion[103].

The change in the game also changed purchasing behaviours. Firstly, there was a lot of high-level discussion and general education of the high-level decision makers. This meant that there was room for lobbying and industry

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97 ITU Global Cybersecurity Index (GCI) 2014 and 2016, www.itu.int/en/ITU-D/Cybersecurity/Pages/GCI.aspx.

98 BSA European Cybersecurity Dashboard 2015, www.bsa.org/~/media/Files/Policy/Security/EU/study_eucybersecurity_en.pdf.

99 Microsoft Malware Infection Rate, Security Intelligence Report, www.microsoft.com/security/sir/threat/default.aspx.

100 McAfee, the economic impact of cybercrime and cyber espionage, July 2013 and Norton Cybercrime Report 2012.

101 Finland's Cybersecurity Strategy, Government Resolution 24.1.2013.

102 Alixpartners Cybersecurity: A Compelling Growth Area for Defense Companies?, fall 2013.

103 Global estimates by research companies on the size of the Information Security Market in 2014-2015 typically vary between $70 and $110 billion. Gartner: global spending on IT Security in 2015 = $76.9 billion *Gartner Says Worldwide Information Security Spending Will Grow*. Gartner Press Release. Aug. 2014, MicroMarket Monitor: the global cybersecurity market in 2014 = $95.6 billion *Global Cybersecurity Market Research Report*. Rep. MicroMarket Monitor, 2014, Markets and Markets: the size of the total cybersecurity market in 2015 = $106.3 billion *Global Forecast to 2020*. Rep. Markets and Markets, Feb. 2015, Visiongain: the global cybersecurity market in 2015 = $75.4 billion *Cybersecurity Market 2015–2025*. Rep. Visiongain, 2015.

politics. The security authorities of the leading nations had formed coalitions and joint practices. The market was split and divided into camps sharing same practices and technologies. Finland mostly outside of these camps. As a result, Finnish industry did not do very well in the new paradigm. The decisions on large new systems were not made by technicians, and they were politically or at least 'camp-member' biased. Large companies from the defence sector entered the market offering holistic and many times politically motivated solutions.

D.2 Relevance and impact of the Safety and Security programme

Within Tekes' Safety and Security programme, there were ten cybersecurity-related enterprise projects and ten research projects. The programme had a wide scope and topics within the theme of cybersecurity also varied widely.

In general, it can be said that the programme supported the agendas of cybersecurity participants quite well. Cybersecurity was on the rise and the broad scope of the programme provided good opportunities for companies to develop and study various products and solutions. One of the key contributions pointed out by the participants was the collaboration and networking dimension of the programme. Among the enterprise participants, large multinational companies like Airbus very likely broadened the view of smaller companies operating mostly in the domestic marketplace.

Out of ten company participants, Blancco and Codenomicon can be pointed out as being particularly successful with their projects. Both have had substantial commercial success after the programme, and their projects are relevant also for the cybersecurity market. Both companies were later sold to non-Finnish buyers; Blancco to UK based Regenersis[104] and Codenomicon to US based Synopsys[105]. It is very unlikely that the Tekes programme had any decisive role in the process leading to the acquisitions, but it is likely that their Tekes projects supported the strategies and actions that may have led to the acquisitions.

The programme also supported the birth of the Finnish Information Security Cluster (FISC) in 2013.[106] FISC was member of the programme, which helped the young industry association to establish the organisation, its working practises and activity areas. This support was important in the early stage of the organisation's development. FISC has been a very active cluster. It has an operational arm, Cyberlab Oy, which conducts commercial assignments for member companies, and it has arranged several business delegations to support international trade for its member companies.

VTT conducted two cybersecurity-related projects, one focusing on the information security of the industrial systems and the other related to the future aspects of information security. Both of these themes are still highly relevant, and the work on these topics have continued.

D.3 Relevance of the linkage to FP7

The FP7 participation of participants in the Safety and Security programme was minimal; a mere 6 percent of Tekes participants have participated in FP7/H2020. Only one cybersecurity company that participated in the Safety and Security programme has also participated in FP7 Security, but its FP7 projects were not related to cybersecurity.

It seems as if participants saw the Safety and Security and the FP7 Security programmes as parallel programmes, without major synergetic possibilities. It is also possible that one excluded the other due to resource limitations among potential participants.

D.4 Current status and prospects of cybersecurity in Finland

The cybersecurity market has matured. Success requires size, speed, financial assets and access to large national and global markets. In general, Finnish companies have had substantial challenges to compete under these terms. Some companies have also lacked ambitions or they have assessed the risk of fast growth be too high. In many cases, ownership has been in the hands of their original founders, like in the case of SSH Communications. This has limited the availability of financial resources substantially. As a result, the three biggest companies in 2005, F-Secure, Stonesoft and SSH Communications, grew by 7.8–9.1 percent per annum in the following 10 years.[107] This was about the same as the general market growth, not more.

Although eight Finnish cybersecurity companies were sold in 2013–2015,[108] the cybersecurity industry in Finland is still strong and there is a new wave of young and innova-

[104] www.blancco.com/en/about-us/in-the-news/regenersis-acquire-eur-60-mln-shares-rise-update.

[105] news.synopsys.com/2015-04-20-Synopsys-to-Acquire-Software-Security-Company-Codenomicon.

[106] Finnish Information Security Cluster is an non-profit organisation promoting the business, research, PPP and general collaboration of the Finnish cybersecurity companies. It was established in 2013 and has 55 member companies.

[107] Information from the company annual financial statements: F-Secure revenue 2005 62MEur and 2015 148, 9,1% CAGR, Stonesoft 2005 22Meur and 2012 40MEur CAGR 8,9%, SSH Communications 2005 9MEUR and 2015 19MEUR CAGR 7,8%.

[108] Blancco, Bittium, Codenomicon, nSense, Panorama Partners, Stonesoft, Trusteq Ubisecure.

tive companies on the move.[109] Also the professional services companies are doing well, are becoming more international and are substantial employers. The effort to reach global markets is still a major challenge, but on the other hand, the customers' buying behaviour is changing slightly. Decision makers and security authorities now understand the value of national and EU-based companies and competence pools. In many countries, public purchasing organisations are creating strategies to support 'wise buying'.

The current cybersecurity industry is polarised. On the one hand, there are very large ICT companies like HP and IBM, as well as large defence contractors like Thales and Airbus. On the other hand, there is a large number of SMEs. This is true in Finland, but also in larger EU countries such as Germany, where security-focused SMEs face almost the same challenges as their Finnish counterparts, which levels the playing field. It can be equally challenging for a German company to sell to a French customer as for a Finnish company.

The European Commission has noted this, and is in the process of establishing a PPP platform for cybersecurity, in order to create a digital single market in cybersecurity.[110] Companies of European origin are estimated to have 8.5 percent of the global market, and 35 percent of the European market[111], so this will be a substantial task.

A maturing market and the role of the large global ICT multinationals leaves two main options for Finnish cybersecurity companies. Either to become a superior professional service organisation, or find a strong and narrow technology niche where they can be the technology leader. Especially the latter requires strong innovation capability and financial resources, and even more so today than in 2007.

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109 Companies representing this wave are among others Meontrust and Rugged Tooling.

110 EU Commission is planned to adopt the establishment of the EU Conctactual Public-Private Partnership for cybersecurity on 27th of June 2016.

111 European Cybersecurity Industry Proposal for a contractual Public-Private-Partnership, European Security Organisation. April 2016.

Appendix E. Fuel Cell programme interview guide: Companies

Interviewee:

Organisation, position:

Project:

Date:

Interviewer:

For smallish companies, 'company' in this guide refers to the whole company. For large companies, it may refer to a 'group' or 'department' within the company (whatever the interviewee feels comfortable with).

Background

1. How and when did you become involved in the project?
2. What was your company's history in R&D on fuel cells?
   - How did the project match your company's strategic objectives?
3. What was your project about? (Very briefly and in layman's terms.)
   - What other organisations participated in the project?

Relevance

4. The objectives of the Fuel Cell programme were to (interviewees will not be aware of the objectives, so we will have to read them out loud):
   - Improve the opportunities for Finnish industry to generate breakthrough products in selected fuel cell product segments.
   - Create an innovative development environment to build a knowledge base in the field.
   - Realise commercialisation in niche market areas (e.g. portable fuel cells).
   - Do this in close collaboration with the FCH JU.
     - How challenging were these objectives (in 2007)?
     - How well was your company aware of the FCH JU connection (when the proposal to Tekes was written)?
     - How relevant were these objectives to your company (in 2007), especially the FCH JU connection?
5. To what extent did your project contribute to the Fuel Cell programme objectives, especially the FCH JU connection?

Efficiency

6. How do you rate Tekes' administration of the Fuel Cell programme concerning:
   - Proposal assessment and selection
   - Project initiation
   - Project reporting
   - Support during project implementation
7. How have results of the Fuel Cell programme been disseminated?
   - What has your company disseminated from your Tekes project? How and to whom?
   - What has Tekes disseminated from your Tekes project? How?
   - What has Tekes disseminated from the Fuel Cell programme? How?

Project results and impact

8. What (shorter-term) results were realised for your company through the project? *Examples:*
   - *New knowledge*
   - *Competence development*
   - *New technologies*
   - *New devices/equipment*
   - *Publications*
   - *Patent applications*
   - *Recruitment of R&D&I staff*
   - *Extended network (with whom?)*
   - *Other results?*
9. What (longer-term) impact was realised for your company through the project? *Examples:*
   - *Improved R&D&I capability*
   - *New products/services/processes*
   - *New testing/validation procedures*
   - *New pilots/demonstrators*
   - *New standards*
   - *New business model*
   - *Increased turnover/sales*
   - *Improved profitability*
   - *Increased market share (where?)*
   - *Increased employment (where?)*
   - *Spin-off company (where?). Please name company!*
   - *Increased exports*
   - *Other impact?*
10. Which of the above would have been realised even if you had not received Tekes funding?

International results and impact

In this section, it is important to keep the Tekes project(s) apart from any FCH JU project(s).

11. What was your company's experience of R&D projects in the FPs/FCH JU before the start of your Tekes project?
12. Has your company participated in proposal(s) to the FHC JU? If yes, what did your Tekes project play? (If no, skip to question 18.) Examples:
    - *Invited to join a consortium/formed our own consortium*
    - *More proposals*
    - *Greater say in R&D direction*
    - *Larger responsibility*
    - *Larger budget*
13. Has your company become affiliated with Hydrogen Europe (formerly NEW Industry Grouping)? (If no, skip to question 18.) If yes:
    - What role did your Tekes project play?
14. Has your company participated in project(s) funded by the FHC JU? If yes:
    - What was the project title?
    - Who were the partners?
    - What role did your Tekes project play in you getting an FCH JU project?
15. What (longer-term) impact was realised for your company through the FCH JU project? Examples:
    - *Improved capability to collaborate in international R&D&I projects*
    - *New products/services/processes*
    - *New testing/validation procedures*
    - *New pilots/demonstrators*
    - *New standards*
    - *New business model*

- *Increased turnover/sales*
- *Improved profitability*
- *Increased market share (where?)*
- *Increased employment (where?)*
- *Spin-off company (where?). Please name company!*
- *Increased exports*
- *Other impact?*

16. Has your FCH JU project(s) made it more (or less?) likely that your company will participate in additional proposal(s) to:
    - The FCH JU
    - Horizon 2020
17. What were the overall benefits of Tekes' Fuel Cell programme running in parallel with the FCH JU? *Examples:*
    - *More effective international networking?*
    - *Increased Finnish participation in the governance of the FCH JU?*
    - *Increased Finnish participation in FCH JU projects?*
    - *Increased Finnish participation in Horizon 2020?*

Concluding questions

18. Who else should we talk to about Tekes' Fuel Cell programme? (Within you company, or elsewhere.)
19. Is there anything else you would like to add concerning the Fuel Cell programme?

Appendix F. Fuel Cell programme survey: Companies

Introduction

Welcome to this survey on your participation in the Fuel Cell programme funded by Tekes in the period 2007–2013.

This survey is part of an evaluation aiming to provide good practices that Tekes can use in the development of new programmes, and in stimulating Finnish participation in European research, development and innovation (R&D&I).

If you participated in more than one project in the programme, please respond according to the compound experiences of your projects.

The survey should take 10-15 minutes to complete, and your answers are treated anonymously.

We very much appreciate that you are taking the time to share your views on the programme!

Background

1. What type of organisation do you represent?
   - Company with less than 10 employees worldwide
   - Company with 10–50 employees worldwide
   - Company with 51–250 employees worldwide
   - Company with more than 251 employees worldwide
   - University, polytechnic etc.
   - Research and technology organisation (RTO)/research institute
   - Non-governmental organisation (NGO), association, foundation, etc.
   - Regional or local municipality (including organisations governed of owned)
   - National government authority or agency
   - My organisation is neither of the above. Please specify organisation type:
   - Free text.
2. If your organisation is a company, is it a subsidiary within a multinational company group (corporation)?
   - Yes, and the group has its headquarters in Finland
   - Yes, and the group has its headquarters in another country
   - No
3. What other types of organisations participated in your project in Tekes' Fuel Cell programme? Tick all that apply.
   - Company
   - University, polytechnic etc.
   - RTO/research institute
   - NGO, association, foundation, etc.
   - Regional or local municipality (including organisations governed of owned)
   - National government authority or agency
   - No other organisation participated

Project results and impact

4. Please assess to what extent your project in Tekes' Fuel Cell programme resulted in the following for your organisation. *(Strongly disagree–Disagree–Neither agree nor disagree–Agree–Strongly agree–Not applicable/don't know.)*
   - New scientific or technical knowledge
   - Competence development
   - New or improved technologies
   - New or improved devices/equipment
   - Scientific (peer-reviewed) publications
   - Other types of publications
   - Patent applications

- Recruitment of scientific or technical staff
- Extended network with Finnish companies
- Extended network with Finnish universities, polytechnics etc.
- Extended network with Finnish RTOs/research institutes
- Extended network with foreign companies
- Extended network with foreign universities
- Extended network with foreign RTOs/research institutes

5. Please assess to what extent your project in Tekes' Fuel Cell programme had the following (longer-term) impact on your organisation. *(Strongly disagree–Disagree–Neither agree nor disagree–Agree–Strongly agree–Not applicable/don't know.)*
   - Improved R&D&I capability
   - New or improved products, services or processes
   - New or improved testing/validation procedures
   - New or improved pilots/demonstrators
   - New or improved standards
   - New or improved business model
   - Increased turnover/sales
   - Improved profitability
   - Increased market share in Finland
   - Increased employment in Finland
   - Spin-off company established in Finland
   - Increased exports
   - Increased market share internationally
   - Increased employment in other country/-ies
   - Spin-off company established in another country
6. Please describe any other results or impact that have been realised for your organisation.
   - Free text.
7. To what extent did the project in Tekes' Fuel Cell programme live up to your organisation's expectations?
   - It exceeded our expectations
   - It fulfilled our expectations
   - It did not fulfil our expectations
   - Not applicable/don't know
8. What would have happened if your project had not been funded by Tekes' Fuel Cell programme? Tick all that apply.
   - The project would not have been conducted
   - The project would have been conducted with reduced scope
   - The project would have been conducted with fewer partners
   - The project would have been conducted with a longer timeframe
   - Not applicable/don't know

Programme administration

9. Please assess Tekes' administration of the Fuel Cell programme with regards to:
   (Strongly disagree–Disagree–Neither agree nor disagree–Agree–Strongly agree–Not applicable/don't know.)
   - Tekes' routine for proposal assessment and selection was appropriate
   - Tekes' process for proposal assessment and selection was fast
   - Tekes' process for proposal assessment and selection was transparent
   - Tekes' routine for project initiation was efficient
   - Tekes' routine for project reporting (technical and financial) was efficient
   - Tekes' requirements for project reporting (technical and financial) were appropriate
   - Tekes' support during project implementation was appropriate
   - Tekes' support with dissemination of results was appropriate

International results and impact

10. Please indicate your organisation's experience of the following types of international R&D&I projects between year 2000 and before the start of your project in Tekes' Fuel Cell programme: *(No such project–1 project–2–5 projects–6–10 projects–More than 10 projects–Not applicable/don't know.)*
    - Privately funded project(s) together with foreign organisation(s) (no public funding)
    - Project(s) funded by NordForsk, Nordic Innovation or Nordic Energy Research
    - Project(s) endorsed by the EUREKA programme (with national public funding)
    - Project(s) funded through the Fuel Cell and Hydrogen Joint Undertaking (FCH JU)
    - Project(s) funded through the EU framework programmes
11. Has your organisation participated in proposal(s) to the Fuel Cell and Hydrogen Joint Undertaking (FCH JU)?
    - Yes
    - No (*automatic skip to question 18*)
    - Not applicable/don't know (*automatic skip to question 18*)
12. Please assess the importance of your project in Tekes' Fuel Cell programme in facilitating your organisation's participation in the proposal(s) to the FCH JU.
    The project in Tekes' Fuel Cell programme meant that my organisation… (*Strongly disagree–Disagree–Neither agree nor disagree–Agree–Strongly agree–Not applicable/don't know.*)
    - … was invited to join a consortium
    - … was able to form its own consortium
    - … got involved in more proposals than we otherwise would have
    - … had a greater say in determining the R&D direction of the proposal(s)
    - … got a larger responsibility (work package leader, task leader, etc.) in the proposal(s)
    - … got a larger budget in the proposal(s)
13. Please describe any other way in which your project in Tekes' Fuel Cell programme was of importance to your organisation's participation in the proposal(s) to the FCH JU.
    - Free text.
14. Has your organisation become a member of Hydrogen Europe (formerly NEW Industry Grouping), one of the three members of the FCH JU?
    - No
    - Yes, but the project in Tekes' Fuel Cell programme was of no importance to us becoming a member
    - Yes, and the project in Tekes' Fuel Cell programme was of some importance to us becoming a member
    - Yes, and the project in Tekes' Fuel Cell programme was of critical importance to us becoming a member
    - Not applicable/don't know
15. Has your organisation participated in project(s) funded by the FCH JU?
    - Yes
    - No (*automatic skip to question 18*)
    - Not applicable/don't know (*automatic skip to question 18*)
16. Please assess to what extent the FCH JU project(s) has had the following (longer-term) impact on your organisation. *(Strongly disagree–Disagree–Neither agree nor disagree–Agree–Strongly agree–Not applicable/don't know.)*
    - Improved capability to collaborate in international R&D&I projects
    - New development partners and/or suppliers outside Finland
    - New or improved products, services or processes
    - New or improved testing/validation procedures
    - New or improved pilots/demonstrators
    - New or improved standards
    - New or improved business model
    - Increased turnover/sales
    - Improved profitability
    - Increased market share in Finland
    - Increased employment in Finland
    - Spin-off company established in Finland

- Increased exports
- Increased market share internationally
- Increased employment in other country/-ies
- Spin-off company established in another country
- Increased likelihood that my organisation will participate in additional proposal(s) to the FCH JU
- Increased likelihood that my organisation will participate in proposal(s) to Horizon 2020

17. Please describe any other impact that has been realised for your organisation through the FCH JU project(s).
    - Free text.

Final question

18. Please add any additional comment regarding Tekes' Fuel Cell programme.
    - Free text.

Tekes' Reports in English

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