RWI Materialien

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Accompanying Evaluation of the Funding Instrument "Spitzencluster-Wettbewerb" (Leading-Edge Cluster Competition) of the Federal Ministry of Education and Research

Final Report – Summary

Vol. 90

Accompanying Evaluation of the LECC

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1. Goals and scope of research

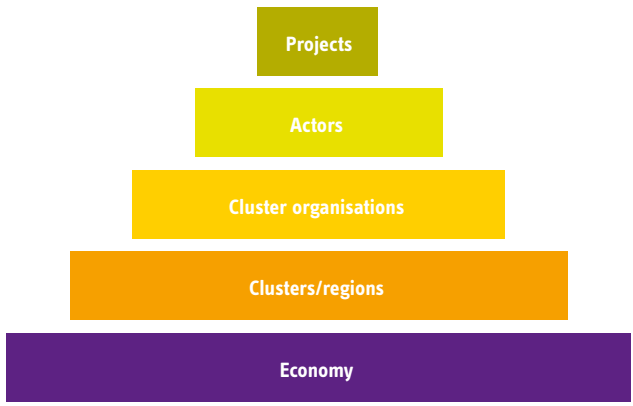
With its Leading-Edge Cluster Competition (in German: Spitzencluster-Wettbewerb; LECC), the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) is supporting innovation clusters in a nationwide contest for the first time. In three rounds, 15 cluster initiatives were selected and provided with funds to support them on their way to becoming international leaders in their field of technology, or, if they already held such a position, to maintain or expand their lead. Through a sustainable mobilisation of regional economic potentials, supporting the strategic development of Leading-Edge Clusters has the goal of increasing growth, securing or creating jobs and enhancing the attractiveness of Germany as a location for innovation and business.

The BMBF contracted a project consortium to conduct an accompanying evaluation of the LECC. This consortium consisted of the Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI), Essen (project coordination); the Institut für Sozialforschung und Gesellschaftspolitik GmbH (ISG), Cologne; the Chair of Economics/ Microeconomics at the Friedrich SchillerUniversity Jena, as well as the JOANNEUM RESEARCH GmbH, Graz. This summary of the final report comprises the main findings of the accompanying evaluation of the LECC for the duration of the project from 11/2008 to 04/2014.

The LECC effects were evaluated on several levels (figure 1): At the *project* level, project activities, the resulting innovations, as well as the exchange of knowledge between the various (joint) projects were evaluated. At the level of *cluster actors* (i.e. cluster partners, members of the cluster organisations) the degree was investigated to which businesses and public research organisations (universities and research institutes) were able to benefit from joint activities in research and development (R&D). At the level of *cluster organisations*, it was analyzed to what extent the cluster initiatives benefited from the impulse generated by the LECC. At the level of *clusters and cluster regions*, the main question was whether or not the cluster activities contributed to enhancing the networking and the technology and knowledge transfer between stakeholders. Another topic under investigation were the potential transmission effects of the LECC both in the cluster regions and at the level of the *overall economy* in terms of increased value-added and employment.

Within the scope of the LECC, a total of EUR 600 million in public funds are being spent between 2009 and 2017. The implementation envisages at least a matching level of co-financing from the firms that receive LECC funds. A closer look at the

Figure 1
Impact levels of the Leading-Edge Cluster Competition



Source: Accompanying evaluation of the LECC.

research expenditure of business firms shows that, while LECC funds may constitute only a relatively small share of the entire R&D budgets of LECC-funded organisations, they can still have significant stimulating effects in the areas of activity of the Leading-Edge Clusters: In 2012, firms that received LECC funding spent a total of roughly EUR 2.5 billion on R&D, on average per cluster. About EUR 170 million per year and cluster were spent on the focus areas in which the Leading-Edge Clusters were active. This figure relates to the entire enterprise, not just the parts that are located in the relevant cluster region. The average amount of LECC funding was EUR 8 million. On average, the amount of public LECC funding has thus been equal to about 5% of the private R&D expenditures in the relevant Leading-Edge Cluster technologies.

The accompanying evaluation particularly had to answer the question to what extent the LECC has been able to fulfil the high expectations and achieve its ambitious goals. In the field of innovation research, it is generally acknowledged that there is neither a linear relationship between R&D and innovation output, nor between public R&D funding and the induced innovation results. Instead, innovation derives from a complex, open-ended exchange process between various research units (organisational units in enterprises and public research organisations and the individuals or groups of researchers active in these organisations) that involves multiple feedback mechanisms.

1. Goals and scope of research

Against this background, the role of public funding should be to provide stimuli, create opportunities and help to overcome obstacles e.g. by compensating for the shortcomings of markets. As a result, the LECC, despite its very limited financial scope compared with the firms' R&D expenditures in the relevant technology fields, provides an opportunity to make an important contribution to improving the competitiveness of the cluster regions and generate initial momentum. The central question treated in this report is to what degree the programmes has succeeded in achieving this goal.

Our analysis focuses on eight central topics, each of which has been scrutinised by asking specific questions to guide the study (table 1). The topics and research questions addressed by the accompanying evaluation may be grouped into three broader sets:

- Questions regarding the selection process, the activities of cluster organisations, and the position of Leading-Edge Clusters in the sectoral and regional innovation environment.

- Questions about activities initiated by the LECC and their effects (e.g. project output, effect at the enterprise level, regional and overall economic impact).

- Questions related to what can be learned from the LECC on the general mechanisms of cluster policies beyond the mere assessment of the competition, as well as recommendations for the funding of clusters in general and the LECC in particular.

The analyses are mainly based on interviews and standardised surveys conducted in the 15 Leading-Edge Clusters, as well as in the cluster initiatives that participated in the competition but were not selected for funding. A broad spectrum of qualitative and quantitative data was gathered. Figure 2 shows the timeline of the interviews and written surveys for the entire observation period.

Due to the time structure of the LECC, the analyses had to focus on the clusters of the first and second round of the competition. For the clusters of the third round, there was neither sufficient time to conduct interviews with LECC-funded institutions nor to capture initial results of the funding. These clusters and their internal developments were studied with a focus on the establishment of the respective cluster organisations.

Table 1

Topics and central questions of the accompanying evaluation

Topic	Central questions
Selection process, activities of cluster organisations and categorisation of the Leading-Edge Clusters	
Selection process and implementation of selection criteria	Which selection criteria have been applied? What is the structure of the selection process? To what extent has the selection process met the goals of public funding for Leading-Edge Clusters? Does the design of the LECC programme differ from similar nationwide programmes in other countries?
Cluster organisation and Clustergovernance	What are the organisational structures of the 15 Leading-Edge Clusters? What are their previous history and origins? What are the tasks of the cluster organisations and on which factors does their effectiveness depend? How did the CM and the organisational structure of the supported clusters develop, and how should the resultant structures be rated? What is the financing structure of the CMs, and what are the consequences with regard to sustainability?
Qualification needs in respect to qualified persons and executive managers	What are the industry and technology-specific qualification needs in the Leading-Edge Clusters? To what extent do cluster strategies address these needs, and what is the expected contribution to achieving the cluster objectives? What measures were taken to cover the identified qualification needs? What is the role of the CM in this context? To what extent did the implementation of the measures fulfil expectations of cluster partners?
Leading-Edge Clusters in their innovation environment	What are the boundaries of sectoral innovation systems with regard to subject matter and geographic area? What are essential characteristics and defining factors of sectoral innovation systems that can be attributed to the Leading-Edge Clusters? What is the role of Leading-Edge Clusters in their sectoral innovation systems?
Impact and impulses of the Leading-Edge Cluster Competition	
Networking and knowledge exchange	What are the effects of the LECC on the intensity and structure of networking between LECC-funded institutions? Does the LECC lead to a centralisation of the knowledge flow structures, or does it crowd out existing partnerships?
Regional impulses	What is the economic and technological relevance of Leading-Edge Clusters in the regions, and to what extent has it been influenced by the LECC? What is the impact of the LECC on the economic and technological interconnections between stakeholders/members of Leading-Edge Clusters and other firms or research institutes in the cluster region?

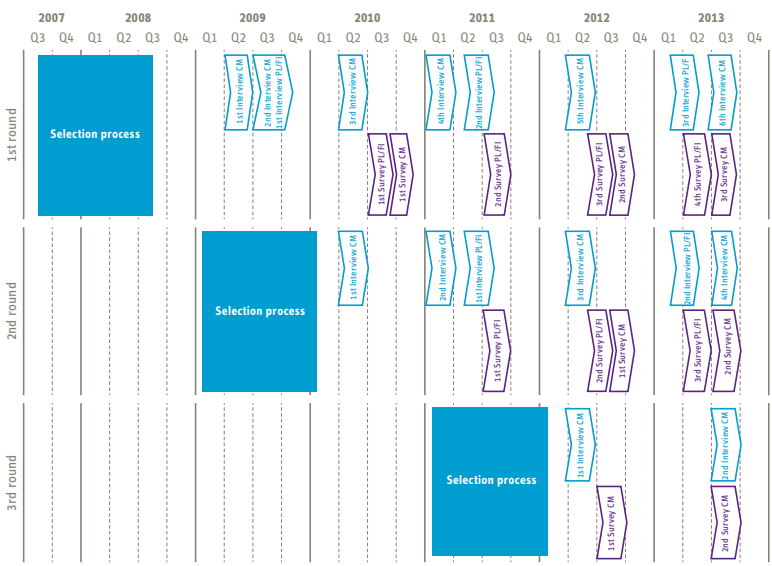
Overview of programme effects and impact analysis	What results does the LECC yield at the various levels – project, actors, cluster organisations, regions, overall economy? How do the results compare to those of other national or international programmes? What are the effects triggered by the LECC with regard to firm R&D spending?
Experiences and recommendations	
Experiences and recommendations	What factors determine the success of cluster initiatives? What are the recommendations for the support of Leading-Edge Clusters until 2017? What insights can be gained for similar programmes to support clusters and network development in the future?

Source: Accompanying evaluation of the LECC. – CM = Cluster management.

The key findings from the three sets of questions and the eight central topics that guided the accompanying evaluation of the LECC are summarised below.

Figure 2

Schedule of the expert interviews and written surveys conducted as part of the accompanying evaluation



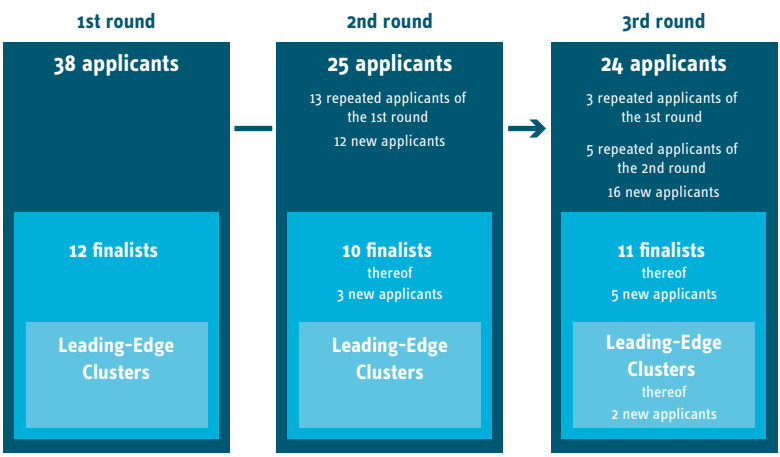
Source: Accompanying evaluation of the LECC. – Abbreviations: CM = cluster management; Fi = LECC-funded institutions; PL = project leadership.

2. Selection procedure of the Leading-Edge Cluster Competition

The LECC applied a two-step selection procedure supported by a jury. The design of the selection process reflects the goals of the competition and takes into account the requirements for strategic coordination in a multi-stakeholder programme. The selection process was transparent and well communicated. As the feedback by the candidates consistently shows, there was sufficient time to coordinate and prepare the proposals. The selection criteria of the jury are plausible and were implemented adequately using a holistic approach that required the consideration of different dimensions of the programme requirements. The jury was independent and had opportunity to consult expert advice in decision-making. Figure 3 illustrates the distribution of LECC applicants over the course of the three rounds of the LECC competition.

Figure 3

Structure of the participants in the three selection rounds of the Leading-Edge Cluster Competition



Source: Accompanying evaluation of the LECC. – Abbreviations: In the 2nd round of the competition, two initiatives from the 1st round entered a joint application. One repeated applicant from the 2nd round also took part in the 3rd round.

2. Selection procedure of the Leading-Edge Cluster Competition

As can be seen, the LECC was successful in motivating new cluster initiatives for the second and third round of the competition. Moreover, several initially unsuccessful cluster initiatives were able to advance their organisational and strategic development in a manner that they succeeded in a later round. In the second round of the competition, only contestants that had already participated in the first round – some of them in different constellations – were selected. In the third round, a number of new candidates succeeded.

The evaluation of the LECC selection process also involved a comparison with other, internationally visible technology development programmes of high nationwide importance: the Pôles de Compétitivité in France, the Competence Centers for Excellent Technologies in Austria (COMET), the Centre of Excellence programme (SHOK) in Finland, as well as (on the German state level) the "Cluster Offensive Bayern" (a Bavarian cluster programme).

Like the Pôles de Compétitivité and COMET, the LECC used an application-based approach to select funded initiatives. The regional (political) level also played a certain role during the pre-selection period in these programmes. This regional focus was less pronounced in the Pôles de Compétitivité. The SHOK programme and the Bavarian Cluster Offensive used a top-down approach that was initiated by a comprehensive analysis during the preparatory stage. The evaluation results show that the application procedure is a key factor for the cluster initiatives to focus and constitute their activities. In addition, the results show that the design of the LECC was suitable for achieving the programme's objectives. Like the LECC, the other selected programmes are implemented since several years.

In respect to targets, all these cluster programmes – except for the Bavarian "Cluster Offensive" – are focused primarily on research and innovation. A difference between the programmes is that the Pôles de Compétitivité and the LECC do not involve any funding of the underlying CM structures. However, there was no indication that the decision not to allocate funding to CM structures resulted in any disadvantages for either programme. After all, the cluster initiatives in both programmes showed a positive development. Another difference is the funding of infrastructures, which is possible within the Pôles de Compétitivité and SHOK and not in other programmes. All programmes, including the LECC, explicitly support applications for complementary funding on the national or EU level. The funding periods are of similar length and appear to be suitable for achieving the goals of supporting cluster development.

3. Cluster organisation and governance

Cluster initiatives are joint organisations of firms, public research (universities and research institutes) and other organisations with the goal of supporting their cluster partners through coordinated activities within an innovation cluster. The terms "cluster partner" and “cluster actor” are used to refer to all firms, public research organisations and other organisations that made a clear and demonstrable commitment and constitute the cluster initiatives. They are usually listed as members of the legal entity of the cluster initiative (if existing) that represents a particular Leading-Edge Cluster.

Leading-Edge Clusters show some peculiarities compared to other cluster initiatives: They have a common cluster strategy which is supported by the cluster partners with often above-average commitment, and have comparatively high visibility. In the LECC, the focus is on technology development through targeted funding of R&D projects. Leading-Edge Clusters have usually formed through a bottom-up approach, thereby ensuring a high level of participation by regional stakeholders during the launch of the cluster initiatives and in their strategy development.

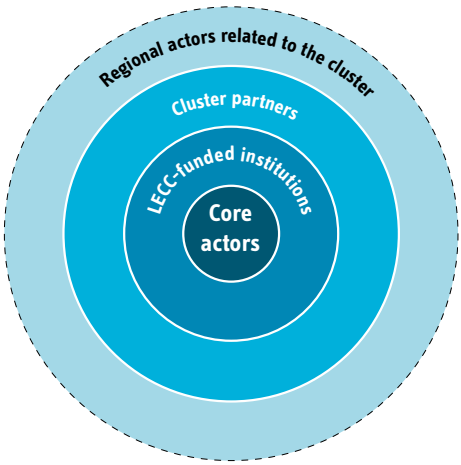
Stakeholders in the cluster regions are all organisations (firms, public research organisations or other organisations) that are either directly (e.g. as cluster members) or indirectly (through their activity in the technology field of the cluster) related to cluster activities. They may be categorised according to their involvement in cluster activities by means of a series of concentric circles (figure 4).

An inner circle of *core actors* is involved in the cluster boards and has the ability to significantly influence the cluster strategy. These actors are usually also involved in cluster projects as LECC-*funded organisations*. Other businesses and public research organisations that receive funding have a minor impact on the overall cluster strategy. Besides the LECC-funded organisations (including core actors), the group of *cluster partners* also includes more or less active members of the cluster initiatives that support the cluster activities in some way without participating in LECC-funded projects. This group of cluster partners plays only a minor role with regard to implementing the cluster strategy. The cluster partners constitute the actual actors in a Leading-Edge Cluster. There are *other organisations (firms, research institutes and other organisations) relevant to the cluster,* which may be active in the region and the Leading-Edge Cluster's technology field while neither participating in the cluster activities nor being members of the cluster initiative.

3. Cluster organisation and governance

Figure 4

Taxonomy of the involvement of stakeholders in the activities of the cluster initiatives



Source: Accompanying evaluation of the LECC.

There may be significant differences between individual Leading-Edge Clusters with regard to the size of the cluster initiative and the way stakeholders are involved in the organisation. These differences result from the specifics of the cluster organisations' origins and their sectoral systems of innovation (table 2).

Thus, the number of cluster partners may vary significantly between clusters: The number of partners ranges from 31 in the Forum Organic Electronics (FOE) up to 349 in the cluster MicroTEC Südwest. The findings of the evaluation show that a greater number of members makes the coordination of cluster organisations more demanding. On the positive side, a greater number of partners allow for a broader transfer of knowledge. Only a relatively small number of cluster partners participate actively in the cluster committees, thereby exerting significant influence on the design of the cluster activities. This is beneficial insofar as an effective development of strategic objectives would not be possible otherwise. Key persons in the cluster committees who play major roles in formulating the strategy and common objectives usually come from large innovative companies, from public research organisations that are active in the relevant field of technology, or from highly innovative small or medium-sized enterprises (SMEs).

Table 2

Number of cluster partners and LECC-funded organisations in the Leading-Edge Clusters

Stakeholder structure	All firms	Major enterprises	SMEs	Research facilities/ universities	Other organisations	Total
BioEconomy Cluster	41 (24)	13 (7)	28 (17)	25 (10)	13 (0)	79 (34)
BioRN	56 (24)	14 (7)	42 (17)	8 (3)	23 (2)	87 (29)
Biotech Cluster m[4]	245 (38)	36 (4)	209 (34)	29 (18)	16 (1)	290 (57)
CI3	101 (20)	30 (4)	71 (16)	51 (19)	22 (3)	174 (42)
Cool Silicon	78 (33)	17 (12)	61 (21)	33 (16)	0 (0)	111 (49)
EffizienzCluster LogistikRuhr	154 (107)	90 (56)	64 (51)	22 (18)	11 (2)	187 (127)
Elektromobilität Süd-West	68 (39)	33 (21)	35 (18)	17 (11)	6 (0)	91 (50)
FOE	18 (15)	14 (14)	4 (1)	13 (10)	0 (0)	31 (25)
Hamburg Aviation	81 (32)	20 (9)	61 (23)	31 (21)	16 (1)	128 (54)
it´s OWL	134 (33)	53 (22)	81 (11)	31 (22)	31 (1)	196 (56)
MAI Carbon	43 (28)	23 (16)	20 (12)	10 (9)	6 (3)	59 (40)
Medical Valley	191 (41)	17 (8)	174 (33)	43 (13)	67 (3)	301 (57)
MicroTEC Südwest	251 (82)	39 (24)	212 (58)	54 (19)	44 (9)	349 (110)
Software-Cluster	188 (27)	9 (8)	179 (19)	18 (15)	6 (6)	212 (48)
Solarvalley	36 (30)	17 (16)	19 (14)	14 (11)	4 (2)	54 (43)
All clusters	1,685 (573)	425 (228)	1,260 (345)	399 (215)	265 (33)	2,349 (821)

Source: Accompanying evaluation of the LECC; annual reports of the clusters (date: December 2012) as well as thethe BMBF's "PROFI database", which covers data on the federal government's funded projects (date: July 2013). – Comments: The number of LECC-funded organisations is given in parentheses.

The formal structures of the cluster initiatives were adapted to the requirements of the LECC according to the specific situation in each Leading-Edge Cluster. The resulting organisational structures fulfilled their objectives in all 15 Leading-Edge Clusters (table 3). Ten Leading-Edge Clusters (four from the first round and three

from each the second and third round of the competition) have adopted the legal form of a registered association ("eingetragener Verein", e.V.) in which the cluster partners are able to participate as equals. By means of the general meetings which are legally required for this type of organisation, these clusters simultaneously created a forum that allows members to exchange information and enhance their networking. 10 of the 15 clusters selected the legal form of limited company under German law (GmbH, Gesellschaft mit beschränkter Haftung), so that their CMs constitute independent entities that remain integrated in the cluster organisation and were assigned tasks in the management of the cluster organisations. Developments in the 15 Leading-Edge Clusters over the past years show that it depends to a large extent on the quality of interpersonal collaboration between (usually) only a small group of key actors, whether and how the organisational structures perform. During the formation of organisational structures, it became apparent that models developed in management studies and organisation science may provide significant assistance in establishing functional structures.

With the exception of FOE, all cluster organisations had some kind of predecessor, i.e. a previously existing network/cluster organisation (*Länder* clusters or enterprise networks) or a business association in the relevant industry or technology field. In 11 cases, these initiatives were active in the same technology field. Thus, the cluster organisations adapted themselves to a pre-existing environment and developed this environment further according to the conditions of the LECC.

For the effectiveness of cluster organisations – and thereby for the degree of target fulfilment – the activation of cluster partners in the Leading-Edge Clusters is extremely important. Part of the activation comprises a joint effort to formulate, pursue and further develop a common cluster strategy. This requires maintaining commitment at a very high level. With regard to strategy development and implementation, a cluster organisation is not comparable with a single company or public research organisation. Clusters partners follow their own independent systems of objectives which ideally overlap with clusters' objective systems to a great extent. Therefore, the task of key actors – especially the CM – is to establish the necessary consensus between the cluster partners and maintain such an alignment of objectives over the process of strategy implementation. This is the only way to retain the commitment of all relevant actors at a high level.

This happens to the extent to which it becomes clear to the cluster partners that their commitment in a Leading-Edge Cluster yields benefits for their organisation. It should be noted that all clusters of the first and second round of the competition created lively and effective cluster organisations which have successfully activated

Table 3

Organisational structures of the Leading-Edge Clusters

Leading-Edge Cluster	Cluster organisation	CM	Number of employees (no. of part-time employees	Management structures New, continued or reorganised	Start of cluster management activities	Precursor initiative: same/ different technology field
BioEconomy Cluster	-	BCM BioEconomy Cluster Management GmbH	3 (0)	new	Jul 12	different
BioRN	BioRN Network e.V.	BioRN Cluster Management GmbH	13 (4)	new	May 08	same
CI3*	CI3 e.V.	Ci3 Management UG (limited liability))	5 (3)	new	Jul 10	same
Cool Silicon	Cool Silicon e.V.	Silicon Saxony Management GmbH	3 (1)	new	Sep 08	same
EffizienzCluster LogistikRuhr*	Logistik Ruhr e.V.	Effizienz-Cluster Management GmbH	11 (5)	new	Oct 09	same and different
Elektromobilität Süd-West*	-	e-mobil BW GmbH	9 (0)	reorganised	Apr 10	different
FOE	-	Innovation-Lab GmbH	6 (3)	new	Oct 07	--
Hamburg Aviation	Luftfahrtcluster Metropolregion Hamburg e.V.	internally	10 (2)	reorganised	2001	same
it´s OWL	it´s OWL e.V.	it´s OWL Clustermanagement GmbH	11 (8)	new	Jan 12	same
MAI Carbon*	Carbon Composites e.V.	MAI Carbon Clustermanagement GmbH	8 (4)	new	Mar 12	same
Medical Valley*	Medical Valley EMN e.V.	internally	10 (4)	continued	Jan 07	same
MicroTEC Südwest*	MST BW e.V.	internally	11(3)	reorganised	Jul 06	same
Biotech Cluster m*4*	-	BioM Biotech Cluster Development GmbH	3 (0)	reorganised	Jun 97	same
Software-Cluster*	-	Software Cluster coordination body at the TU Darmstadt	5 (1)	continued	Oct 07	different
Solarvalley	Solarvalley Mitteldeutschland e.V.	Solar Valley GmbH	7 (0)	new	Sep 09	same

*Source: Accompanying evaluation of the LECC; strategy papers of the individual clusters as well as annual and progress reports, written surveys of CMs (Date: mid-2013). – Comments: *Candidacy in one of the previous rounds of the competition.*

and supported the cluster partners and overcame occasional challenges. By the end of the evaluation, the clusters of the third round of the competition appeared to be on track. However, a final assessment is not yet possible due to the short time since the start of the funding.

The 15 Leading-Edge Clusters are very heterogeneous, not just with regard to their objectives, but also in size and tasks of their CMs. When establishing their CMs, five clusters were able to build on experiences from an earlier participation in the LECC. They continued using existing CM structures or structures that were established as part of the application. In four clusters, pre-existing CMs were reorganised in order to meet the new challenges of the LECC. Hamburg Aviation uses organisational structures that were established as part of the Aviation Initiative by the Hansestadt Hamburg. The CM tasks were primarily performed by the economic authority of the Hamburg Senate. Right from the outset, the plan was to disengage the CM and the remainder of the cluster organisation from public administration. This was achieved in 2012. Nine Leading-Edge Clusters decided to found a new CM, either because there were no pre-existing structures or because a new beginning was considered more promising. With regard to establishing a CM, the Software Cluster was facing a special challenge because four separate local clusters in different federal states needed to be merged.

Overall, it can be said that while most clusters took quite some time to establish their organisational structures, they did not face any major problems. Contrary to some expectations, the presence of pre-existing structures at the start of the LECC funding did not always turn out to be helpful. The reason for this was that existing cluster organisations needed to adapt their established routines to the requirements of the LECC, for example with regard to collaboration with the project management organisations, which required significant organisational effort.

The CMs of the Leading-Edge Clusters vary in their human and financial resources as well as in their responsibilities. These differences are partially due to the specific structures of the cluster organisations and the requirements of their innovation environments. In other cases, they can be traced back to differences in the mission statements of the CMs. In the period from 2009 to 2013, annual CM budgets were between EUR 300,000 and EUR 1.75 million. The median budget was about EUR 715,000. Within the majority of the Leading-Edge Clusters, the cluster organisations were financed by a mix of public and private funds. However, public funds predominated. In 2013, the share of public funds was between 33% and 100% for the clusters of all three competition rounds. For two thirds of the clusters, the share of public funding was above 50%. With increasing professionalism

of the clusters, a decrease in the share of public funding should be expected. Public funding should be substituted with e.g. fees paid by members who in return expect added value from participating in the cluster, or by the creation or expansion of commercial services. So far, this could be observed only to a very limited extent. In order to compensate for the termination of public funding at the end of the LECC, almost all clusters of the first and second round of the competition plan to acquire public or private funds. Alternatively, they consider a reduction or realignment of their services.

All 15 CMs cover a broad spectrum of services. They organise events, broker internal and external contacts and offer common infrastructures (such as IT platforms). The range of services offered by the CMs derives from the development of the cluster strategies and was adjusted to meet the specific requirements of each Leading-Edge Cluster. The evaluation of CM services by the LECC-funded organisations indicated some potential for improvement, especially by establishing a joint IT platform and initiating further training and education activities. The assessment of CM services declined over time. However, it was not possible to identify any systematic causes for this development. It can be assumed that the initial euphoria of cluster partners, which was observable at times, wore off. All in all, the LECC contributed to increasing the professionalism of the CMs in the clusters of the first and second competition rounds. This in turn played an important role for the development and maintenance of the formed network structures.

While the continued activity of cluster organisations beyond the LECC funding period is an indication for the success of the cluster initiatives, it is not a necessary condition for a successful realisation of cluster strategies. For the clusters of the first and second competition rounds, it is to be expected that the respective cluster strategies will be continued, possibly in a modified manner, even after the financial support from the LECC expires. At the end of the observation period (September 2013), organisational changes in the structure of cluster initiatives or CMs were planned only in the clusters Cool Silicon and EffizienzCluster LogistikRuhr. At the same time, it was not clear in many cases how the management structures in the Leading-Edge Clusters will be financed sustainably in future.

In addition to continued financing of the structures established over the course of the LECC, it is especially important that cluster partners continue to identify themselves with the Leading-Edge Cluster and participate beyond the funding period. Publicly funded research organisations face the problem that, for legal reasons,

they cannot pay their membership fees for cluster organisations from their basic funds and therefore have to rely on alternative models of membership or third-party financing.

A survey of LECC-funded enterprises and public research organisations of the first competition round in 2013 found that, at the time of the survey, only 27% had decided to continue their participation in the Leading-Edge Cluster. At the end of the survey period, a majority were still uncertain about their further commitment in the Leading-Edge Cluster. For businesses and public research organisations alike, a very important question was whether their own strategy was compatible with the future objectives of the cluster. The clusters of the first competition round apparently still had some backlog with regard to the implementation and/or communication of further strategic planning of the cluster organisations.

4. Fulfilling needs in respect to qualified persons and executive managers

A necessary prerequisite for innovation and the success of innovation policies is that the employees who are directly or indirectly involved in innovation activities are suitably qualified. Qualification, i.e. the entirety of all individual competences, is therefore an important determinant of innovation that feeds back to the qualification needs. Qualification needs may not be important solely for innovation, and the needs themselves may be changed by external factors as well. However, the handling of changing qualification needs – which may express themselves either in a demand for persons with certain training (formal qualification) or in a demand for certain competences – plays an important role for the achievement of the goals of the LECC.

With this in mind, the question is investigated to what extent the LECC is able to contribute to a targeted support of young talent, to practical qualification, as well as to the acquisition of experts and leadership personnel, including foreigners. The investigation is intended to provide a comprehensive assessment of the relevant activities in Leading-Edge Clusters. Key elements of this assessment include, on one hand, a description of the needs and challenges faced by the cluster stakeholders, and on the other hand a characterisation of the mechanics underlying these activities and the effective contribution of the LECC to the training and recruitment of qualified personnel.

All clusters exhibit qualification needs in respect to qualified persons, which may be attributed to the fact that the relevant stakeholders are active in knowledge-intensive industries. A majority of cluster stakeholders are facing difficulties in cov-

ering their qualification needs. The problems are primarily related to personnel with entry-level academic degree (bachelor, master, diploma). Participation in the LECC has even increased these needs. A consequence of the LECC noted by the cluster stakeholders is a change in the importance of specific competences. This refers to an increased relevance of technical expertise on part of the public research organisations, as well as methodical competences. Qualification needs should therefore not be focused too narrowly on persons with a specific training.

Over the next few years, the LECC-funded firms see problems primarily with entry-level job training and with the recruitment of skilled workers, master craftspeople and technicians. The shortage of college graduates which is currently the main problem with regard to recruiting expert personnel will be playing a minor role in the future. Against that background, it was only logical that the LECC intended to provide targeted support for young talent and that this support included entry-level job qualification. Because of the current shortage of college and university graduates, the strategy documents of the clusters placed a greater importance on academic training than on entry-level job training. However, the findings of the evaluation indicate that the latter should receive more attention in the years to come. Some of the clusters have already identified potential trainees as a target group and launched activities to reach out for these people. The data also suggests a need to address training and further education earlier and sharpen the focus on the professional orientation of young people.

In practice, the most common way to cover qualification needs is a mix of recruiting qualified personnel and expanding the qualifications of existing personnel. These two components are sometimes interrelated, e.g. when qualification offers are integrated into the recruitment strategy. When considering the stakeholders' activity in knowledge-intensive industries or technology fields, this mixed approach is a reasonable strategy that is basically pursued in all clusters with a different weight of the two components.

Covering industry or technology-specific qualification needs is a topic in all cluster strategies. However, there are large differences both in scope and in the level of detail. At one end of the spectrum, there are two cases where detailed strategies were developed by the clusters to ensure the availability of technical and leadership personnel in the short, middle and long term. At the other end, there are two cases in which the cluster managements primarily referred to the wide variety of already existing activities by of the local educational institutions. The other clusters were somewhere between these two extremes. The expected contribution of cluster activities to achieving the objectives in this area varies accordingly.

4. Fulfilling needs in respect to qualified persons and executive managers

Qualification, i.e. the training and further education of personnel, is high on the agenda in all clusters. However, its actual importance varies. As mentioned above, cluster activities in the field of training and further education currently have a focus on college and university education, which adequately reflects the present demand of the stakeholders. The main focus is on implementing the key projects in the cluster strategies, e.g. *the Hamburg Centre of Aviation Training* (HCAT) at Hamburg Aviation, the *BioRN Academy*, the *eAcademy* in the Biotech Cluster m[4], or the *Supply Chain School* of the EffizienzCluster LogistikRuhr. These highly visible projects are complemented by other activities specific to the clusters. Here, the clusters are facing very different challenges. Roughly one in twenty LECC projects is devoted to training and further education.

The CMs are acting as a broker or as a central point of contact for the qualification activities. In each cluster, there is one person in charge of qualification activities. This person is employed directly by the CM or by a cooperation partner. In the Software Cluster, there is even an independent committee in charge of qualification. The fact that the CMs are playing more of a support role, rather than providing direction, explains that the training and further education activities at cluster level have been somewhat sporadic and situational. Such activities can therefore be considered an adequate complement to the more prospective or holistic qualification strategies pursued by a majority of cluster stakeholders. Deficits can be found with regard to the integration and information of cluster stakeholders.

An important aspect in respect to the previous recruitment and qualification successes is that LECC-funded R&D projects frequently included a targeted training and education component, for example by planning and integrating academic theses (dissertations, post-doctoral theses) into the projects from the beginning. It is a rare exception that a qualification thesis is planned but not realised. All in all, the activities induced by the LECC are showing initial positive effects on the acquisition of qualified personnel by the cluster stakeholders. These effects have been more pronounced for public research organisations than for enterprises. Furthermore, public research organisations are significantly more optimistic than enterprises about the expected impact on the recruitment of qualified employees in the coming two or three years. In summary, the LECC has made the intended contribution to targeted training measures, to practical qualification, as well as to the acquisition of expert and leadership personnel, primarily by acting as a catalyst. So far, this contribution has mainly been focused on academic education and has therefore had a greater impact on public research organisations than on enterprises.

5. Leading-Edge Clusters in the national and international innovation environment

It is too early to quantify the extent to which the LECC has contributed to strengthening the clusters. However, it is possible to estimate whether the conditions are suitable for the competition to exert a noticeably positive influence in future. To answer this question, the role of Leading-Edge Clusters in their innovation environment was investigated in order to assess their regional and sectoral positioning.

Figure 5 shows the geographic distribution of the 15 Leading-Edge Clusters and roughly 640 cluster initiatives that were identified in Germany at the national or *Länder* level by the end of 2013. The sheer number of cluster initiatives, which in almost all cases receive funding, primarily by the states, shows the importance that promoting clusters has gained for innovation policy in Germany. While all the German Länder support clusters, the number of funded clusters and the intensity of support vary considerably. The Leading-Edge Clusters are integrated into existing network and cluster structures that are also supported by the Länder.

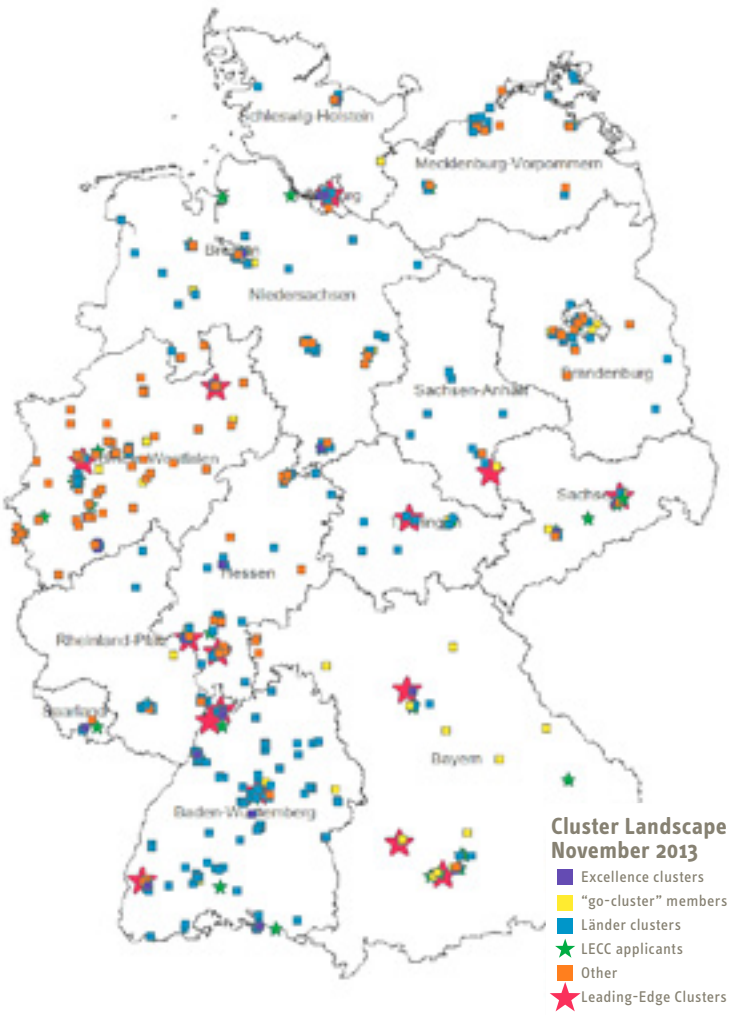
The financial support for *Länder* clusters is usually for a limited term only, sometimes using financial support from the European Fund for Regional Development (EFRE). The regional distribution of cluster initiatives results, among other factors, from the regional industrial structure: The more a region is industrialised, the greater the number of clusters initiatives and networks (e.g. in Northrhine-Westphalia and Baden-Wuerttemberg). There is a north-south divide in the distribution of the 15 Leading-Edge Clusters: Nine are located in southern Germany. In addition to the industrial structure, the observed regional differences also reflect the research intensity of the local economy. Finally, the observed differences also depend on the degree to which firms, science and government succeed at joining forces to pursue a common strategy.

The LECC had no restrictions in respect to sectors or technology fields, which is why the Leading-Edge Clusters are rooted in different sectoral innovation environments that exhibit diverse patterns of research and innovation. Figure 6 compares the sectoral distribution of the Leading-Edge Clusters with the distribution of all the participants in the LECC, as well as the entirety of comparable innovation clusters in Germany that were identifiable at the national and Länder levels. The number of innovation cluster initiatives (370) is significantly lower than the total

5. Leading-Edge Clusters in the national and international innovation environment

Figure 5

Clusters and networks at the federal and Länder level in Germany



Source: Accompanying evaluation of the LECC; based on an own inquiry (date: November 2013). – Comments: Locations are given for the contact address of the cluster organisations. If a cluster is represented in several categories (e.g. a Leading-Edge Cluster and member of go-cluster), then it will be shown only once in the figure but counted several times in the key. The map was created using RegioGraph 13.

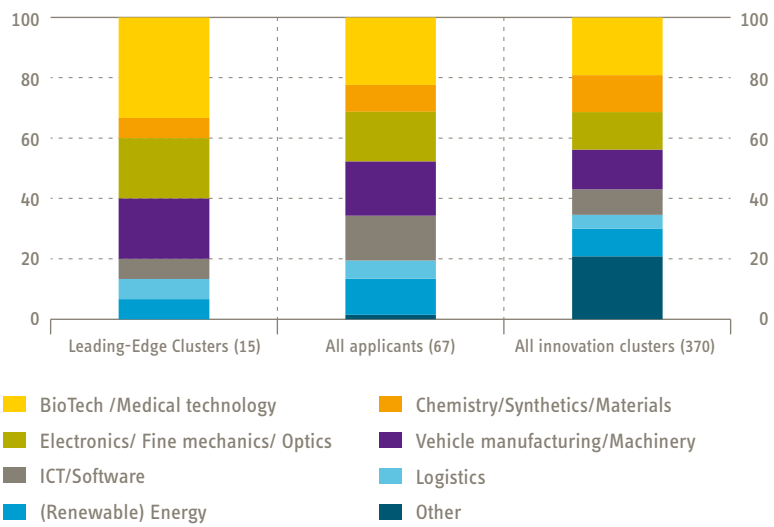
number of cluster initiatives. The latter also includes cluster initiatives that cannot be categorised as innovation clusters due to the industries in which they are active or other characteristics.

The LECC had an above average number of applications from cluster initiatives in the fields of biotechnology and medical technology. A possible cause may be that several funding programmes for networks and clusters in this industry have been conducted in the past (e.g. BioRegio), which led to the development of structures that were beneficial in the LECC candidacy. This is true not only for the group of candidates, but even more for successful initiatives: The share of biotechnology and medical technology clusters is even higher in the 15 Leading-Edge Clusters.

An international comparison showed how Leading-Edge Clusters are rooted in their sectoral innovation systems and displayed their innovative potential. The assessment of this aspect is based on literature research, the examination of patent microdata from research and innovation surveys, and the results of interviews with industry experts, consultants and cluster stakeholders. Even though the

Figure 6

Industry distribution of the cluster initiatives in comparison



Source: Accompanying evaluation of the LECC, based on an own inquiry (date: November 2013).

industries or sectors as well as the clusters operating in these different environments are usually characterised by a high degree of heterogeneity, they exhibit some predominant and common patterns of research and innovation behaviour.

All Leading-Edge Clusters show strengths and potentials that characterise them as "leading-edge regions" when compared to other international clusters and enable them to maintain or expand their position in the international competition. The reasons for this good position are the existing technological strengths and scientific excellence, as well as the presence and regional involvement of globally operating, leading companies (such as in the clusters BioRN, CI3, EffizienzCluster LogistikRuhr, Elektromobilität Süd-West, FOE, Hamburg Aviation, Medical Valley and Software Cluster). In some cases (it's OWL and MicroTEC Südwest), the *hidden champions* (major firms that attain a leading role in their respective markets) provide the momentum for innovative potential and future competitiveness.

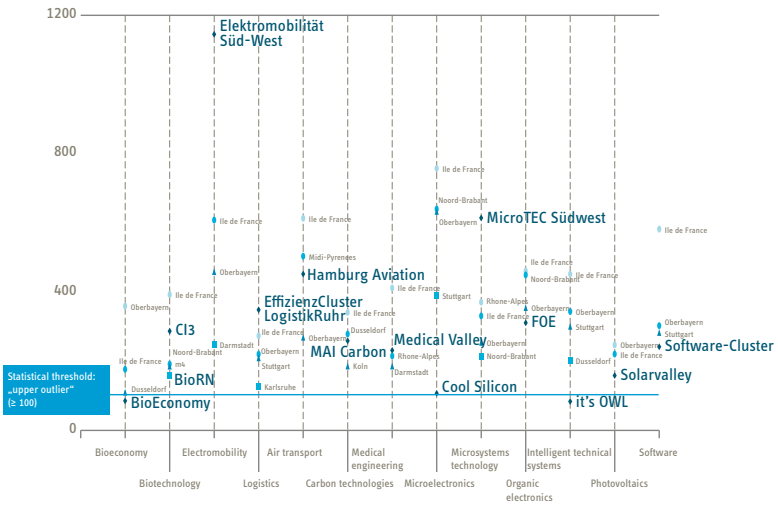
In some fields, in particular biotechnology, innovations are driven primarily by basic research and therefore determined by the quality of key university institutions. In others, such as microelectronics, micro-system technology, medical technology, and intelligent technical systems, internationally renowned research facilities outside of universities significantly determine the positioning of the relevant clusters. Another factor that influences the position of the clusters in the international innovation environment is a core role as a production location (e.g. Cool Silicon, it's OWL and Solarvalley).

Figure 7 shows the technological positioning of various clusters in the European environment. It shows the extent to which the regions of the Leading-Edge Clusters have a position of international leadership in their field of technology with regard to their share of the patent applications at the European Patent Office (EPO). The patent analysis was performed in several steps: By using a combined query for selected classes of patents and technical terms, the number of patent applications for the relevant sector at the EPO was determined and then assigned to regions based on the location of the inventor.

The statistical definition of an upper outlier was used to define "leading-edge regions". These are regions whose share of inventors is further away from the median than three times the interquartile range. On this basis, European "leading-edge regions" are identified, a group to which the regions of the Leading-Edge Clusters belong.

Figure 7

EPO-patented inventions in the Leading-Edge Cluster regions in comparison with other European clusters in the relevant technology fields



Source: Accompanying evaluation of the LECC; own calculations based on data from PATSTAT and OECD-REGPAT. – Comments: Leading-Edge Cluster regions are shown as statistical outliers with regard to EPO patented inventions (to indicate technological leadership) in the relevant field of technology.

The analysis shows 12 of the 15 Leading-Edge Clusters as having a position of technological leadership in the European environment. Only the BioEconomy Cluster and it's OWL are slightly below the – albeit very strict – threshold for an upper outlier. Cool Silicon is only slightly above. All other clusters are more or less clearly above this ambitious threshold. Especially Solarvalley has become much more important with regard to patented inventions in recent years and is now clearly above the threshold.

6. Networking and knowledge exchange in the Leading-Edge Clusters

With the incentives for networking between regional actors, the LECC supports both the generation and the transfer of knowledge. Within the scope of cluster activities, networking and knowledge exchange may occur as part of the initiated projects, but also through personal contact outside of the project context or during informal meetings. Cooperation in R&D projects is of central importance in the LECC because it enhances networking relationships, initiates learning processes in the participating organisations, and enables the utilisation of synergies between actors. Learning processes take place through collaboration in projects where different individuals from companies and public research organisations participate. These individuals proceed to spread knowledge within their organisations.

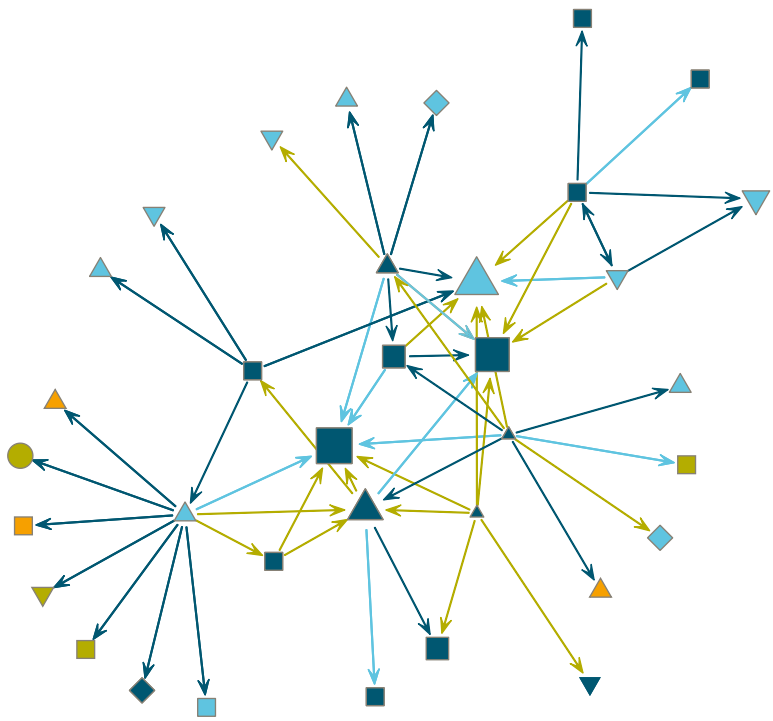
Such cooperation may either be bilateral or multilateral within larger project consortiums. A cooperation network as studied with the tools of network analysis represents all interconnections constituted by such cooperation. The analysis of networks therefore goes beyond individual collaborative relationships to consider the structure resulting from all bilateral or multilateral cooperative ties. For companies and public research organisations in Leading-Edge Clusters, cooperation within a research consortium is usually only a part of their total collaborative activities.

In order to be able to analyse the impact of the LECC's support on networking and the structure of networks, the cooperation activities related to the LECC were investigated in the context of these other partnerships. As a data source, the written surveys of the LECC-funded organisations in the clusters of the first round of competition in 2011 and 2013 as well as those of the second round of competition in 2012 were used. Additional information was collected from personal interviews with selected partners in the Leading-Edge Clusters.

Figure 8 exemplifies how this information is utilized to reconstruct network graphs for the collaborative network of the cluster Forum Organic Electronics. In addition to visualisation, which in this case illustrates the central importance of large corporations in the cluster region, the relational data allows for statistical calculations to describe network structures in the clusters. For example, there are significant differences with regard to size, regional involvement and other structural properties in the R&D cooperation networks of the ten Leading-Edge Clusters in the first two competition rounds.

Figure 8

Cooperation network of the cluster Forum Organic Electronics



Source: Accompanying evaluation of the LECC; written survey of the LECC-funded organisations in 2013. – Comments: The size of the nodes is proportional to the frequency with which an actor is named as the most important cooperation partner. Arrows pointing in the direction of the named cooperation partner; dark blue = not initiated or intensified by the LECC, light blue = intensified by the LECC (existed before 2007), light green = initiated by the LECC (did not exist before 2007).

6. Networking and knowledge exchange in the Leading-Edge Clusters

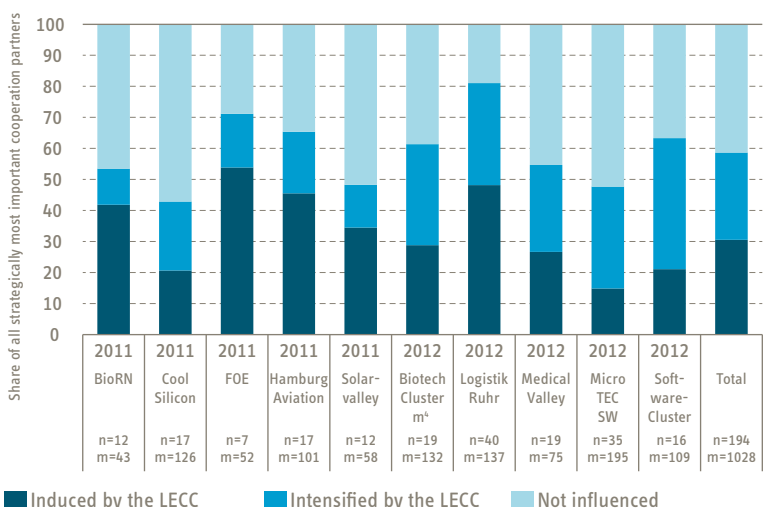
The stimulus from the LECC had an impact on the *intensity and geographic range* of networking and changed the *centralisation structure* of networks. Since the start of the LECC, the intensity of network cooperation increased in all clusters of the first and second competition rounds, which was became evident as collaborative activities significantly increased. This is primarily due to improved awareness of potential partners as consequence of the LECC. Especially for the businesses among the LECC-funded organisations, the importance of cooperation in their overall R&D activities has increased. R&D cooperation between competitors occurred much more frequently than on the national average, as a comparison with data from the Mannheim innovation panel shows.

The LECC initiated new R&D partnerships and intensified existing contacts. A substantial mobilisation effect, extending beyond the LECC-funded cooperation projects, can be observed in the initiated relationships. Figure 9 shows the influence of the LECC on relationships in R&D cooperation networks in Leading-Edge Clusters. In some of the clusters (EffizienzCluster LogistikRuhr, FOE, Hamburg Avi-

Figure 9

Share of LECC-influenced relationships in all strategically important cooperation relationships

in %



Source: Accompanying evaluation of the LECC; written survey of LECC-funded organisations in 2011 and 2012. – Comments: n = Number of responses; m = Number of identified relationships within the cooperation network.

ation), almost one half of all relationships were initiated by the LECC. In the clusters MicroTEC Südwest and Cool Silicon, the LECC appears to primarily intensify existing relationships. These differences between clusters depend primarily on whether there were pre-existing, intensive R&D networks before the LECC or if these networks had to be built from scratch. The latter was the case in the Effizienzcluster LogistikRuhr, where many stakeholders had not been involved in R&D activities before the competition.

The number of cooperations that bridge the gap between science and business has increased. However, the relative importance of cooperation among public research organisations or between public research organisations and businesses has remained almost unchanged. As intended by the LECC, in many cases the competition was used to build new cooperative relationships within the Leading-Edge Clusters. Numerous new collaborations in project consortiums were initiated. However, these partners had in general not been completely unknown to each other.

The LECC also had the desired impact on the *geographic range* of networks. However, there are considerable differences with regard to the degree of regional networking and international engagement between the clusters (figure 10). For example, the Effizienzcluster LogistikRuhr and the Software Cluster show a comparatively high degree of networking within the cluster region. Hamburg Aviation and Solarvalley are primarily embedded on the national level, whereas the stakeholders in the two biotechnology clusters BioRN and Biotech Cluster m^4 are involved in markedly international networks. Despite these differences, the focus of all R&D cooperation networks lies within their cluster region. The R&D cooperations which were initiated by the LECC show a stronger regional element than other partnerships. This result illustrates that the LECC contributed to opening and exploiting regional innovative potential.

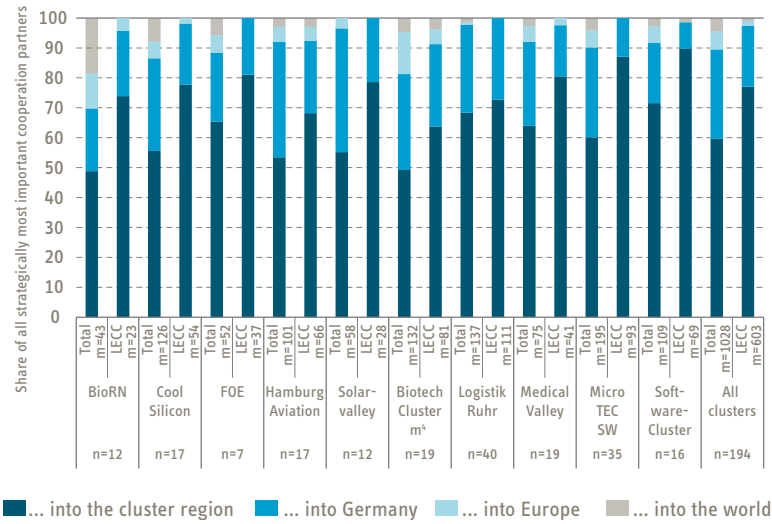
An examination of the *centralisation structure of the networks* shows that relationships formed over the course of the LECC are often more focused on key stakeholders (usually large corporations or public research organisations). During the LECC, these stakeholders have established themselves as important partners and made essential contributions for the technological and organisational development of the clusters. This development is understandable for competitions such as the LECC, because the common cluster strategies are usually developed under the leadership of a relatively small group of renowned and technologically competent actors that subsequently participated in the LECC-funded projects. Many SMEs used the LECC as an opportunity to build relationships with large corporations that

6. Networking and knowledge exchange in the Leading-Edge Clusters

Figure 10

Geographic distribution of strategically important collaborative relationships – comparison of the entire network of cooperation influenced by the LECC

in %



Source: Accompanying evaluation of the LECC; written survey of LECC-funded organisations in 2011 and 2012. – Comments: n = Number of responses; m = Number of identified relationships within the cooperation network.

would have been difficult to access otherwise. The establishment of long-term R&D contacts is especially important for SMEs in order to build relationships for innovation and assist the effective commercial exploitation of their developments.

The results of the analysis also show that some large corporations contact companies and research institutes for specific purposes, for example to solve current research problems or to benefit from their competence in the medium or long term. While excessive concentration of the networks on a few key actors may harbour a risk of becoming too dependent on their development, this study has found no indication of such a risk in practice.

All in all, the LECC's short-term goal of intensifying or enhancing the networking between innovative stakeholders in the cluster regions has been achieved. To what extent this enhanced networking will have a long-term impact on successful

innovation depends on whether the cooperation with local or supra-regional partners will remain at a high level in the future. The results of the investigation show that many relationships that were initiated are intended for long-term cooperation and should therefore have a sustainable impact on the cluster networks.

7. Regional impacts of the Leading-Edge Cluster Competition

One of the stated goals of the LECC is to generate long-term value through the exploitation of regional innovation potentials. In this context, a main focus is on the analysis of mobilisation processes at the core and in the environment of the clusters. Specifically, the significance of regional location factors, of geographical proximity to R&D partners as well as first observable and potential future impacts of the competition on the cluster regions were investigated. At the moment, the immediate effects of the competition in the Leading-Edge Clusters can primarily be observed (input and activity effects, partially first outputs) while outcomes and economic impact will rather be observable in future years. Hence, it was necessary in a first step to categorise the clusters with regard to the relevance of technological and economic location factors for the LECC-funded organisations.

The investigation of the regional impacts of the LECC incorporates the information from the written survey of LECC-funded organisations, the interviews with the CMs and cluster actors and the findings from the analysis of the sectoral innovation systems and networking. The results of the surveys were primarily evaluated by means of descriptive analyses. In order to account for the heterogeneity of the responses between the clusters, the correlations between cluster specifics and response behaviour were estimated by means of multivariate regression methods.

The *analysis of the relevance of regional location factors* considers general economic conditions for cluster activities, for example regional labour and sales markets, the technological conditions, as well as geographical proximity to R&D partners as a determinant for knowledge exchange. With regard to regional location factors, actors in all clusters selected in the first two competition rounds rate the local supply of highly skilled employees (college and university graduates) as most important, followed by the availability of medium skilled workers. This underpins the importance of cluster activities to qualify current and future employees. Differences between the clusters with regard to the importance of the regional labour market can be explained by differences in the composition of actors or differences in the technological focus.

7. Regional impacts of the Leading-Edge Cluster Competition

Compared to the local labour market, the local sales market is of minor importance for the LECC-funded organisations in the clusters of the first two competition rounds. Clusters with a comparatively high number of public research organisations show higher ratings for this item than other clusters. This can be explained by the fact that public research organisations tend to acquire their third-party funds locally – at least when it comes to third party funding by companies – while companies, even those with important local customers, operate to a greater extent on supra-regional markets. Industry-specific factors play a crucial role for the importance of the regional sales markets. For example, the revenues of Hamburg Aviation and Medical Valley are more concentrated on large local companies than in the case of the Biotech Cluster m[4].

Regarding their technological environment, LECC-funded organisations mostly agree that, though *geographic proximity* facilitates R&D cooperation, it is not a necessary requirement for its success. 90% of the LECC-funded organisations consider cooperation with geographically close partners as less cost-intensive. 80% think that geographical proximity facilitates information exchange. 35% of the LECC-funded organisations regard geographical proximity as a central precondition for the success of the cooperation. However, technological aspects and the partners' qualification play a superior role for the selection of cooperation partners than their geographical location. Accordingly, LECC-funded organisations concentrate their search for R&D partners rather on the national than on the regional level. Furthermore, organisations in Leading-Edge Cluster projects report higher satisfaction with the cooperation, when the partners have already worked before in other contexts. All in all, the analyses show that the requirements of Leading-Edge Cluster actors in respect to their regional environment are driven by their orientation towards knowledge-intensive industries. The supply of qualified employees and the requirements for regional R&D cooperation are of greater importance than the proximity to customers or suppliers.

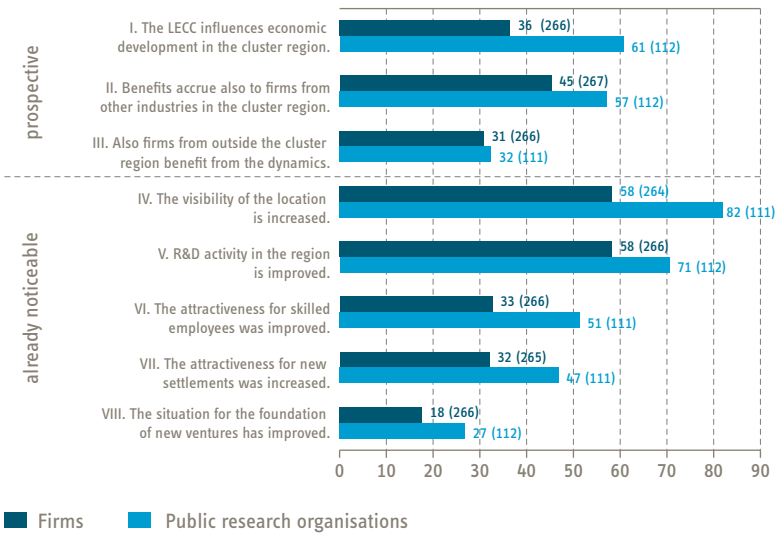
According to the LECC-funded organisations in all clusters of the first two competition rounds, the LECC has already triggered or will trigger *regional impetuses*. Figure 11 shows the assessment of potential or observable effects of the LECC separately for firms or research institute.

44% of the LECC-funded organisations expect that the success of the Leading-Edge Cluster will have a noticeable effect on the development of the cluster region. The largest effects of the LECC can be found in the increased visibility of the location

Figure 11

Impact of the Leading-Edge Cluster Competition on the development of the cluster regions

in %



Source: Accompanying evaluation of the LECC; written survey of LECC-funded organisations in the clusters of the first competition round in 2012 and the second competition round in 2013. – Comments: Percentage of stakeholders who responded with a "1" or "2" on a scale from 1 (completely agree) to 5 (disagree). The items in the two categories "prospective" and "already noticeable" are arranged in descending order of importance. The number of responses (n) is given in parentheses.

and the improved regional R&D activity. Public research organisations exhibit a significantly more positive view – probably because of the greater importance of external funds for research and a resulting different view on the regional impacts.

The assessment of the impacts varies considerably between the clusters. This can mainly be explained by the clusters' composition, in particular the ratio of public research organisations to companies. Clusters with a high share of public research organisations have a considerably more positive view of the effects. Furthermore, geographically extended clusters, as well as clusters with a large number of LECC-funded organisations, appear on average to have a more sceptical view of the

competition's effects on the region. A possible cause may be that the close geographical proximity between partners in more concentrated clusters fosters the exploitation of synergy effects.

At the moment, several types of regional impulses of the LECC can already be observed, primarily an improved visibility of the Leading-Edge Cluster regions and enhanced regional R&D activity. The actor interviews yielded that collaboration in the joint projects has improved the innovative climate and resulted in the formation respectively in an advancement of a common culture of innovation. While the stimuli from the LECC may not be able to fully compensate for critical economic trends, the LECC-funded projects still laid the basis for future increases in the generation of regional value added. By intensifying and initiating further R&D cooperation, the LECC is primarily effective in earlier stages of the value chain. Hence, its effects on growth and employment are not noticeable in the short run.

8. Impact of funding by the Leading-Edge Cluster Competition

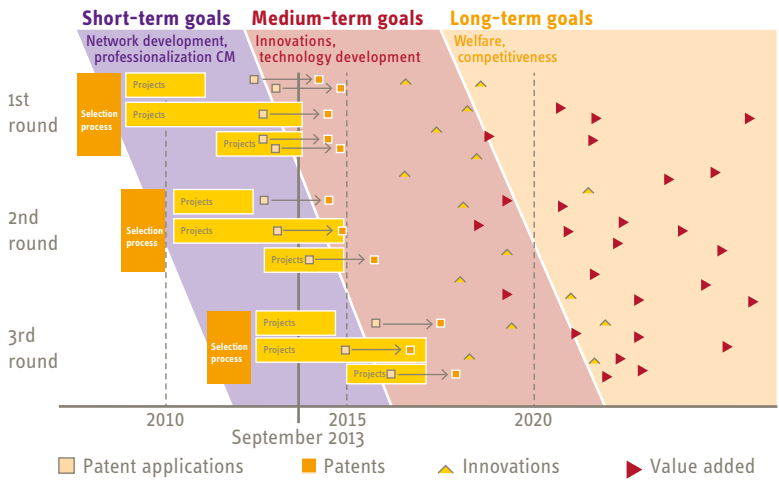
The previous chapters presented the results of the investigation for important aspects of the LECC. In order to arrive at an overall picture, the timeline of the various effects of the competition was examined in a first step. This assessment was based on data from the written surveys and expert interviews. The causal effects of the LECC were analysed in a second step. On the basis of an econometric group comparison analysis, the leverage effect of the LECC on firm R&D activities was estimated. The analysis was based on data from the R&D survey by the Stifterverband Wissenschaftsstatistik as well as our own survey results and other company data. In a third step, the results of the competition at the various levels under investigation were brought together. This compilation served as the basis on which the special characteristics of the LECC in comparison with other funding instruments were investigated.

The effective dimensions of the LECC are reflected in the funding guidelines for the competition in the form of short-term, midterm and long-term objectives (figure 12). The general timeline of the effects outlined here was confirmed by the analysis.

The effects that correspond to these goals range from activities that were initiated (expenditure of additional funds by the stakeholders, networking, knowledge exchange, changes in the CM processes) to direct and indirect results of the cluster activities (innovation, technology development) to long-term economic effects

Figure 12

Timeline and objectives of the Leading-Edge Cluster Competition and the funded projects



Source: Accompanying evaluation of the LECC.

(increased competitiveness, value-added, employment and wealth). To be certain that the results described here are actually caused the LECC, it would be ideal to make a comparison with the development of the Leading-Edge Clusters without the LECC. This so-called contrafactual situation is not observable. However, the methods of econometric group comparison analysis make it possible to scrutinize whether an observed effect has actually been caused by the LECC. These methods were used wherever the available data permitted. In many cases where this was not possible, the question whether observed results were caused by the LECC was addressed based on well-founded assessments.

The econometric analysis of the effects of the LECC looked at R&D expenditures, R&D personnel, and the R&D intensity of LECC-funded businesses. The result of the investigation was that companies significantly increased their R&D activities through participation in the LECC, roughly matching the public funding by the LECC with an increase in their own R&D activities. A comparison with companies that did not receive any funding during this period did not indicate any band-wagon effects in the sense that companies that received funding did not increase

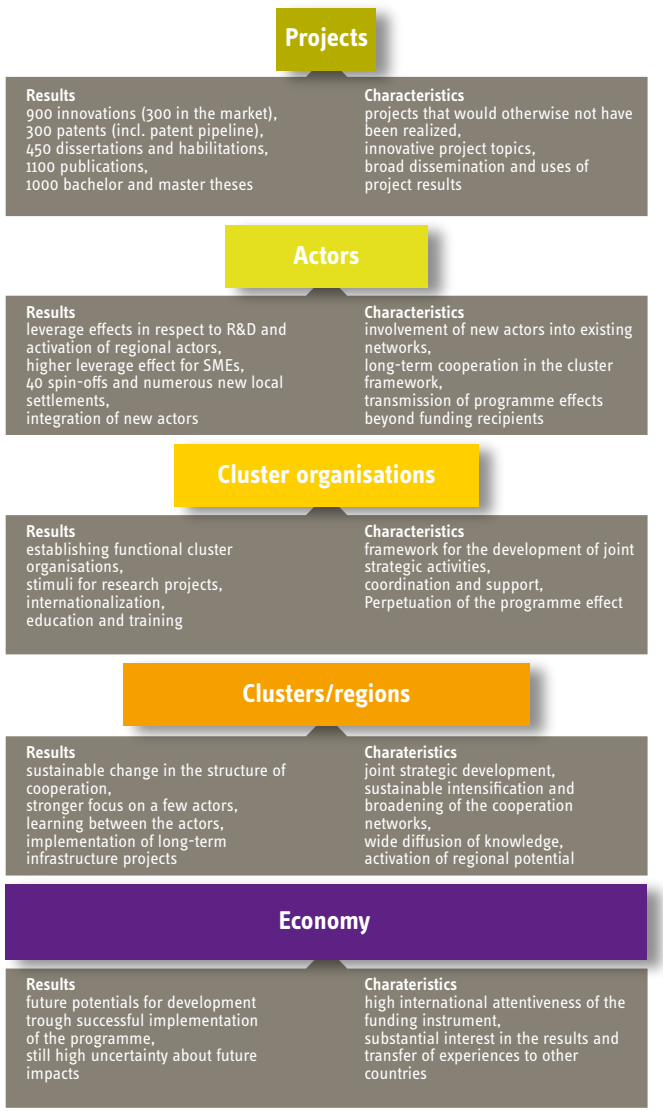
their R&D expenditures to a similar extent. Of course, the existence of bandwagon effects cannot be excluded in every single case. However, the statistical analysis showed that the LECC yielded an increase of company R&D expenditures that roughly matches the amount of public funding (leverage effect of almost 1). LECC-funded SMEs showed a considerably higher increase in R&D expenditures than large corporations. The estimated leverage effect for SMEs was 1.36 times the amount of public funding from the LECC. This is a similar magnitude as in the programme "KMU-innovativ", a programme financed by BMBF that especially addresses Hightech-R&D in SMEs. This means that the SMEs increase their R&D expenditures beyond the amount of the LECC-funding by an additional EUR 0.36 per euro of public funding.

The funding guidelines require that on average firm financing of cluster projects should at least match the LECC funding over the term of the programme (a 50% funding rate corresponds to co-financing of 50% of the project cost that is eligible for funding). It is often assumed that the co-financing increases a company's R&D budget by at least the funding amount plus the amount of co-funding. This is not realistic in practice. Large companies in particular have R&D budgets that are fixed in the short term and usually cannot be increased beyond the funding amount. However, expected public funding may already have been anticipated in the budget planning. In many cases, the means of co-funding comes from a reduction of R&D activities in other areas, or from parts of the budget that were earmarked for co-financing publicly funded projects anyway. Econometrics-based analyses did not find any increase of R&D budgets beyond the amount of funding, neither from re-allocation nor from co-financing out of budgets earmarked for expected projects. Even though the co-financing requirement does not result in an increase of private R&D expenditures, the funding still serves to channel R&D assets to areas where the overall economic benefits are maximised. This is the case for the LECC, as it supports cooperation projects that are in line with the cluster strategies.

Other results of the LECC that are observable at this time reflect peculiarities resulting from the design of the funding instrument. The long-term orientation of the structures, the commitment of central stakeholders, and the participation of new stakeholder groups as cluster partners yielded remarkable results. The funding has more wide ranging effects than is usually the case for instruments of joint project funding. These results are observable at all levels under investigation. In many cases, the effects of the programme go beyond the results found for LECC-funded organisations (figure 13).

Figure 13

Results of the Leading-Edge Cluster Competition at various levels – synopsis



Source: Accompanying evaluation of the LECC.

8. Impact of funding by the Leading-Edge Cluster Competition

- **Project level:** With 300 patent applications or patents scheduled for application, as well as 300 innovations (and another 600 planned), the clusters succeeded in generating numerous inventions from LECC projects and take them to the market or integrate them in new processes. Moreover, the projects yielded more than 2,500 bachelor and master theses, dissertations, post-doctoral theses and publications in technical journals. A special characteristic of the LECC is the execution of projects that would not have taken place otherwise. This applies to projects requiring long-term commitment by the stakeholders, or projects that would not have been successful in the existing funding schemes. In addition, the overall environment created by the cluster organisations and strategic processes often resulted in a better proliferation of the project results, both among the participating organisations and beyond, than what would have been the case with traditional approaches of project funding. One reason for this observation is that the cluster organisations frequently adopted targeted measures to bring the project results into practice.

- **Actor level:** As mentioned above, from the perspective of the funding recipients the LECC had a leverage effect on increase in R&D expenditures by companies. For SMEs, the leverage effect lead to an increase in R&D spending of about 1.36 times the amount of public project funding. As other investigations showed, new cooperation partnerships with a long-term orientation were initiated. Special characteristics of the LECC include (i) a leverage effect due to the strong commitment of key actors that is observable also at the programme level; (ii) a broad knowledge transfer brought about by networking between numerous stakeholders, including companies and public research organisations that did not receive any funding; and (iii) opportunities that were generated by the competition for new companies and public research organisations to gain access to already established R&D networks. These networks were able to benefit from information about new technological developments, from a long-term build-up of trust and from the higher visibility of the clusters, which was especially important for SMEs.

- **Level of the cluster organisations:** Cluster organisations in all clusters have become more established and professional. In all cases, this had a permanent effect on the institutional environment in which the companies and public research organisations in the relevant technology fields of the clusters operate. The cluster organisations create a framework for numerous joint activities under the umbrella of the cluster strategy. In comparison with other funding programmes, these effects are to be considered as specific impact

of the LECC. Compared with other cluster policy programmes, the LECC has resulted to a stronger focus on a common cluster strategy and a higher level of professionalism of the cluster organisations.

- **Cluster and regional level:** Special characteristics of the LECC include: (i) A high mobilisation of regional potential. (ii) A strengthening of the regional cooperation in the clusters and the initiation or acceleration of important developments in the cluster regions. (iii) Broad distribution effects beyond the small circle of funding recipients (e.g. participation of additional stakeholders in the cluster activities, increased visibility of the Leading-Edge Clusters, companies and public research organisations located in the cluster regions). (iv) Efforts to cover specific qualification needs as well as increased networking and internationalisation of cluster activities. Through regional networking, the LECC has strengthened the clusters and cluster regions and initiated new developments

- **Economy level:** The successful execution of the LECC has released economic development potentials. However, it is still too early to assess the effectiveness of the LECC with regard to aspects like additional employment or value-added created. An observable characteristic of the LECC has been the high visibility of the clusters and the funding programme, including visibility at the international level, which resulted in a multitude of requests and cooperations from outside the cluster regions (e.g. cooperation with other national and international clusters). The question to what extent and in which form the LECC will result in an increased economic success at the various levels relative to comparable programmes can only be answered in a few years.

In consideration of all the results available at this time, the LECC had remarkable effects with regard to initiating additional activities in the cluster regions, some results of which are already observable. The expectation that the competition should cover a wide and open-ended spectrum of objectives with the design of its funding instrument has therefore been fulfilled. However, at it is not yet possible to assess the effects of the LECC that result from better networking between actors and the integration of new partners into the clusters – which is essentially a key benefit of cluster funding compared with traditional funding programmes. A quantitative analysis of these effects is not possible based on the data currently available. The same is true for long-term effects on revenues and employment at the companies participating in the clusters.

9. Clusters and innovation policy: findings and recommendations

International comparison shows the LECC in a good position in terms of both programme design and results achieved so far. Significant trigger effects were achieved and the integration of medium-sized businesses into the cluster activities worked better then in comparable programmes. Good compromises were found for the funding duration as well as for the definition of regional boundaries between clusters. This has not always been the case in the programmes financed by other countries. The selection process for the clusters as well as for individual R&D projects meets high standards even in an international comparison. Two aspects of the funding programme have turned out to be good practices: Not providing significant funding to set up cluster organisations and the funding of collaborative (R&D) projects in the clusters. A special feature of the LECC was that the clusters, after successfully participating in the selection process and assuming that they successfully passed the intermediate assessment, could be reasonably confident of receiving the entire funding amount and plan accordingly. Other cluster programmes, such as the Pôles de Compétitivité, required separate funding applications for each project. There is a trade-off between setting incentives for increased attention to the programme on one hand and increased flexibility with regard to allocating the funds depending on the success in the implementation of cluster initiatives on the other. For the LECC, the positive effects of the selected approach predominate because this approach is most suitable for consistently pursuing the cluster strategies at the project level.

9. Clusters and innovation policy: findings and recommendations

The experiences from the LECC – as well as from other, similar funding programmes in Germany and other countries – can be used for the design and execution of future funding activities. This chapter tries to determine the prerequisites for the success of cluster initiatives. On this basis, recommendations are made for the remaining funding duration of the LECC until 2017, for future cluster and network funding, and for future innovation policies. Wherever possible, the findings of the accompanying evaluation were reflected against a background of existing cluster research and other evaluation studies. There was a high degree of correspondence in many points, as well as some new aspects that are not to be found in the literature (yet).

The "functioning" of technology-oriented cluster initiatives depends primarily on the following factors:

- Technology oriented clustered initiatives can only be successful if they have a **critical mass of existing technological and innovation potential** to build on already when the initiatives are constituted. If that is the case, the programme may be able to benefit from *windows of opportunity* that arise not just in early development stages of entirely new technologies, but also in established industries. This happens e.g. when comprehensive technological changes take place or when new challenges arise that require a reconfiguration of known technologies and production factors.

- For the success of cluster initiatives, an **assertive cluster organisation** represented by suitable cluster managers is indispensable. The cluster organisation and the CM at its core usually need some time in their constitution phase before they are fully functional. Like their corresponding industries, clusters are subject to medium and long-term structural changes. These changes force cluster initiatives to readjust their orientation from time to time and develop their organisations further. In the long run, these cluster institutions should therefore be seen as temporary intermediaries that may be replaced with new structures as this is appropriate.

- Cluster initiatives are based on **exploiting the benefits of geographic proximity.** For innovative clusters and in consideration of today's transportation and communication technologies, the word "proximity" can be interpreted pragmatically. The importance of geography varies considerably between the participants of the LECC. In some cases it provides a point of identification that contributes to the mobilisation of regional stakeholders and resources. In other cases it is the result of past developments and taken for granted. In yet other cases, geographic proximity does not play a significant role for joint R&D activities. A continuous exchange between R&D employees with different qualifications in one place can be helpful for developing innovations, but is it not a necessary prerequisite for collaboration within a cluster.

- On one hand, the success of cluster initiatives depends on **cluster-internal factors.** Within limits, cluster organisations are able to compensate for and actively respond to interference from the environment. They are successful especially when sufficient technological and innovation potential is available, when joint activities can be advanced within the cluster organisation, and when positive effects can be achieved by a close regional exchange between

cluster stakeholders. On the other hand, **environmental factors** also play a role for cluster development, in particular international market events as well as framework conditions and their changes (e.g. when certain technological problems cannot be solved or when market constellations change). Such events may necessitate changes in the cluster strategy or, in extreme cases, render the objectives of the cluster organisation obsolete, such that responsiveness and adaptability are required.

The funding of cluster and network initiatives is becoming an increasingly important instrument of innovation policy. Cluster funding addresses technology-political constellations which are characterised by the following factors:

- The development of technologies to be funded is marked by a **spatial agglomeration** of relevant companies and public research organisations.
- The addressed technologies are at a stage where a **technological breakthrough** is to be expected in the foreseeable future.
- The clusters to be funded exhibit a **critical mass of relevant innovation capacities** that may be expected to play a major role with regard to the development of the relevant technologies or industries in the future.
- The cluster initiative to be funded is supported by strong **commitment of the stakeholders** it represents.
- The technologies and industries in question have **significant importance for the total economy.**

If one or several of these prerequisites are not fulfilled, then cluster funding is not advisable, or at least not at the federal level. If from the perspective of the total economy there is still a need for funding, then this should be covered by other instruments of research and innovation policy, such as thematic technical programmes, network funding or funding for R&D cooperation. The instrument of cluster funding is therefore by no means a panacea to solve all conceivable problems of technology policy. Quite the contrary: Excessive or even indiscriminate use would necessarily result in a devaluation of the instrument. Regarding the funding of Leading-Edge Clusters, the concept of the LECC was designed in a way that the above prerequisites are all fulfilled. The findings of the accompanying evaluation also confirm that the basic concept of the competition has been implemented as intended.

Recommendations for the remaining funding period of the Leading-Edge Cluster Competition until 2017.

As well-established and functional cluster structures already exist, any recommendations from research accompanying the ongoing LECC should not call for a basic reorientation of the structures and processes, but instead make suggestions for optimisation where this is possible and meaningful. With this in mind, the following recommendations are made for the ongoing competition:

- The cluster conferences held in 2010 and 2012 had great external impact and were also well regarded in expert circles. Inter alia, they acted as a forum of exchange for stakeholders in Leading-Edge Clusters, internally and with other experts in the field of cluster policy. Based on the evaluation, we recommend to conduct **cluster conferences of a suitable form in the future** as well.

- The duration of LECC funding was limited to five years. This has turned out to be a good practice. However, it may be advisable to **continue the funding by the BMBF for certain elements of cluster development beyond the term of funding in individual clusters.** A funding programme to support activities for international cooperation would be conceivable.

- The **experience exchange workshops should be continued under a slightly different focus.** In the past, they have for instance given the opportunity to present and discuss evaluation results. A future focus should be on the mutual learning from experiences. In particular, the clusters in the third round of the competition may learn from the experiences of the clusters in the first and second rounds.

- Many effects of the LECC can only materialise in the long term. Therefore, an accompanying evaluation faces limitations in respect to the assessment of such effects. The development of Leading-Edge Clusters and its possible effects for the total economy should therefore be **evaluated ex post after an interval of about five years from the end of LECC funding.**

9. Clusters and innovation policy: findings and recommendations

Recommendations for future cluster and network funding

Based on the evaluation of the LECC, the following recommendations are made regarding future funding for clusters and networks:

- The experiences from the LECC show that **cluster funding should continue to play an important role as an instrument of innovation policy.** Reasons for this are the high potential mobilisation effect, the positive stimulus for networking, and the transfer of knowledge that can be triggered by cluster funding.

- Future cluster programmes should continue to **orient their funding on immediate and wide-ranging commercial exploitation of results without restriction to a certain technology,** not least in order to support job creation.

- Similar to the LECC, future instruments of cluster funding should maintain a **regional focus, with a certain amount of flexibility in the definition of regional boundaries.** Supra-regional networking should not be neglected, and the networking with stakeholders and clusters outside the cluster region should be promoted. Funding policies should aim for a **mix of geographic proximity and collaboration focused on scientific excellence.**

- Like the LECC did when selecting its candidates, future programmes for cluster and network funding should look for (i) a **convincing commitment by key stakeholders;** (ii) a **clear focus on a common strategy**; and (iii) the **existence of a functional organisational structure.**

- Experiences from the LECC show that it makes sense to **communicate results and successes of cluster funding programmes early on,** because this is probable to have a motivating effect on the stakeholders and increase the visibility of funding.

- Since the development of a cluster concept during the application for a funding programme takes considerable effort, it should be considered **to provide funding for the strategy development itself** some cases, when the necessary resources are not available (e.g. young cluster initiatives). Possibly, this measure could be complemented with coaching seminars and "certified cluster managers".

- A future **focus should be on the development of CMs and the benchmarking of organisational development early on.** Thereby, the strategy development and benchmarking processes of cluster organisations should be promoted. Furthermore, the monitoring of project development should be **closely coordinated between cluster managements and project executing organisations.**

- As has been the case with the LECC, cluster programmes should aim at a balanced **integration of SMEs and large companies.** As the findings of the evaluation show, especially the cooperation between SMEs and large companies creates new R&D contacts from which impulses for innovation may result.

- After 2017, it should be assessed whether **another "Leading-Edge Cluster Competition"** would make sense. The high visibility and attractiveness of the LECC has among other factors been a function of its uniqueness. In case of a simple repetition of the competition, this effect would be reduced. Alternatively, a programme for targeted **support for young innovation clusters or networks** could be launched.

- As many cluster initiatives are funded in Germany, a **critical assessment of the funding especially at the Länder level** would make sense. The cluster dialogue within the scope of the technical conferences between the federal government and the states (Bund-Länder-Fachgespräche) might play an important role here. In principle, a **coordinated continuation of the various approaches to support cluster activities** is recommended.

Recommendations for future research and innovation policies

Based on experiences with the LECC, the following recommendations are made for future research and innovation policies:

- The **BMBF should continue to implement innovative, complex funding approaches** in order to counteract the risk that innovative impulses remain restricted to well-trodden paths.

- **Flanking a highly visible funding programme such as the LECC with a jury process has turned out to be beneficial.** The following aspects are most critical for a jury process: (i) selection of suitable jury members, which should comprise a balanced mix of representatives from businesses and science; (ii) the provision of information about the programme applicants to assist decision-making; (iii) expert assessment of the candidacies.

9. Clusters and innovation policy: findings and recommendations

- The **two-step process with an intermediate assessment has proven itself and should continue to be practised in the future.** It provides an opportunity to adjust activities, to initiate new projects and to assess the project environment.

- The **openness of the competition for all technologies should remain the basis of future programmes.** On one hand, this has increased the visibility of the funding instrument. On the other, it contributes to maximising the programme's impact.

- The **duration of the funding term of five years can be used in other programmes.** However, the cycle length should be adjusted to match relevant innovation cycles for industry or technology-specific programmes, if required.

- Similar to the research campus (Forschungscampus) programme, **long-term infrastructure programmes** and shared facilities of the involved stakeholders should be supported to improve the sustainability of funding effects.

- When conducting future technology funding programmes, the **diffusion of results and knowledge transfer** should be supported and adjusted to the conditions in the relevant industries and technology fields.

- "Spitzencluster-Wettbewerb" and "Spitzencluster" have received great attention as labels on the national and European level, which has contributed to the visibility of the funding programme in Europe. However, this has not quite been the case for the USA and Asia. For future funding programmes, the **beacon effect of the programme's name should be taken into consideration in advance.**