

Commission for Technology and Innovation CTI

SCCER Accompanying Research Synthesis

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Summary

1. Introduction

The Federal Council's 'Swiss Coordinated Energy Research' action plan aims to promote energy research through to 2020, and thereby support the implementation of the Energy Strategy 2050. Central to the first phase of the action plan (2013–2016) is the establishment of eight networked inter-university Swiss Competence Centers for Energy Research (SCCERs).

The research accompanying the SCCERs ('Accompanying Research') analysed their development in the following four areas and drew up the corresponding recommendations for action: (1) thematic, institutional and knowledge value chain-related shortcomings; (2) interdisciplinary collaboration; (3) contacts with enterprises; and (4) international positioning. The Accompanying Research was conducted in five modules. While Modules 1–4 examined the four areas set out above, Module 5 was responsible for coordinating the research and synthesising the outcomes. The following findings and recommendations are based on the reports on Modules 1–4.

2. Findings on the four areas of the Accompanying Research

Thematic, institutional and knowledge value chain-related shortcomings

Considering the thematic objectives laid down in the call for proposals for 2013–2016 and the available financial resources, the SCCERs have, on the whole, set suitable thematic and institutional priorities for their work. It should be noted that there is no clear definition of the technological direction that the SCCERs are expected to take. They are intended to make rapid, tangible contributions to the attainment of Energy Strategy 2050 targets (research with a high 'technology readiness level' TRL). At the same time, however, they are called upon to produce new and innovative solutions that will take time for the market to adopt (research with a low TRL).

Relevant gaps exist in particular in the fact that the organisation of applied research in photovoltaic and solar energy is unclear, that socio-economic research in the technical SCCERs is inadequate, and that there are shortcomings in knowledge and technology transfer (KTT). Other shortcomings concern the lack of attention paid to energy usage and its efficiency potential, the insufficient involvement to date of industry, SMEs and policymakers, and the low level of integration between universities of applied sciences, universities and private research institutions (in part because the funding terms are not particularly attractive).

Where possible, these gaps should be closed during the next phase of the action plan (2017–2020), taking into account the priority themes of the Energy Strategy 2050, the financial

resources available, the focus required for efficient energy research and existing research know-how of universities of applied sciences (UAS) and private research organisations.

Interdisciplinary collaboration

The promotion of the SCCERs should be understood as a means of stimulating interdisciplinary collaboration in energy research. The SCCERs are a useful starting point for a concerted effort involving researchers from a variety of disciplines and research institutions. Past cooperation provides the basis for an increasingly shared understanding of the task at hand, and the foundations of an energy research community – one which at present is still very much focused on technological areas.

It will take time to establish and develop interdisciplinary collaboration, however. Furthermore, the overarching objectives that it is intended to pursue have not yet been defined in explicit terms (short-term vs. longer-term impacts). Since interdisciplinary collaboration on research work is still at a very early stage, it is too soon to expect it to have produced any major findings.

The framework for interdisciplinary collaboration could be optimised by improving the distribution of information within the SCCERs, by clarifying the role to be played by SCCER CREST¹, and by examining how incentives for interdisciplinary activities might be made more appealing. The 'innovation roadmaps' should be used systematically to plan interdisciplinary dialogue, and revised and enhanced on a regular basis.

Contacts with enterprises

By the autumn of 2015, the SCCERs had succeeded in establishing a substantial 329 formal contacts with 259 companies of different sizes, and the number is still growing. Many of these contacts are new ones made since the SCCER promotion programme began. Expanding informal contact between researchers and business is an important step towards establishing formal contacts. That said, the SCCERs have still to engage many of the companies which are important in their research fields. The corporate sector has contributed 13 percent of the SCCERs' budgets to date. The SCCERs aim to broaden these corporate contacts still further. There are 125 formal contacts with the Confederation, cantons, cities and other public-sector institutions, which are involved primarily in funding the SCCERs.

Despite their diversity of contacts with companies and public-sector institutions, the SCCERs appear to have difficulty with knowledge and technology transfer (KTT). In addition to the relatively short period for which the SCCER programme has been running, this is likely to be

¹ CREST: Competence Center for Research in Energy, Society and Transition.

attributable to insufficiently well developed KTT strategies, shortcomings in KTT services, and a lack of awareness among researchers about these KTT mechanisms.

To network the SCCERs more closely with the business sector, and to improve KTT, greater importance should be attached to the SCCERs' innovation roadmaps as an instrument of strategic planning. They should also become more binding in nature. At the same time, the SCCERs' KTT efforts require conceptual, organisational and effective improvements. One further idea might be to make part of the SCCERs' funding conditional upon their KTT performance.

International positioning

To date, international positioning has not been a major priority for the SCCERs. Only one of them (FURIES²) has any specific internationalisation strategy.

SCCER partners do have good international networks, however, and engage in a wide range of international activities. They are involved to differing degrees in international research programmes. However, the SCCERs' actual contributions to these activities have been small so far. Instead, they have helped less well established partners to make international contacts, co-ordinated international conference and project participations and facilitated international proposals. The SCCERs have undertaken various activities to increase their international visibility. Experts confirmed that the SCCERs have gained some international visibility but the process is only at the beginning.

Where the SCCERs' future international activities are concerned, the strategic targets that their international positioning is intended to achieve should be clarified. The key question here is the extent to which internationalisation is to be regarded as a means of achieving the SCCERs' research targets, and to what extent it makes sense for SCCERs to boost their international visibility. Depending on the answer, the SCCERs should then define and implement their own international strategies and activities. They should also be represented in major international bodies (such as the IEA) and research programmes (such as Horizon 2020).

Similar programmes in other countries (the UK, Sweden and Austria) have longer funding cycles (with a flexible approach to continuing or stopping funding depending on the achievement of objectives) and different approaches to evaluation, involving fewer but more comprehensive evaluations. These elements may also be helpful in the future management of the SCCERs.

² FURIES: Future Swiss Electrical Infrastructure.

3. Conclusions and recommendations

The findings on the four areas of the Accompanying Research led to the following conclusions:

- Where the four areas examined are concerned, the SCCERs are on the right track. They have set suitable priorities, created a good basis for interdisciplinary collaboration, achieved considerable progress on networking with business, and made efforts with regard to their international positioning.
- There is still (substantial) room for improvement on all four areas, however. This is particularly true of interdisciplinary collaboration, networking with major companies, knowledge and technology transfer, and international cooperation. It must be remembered that the SCCERs have not been in existence for very long, and that progress in the areas covered here will take time and systematic effort.
- The strategic objectives of the SCCERs have still not been formulated in specific terms. In particular, there is a need to determine what contributions the SCCERs should make towards Energy Strategy 2050 targets in the short, medium and long term – including priorities between the different technology readiness levels of research outcomes.

On the basis of this Accompanying Research, the following general recommendations for action can be made to the CTI and the SCCERs:

1. The CTI should consider longer funding periods (with a flexible approach to continuing or stopping funding) and performance-oriented elements in financing.
2. In response to a specific request from the CTI, the SCCERs should set out as clearly as possible the strategic objectives that are to be pursued in the four areas in the short, medium and long term, possibly differentiating between the topics within their particular SCCER.
3. The SCCERs should systematically refine and implement the innovation roadmaps as a framework for strategy development and monitoring.
4. The CTI and SCCERs should investigate whether or not the thematic and institutional gaps that have been identified (especially regarding socio-economic research) can actually be closed, bearing in mind the available resources and the prioritisation and focus that are required. The CTI should verify current funding terms to further integrate existing energy research knowledge.
5. With the support of the CTI, the SCCERs should strengthen interdisciplinary collaboration (e.g. to encourage lighthouse projects).
6. The SCCERs should strengthen the awareness about their market approach, involve business – especially major companies in the SCCERs' specific fields – more closely and foster the establishment of effective, systematic KTT.

7. The SCCERs should lend their partners greater support with international activities, especially regarding participation in international programmes.

Zusammenfassung

1. Einleitung

Der Bundesrat will mit dem Aktionsplan „Koordinierte Energieforschung Schweiz“ die Energieforschung bis ins Jahr 2020 stärken und damit die Umsetzung der Energiestrategie 2050 unterstützen. Zentraler Bestandteil der ersten Phase des Aktionsplans (2013–2016) ist der Aufbau von acht interuniversitär vernetzter „Swiss Competence Centers for Energy Research“ (SCCER).

Die Begleitforschung der SCCER analysierte die Entwicklung in folgenden vier Themenfeldern und erarbeitete entsprechende Handlungsempfehlungen: (1) thematische und institutionelle Lücken sowie Lücken in der Wertschöpfungskette (2) Interdisziplinäre Zusammenarbeit, (3) Vernetzung mit der Wirtschaft und (4) Internationale Positionierung. Die Begleitforschung wurde in fünf Modulen durchgeführt. Während die Module 1 bis 4 die vier Themenfelder bearbeiteten, war Modul 5 für die Koordination und die Synthese verantwortlich. Nachfolgende Ergebnisse und Empfehlungen basieren auf den Berichten zu den Modulen 1 bis 4.

2. Ergebnisse zu den vier Themenfeldern der Begleitforschung

Thematische und institutionelle Lücken sowie Lücken in der Wertschöpfungskette

Unter Berücksichtigung der thematischen Ziele der Ausschreibung für die Jahre 2013–2016 und den verfügbaren finanziellen Mitteln haben die SCCER grundsätzlich adäquate thematische und institutionelle Prioritäten gesetzt. Zu beachten ist, dass die Erwartungen an die SCCER bezüglich technologischer Stossrichtung nicht klar definiert sind. Einerseits sollen die SCCER rasche und konkrete Beiträge an die Ziele der Energiestrategie 2050 liefern (Forschung mit einem hohen Technologie-Reifegrad TRL³). Andererseits werden neue und innovative Lösungen gefordert, deren Anwendung im Markt Zeit benötigt (Forschung auf einem tiefen TRL).

Relevante Lücken bestehen vor allem bei der unklaren Organisation der angewandten Photovoltaik- und Solarthermie-Forschung, der inadäquaten sozio-ökonomischen Forschung in den technologisch ausgerichteten SCCER und beim Wissens- und Technologietransfer (WTT). Weitere Lücken betreffen die fehlende Behandlung des Themas Effizienzpotenziale von Elektrizitätsanwendungen, die bisher ungenügende Integration der Fachhochschulen, Universitäten und privater Forschungsinstitutionen (u.a. aufgrund wenig attraktiver Förderbedingungen) sowie den noch nicht ausreichenden Einbezug der Industrie, von KMU und politischer Entscheidungsträger.

³ „Technological Readiness Level“ (TRL).

Die Lücken sollten in der nächsten Phase des Aktionsplans (2017–2020) unter Berücksichtigung der prioritären Themen im Hinblick auf die Energiestrategie 2050, der verfügbaren finanziellen Mittel und der erforderlichen Fokussierung im Sinne einer effizienten Energieforschung möglichst geschlossen werden.

Interdisziplinäre Zusammenarbeit

Die Förderung der SCCER ist als Stimulus der interdisziplinären Zusammenarbeit in der Energieforschung zu verstehen. Mit den SCCER wurde ein geeigneter Startpunkt geschaffen, um eine gemeinsame Energieforschung mit Forschenden aus verschiedenen Disziplinen und Forschungsinstitutionen zu ermöglichen. Aus der bisherigen Zusammenarbeit resultieren ein anwachsendes gemeinsames Aufgabenverständnis und der Beginn der Entwicklung einer derzeit noch stark technologiefeldbezogenen Energieforschungscommunity.

Der Aufbau und die Entwicklung der interdisziplinären Zusammenarbeit benötigt jedoch Zeit. Zudem sind die mit der interdisziplinären Zusammenarbeit verfolgten übergeordneten Ziele noch nicht explizit definiert (kurzfristige vs. längerfristige Wirkungen). Da die interdisziplinäre Zusammenarbeit in der Forschungsarbeit erst beginnt, können noch keine wesentlich auf diesen Kooperationen beruhenden Forschungsergebnisse erwartet werden.

Die Voraussetzungen für die interdisziplinäre Zusammenarbeit können durch eine Verbesserung der Informationsverbreitung innerhalb der SCCER, die Klärung der Rolle des SCCER CREST⁴ und die Stärkung der Anreize für interdisziplinäre Aktivitäten optimiert werden. Die „Innovation Roadmaps“ sollten systematisch zur strategischen Planung des interdisziplinären Austausches genutzt und regelmässig weiterentwickelt werden.

Vernetzung mit der Wirtschaft

Den SCCER ist es gelungen, eine substanzielle und steigende Anzahl Kontakte mit privaten Unternehmen aufzubauen. Bis Herbst 2015 haben die SCCER 329 formelle Kontakte mit 259 Unternehmen unterschiedlicher Grösse etabliert. Viele dieser Kontakte sind seit der Förderung der SCCER neu entstanden. Der Ausbau informeller Kontakte der Forschenden zu den Unternehmen ist ein wichtiger Weg zur Schaffung formeller Kontakte. Die SCCER konnten jedoch viele in ihrem Forschungsbereich wichtige Unternehmen noch nicht involvieren. Die Unternehmen haben bislang 13 Prozent an die Budgets der SCCER beigetragen. Die SCCER wollen die Kontakte zu Unternehmen weiter ausbauen. Zu Bund, Kantonen, Städten und weiteren öffentlichen Institutionen bestehen 125 formale Kontakte, die vor allem zur Finanzierung der SCCER beitragen.

⁴ CREST: Competence Center for Research in Energy, Society and Transition.

Trotz vielfältiger Kontakte mit Unternehmen und öffentlichen Institutionen scheinen die SCCER Schwierigkeiten mit dem Wissens- und Technologietransfer (WTT) zu haben. Dies dürfte – neben der noch relativ kurzen Laufzeit – auf wenig ausgereifte WTT-Konzepte, ungenügende WTT-Dienstleistungen und die mangelhafte Bekanntheit der WTT-Dienstleistungen bei den Forschenden zurückzuführen sein.

Zur Stärkung der Vernetzung mit der Wirtschaft und des WTT sollten einerseits die „Innovation Roadmaps“ der SCCER als strategisches Planungsinstrument an Gewicht und Verbindlichkeit gewinnen. Andererseits sollte der WTT der SCCER konzeptionell, organisatorisch und leistungsmässig verbessert werden. Zudem könnte die Finanzierung der SCCER teilweise von deren Transferleistungen abhängig gemacht werden.

Internationale Positionierung

Die SCCER haben der internationalen Positionierung bisher grösstenteils keine grosse Priorität beigemessen. Mit Ausnahme eines SCCER (FURIES⁵) verfügen sie über keine explizite Internationalisierungsstrategie.

Die SCCER-Partner verfügen jedoch über gute internationale Netzwerke und setzen vielfältige internationale Aktivitäten um. Sie beteiligen sich in unterschiedlichem Ausmass an internationalen Forschungsprogrammen. Der bisherige Beitrag der SCCER zu diesen Aktivitäten dürfte jedoch gering sein. Die SCCER haben vor allem weniger gut etablierte Partner dabei unterstützt, internationale Kontakte zu knüpfen und Partner für internationale Projekte zu finden. Die SCCER haben verschiedene Aktivitäten umgesetzt, um ihre internationale Sichtbarkeit zu erhöhen. Experten bestätigen, dass die SCCER an internationaler Sichtbarkeit gewonnen haben, der entsprechende Prozess jedoch erst begonnen hat.

Im Hinblick auf die künftigen internationalen Aktivitäten der SCCER sollten die mit der internationalen Positionierung angestrebten strategischen Ziele geklärt werden. Im Vordergrund steht die Frage, inwiefern die Internationalisierung als Mittel zur Erreichung der Forschungsziele der SCCER zu verstehen ist und inwiefern es für die SCCER zweckmässig ist, deren internationale Sichtbarkeit zu erhöhen. Abhängig davon sollten die SCCER ihre eigenen internationalen Strategien und Aktivitäten definieren und umsetzen. Zudem sollten die SCCER in wichtigen internationalen Gremien (v.a. IEA) und Forschungsprogrammen (z.B. Horizon 2020) vertreten sein.

Ähnliche Programme anderer Länder (Grossbritannien, Schweden, Österreich) verfügen über längere Förderperioden (mit einem flexiblen Ansatz zur Weiterführung oder Beendigung der Förderung in Abhängigkeit der Zielerreichung) und andere Evaluationsansätze, die weniger,

⁵ FURIES: Future Swiss Electrical Infrastructure.

jedoch vertiefende Evaluationen umfassen. Diese Elemente könnten sich auch zur zukünftigen Steuerung der SCCER eignen.

3. Folgerungen und Empfehlungen

Aufgrund der Ergebnisse zu den vier Themenfeldern ergeben sich folgende Folgerungen:

- Die SCCER sind im Hinblick auf die vier Themenfelder auf gutem Wege. Sie haben adäquate Prioritäten gesetzt, eine gute Ausgangslage für die interdisziplinäre Zusammenarbeit geschaffen, die Vernetzung mit der Wirtschaft substanziell vorangetrieben und Anstrengungen im Hinblick auf die internationale Positionierung unternommen.
- Bei den vier Themenfelder bestehen jedoch noch teilweise gewichtige Verbesserungspotenziale, insbesondere bei der interdisziplinären Zusammenarbeit, der Vernetzung mit wichtigen Unternehmen, dem Wissens- und Technologietransfers und der internationalen Kooperation. Zu berücksichtigen ist, dass die SCCER erst seit kurzer Zeit bestehen und die Entwicklung in den vier Themenfeldern Zeit und systematische Anstrengungen erfordert.
- Die strategischen Ziele der SCCER sind noch nicht explizit formuliert. Insbesondere ist zu klären, welche Beiträge die SCCER in kurzer, mittlerer und langer Frist an die Ziele der Energiestrategie 2050 leisten sollen (inkl. Prioritätensetzung bezüglich unterschiedlicher Technologie-Reifegrade der Forschung).

Aufgrund der durchgeführten Begleitforschung können folgende übergeordneten Handlungsempfehlungen zuhanden der KTI und die SCCER formuliert werden:

1. Die KTI sollte längere Förderperioden und leistungs- bzw. erfolgsorientierte Elemente in der Finanzierung prüfen.
2. Aufgrund einer expliziten Aufforderung der KTI sollten die SCCER die in den vier Themenfeldern kurz-, mittel- und langfristig angestrebten strategischen Ziele möglichst klar formulieren (möglichst differenziert nach Themen innerhalb der jeweiligen SCCER).
3. Die SCCER sollten die „Innovation Roadmaps“ als Rahmen für die Strategieentwicklung und das Monitoring systematisch weiterentwickeln und umsetzen.
4. Die KTI und die SCCER sollten prüfen, ob die festgestellten thematischen und institutionellen Lücken (insbesondere betreffend sozioökonomische Energieforschung) unter Berücksichtigung der verfügbaren Mittel und der erforderlichen Priorisierung und Fokussierung geschlossen werden können. Die KTI sollte die bestehenden Fördermodalitäten überprüfen, um bestehendes Wissen in der Energieforschung verstärkt einzubeziehen.
5. Die SCCER sollten mit Unterstützung der KTI die interdisziplinäre Zusammenarbeit stärken (z.B. durch Leuchtturmprojekte).

6. Die SCCER sollten das Bewusstsein für die Marktorientierung der Energieforschung erhöhen, verstärkt mit Unternehmen zusammenarbeiten (v.a. mit den für die jeweiligen SCCER wichtigen Unternehmen) und die Etablierung eines systematischen und effektiven Wissens- und Technologietransfers vorantreiben.
7. Die SCCER sollten ihre Partner verstärkt bei internationalen Aktivitäten unterstützen, insbesondere bei der Beteiligung an internationalen Programmen.

Résumé

1. Introduction

Le plan d'action du Conseil fédéral sur la Recherche énergétique suisse coordonnée a pour vocation de renforcer la recherche sur l'énergie en Suisse d'ici 2020 afin de contribuer à consolider la mise en œuvre de la Stratégie énergétique 2050. Durant la première phase (2013–2016), ce plan d'action se concentre sur la création d'un réseau de huit pôles de compétence universitaires (Swiss Competence Centers, SCCER).

La recherche d'accompagnement a analysé le développement de quatre champs thématiques avant d'élaborer des recommandations pratiques : (1) lacunes thématiques et institutionnelles, lacunes dans la chaîne de production du savoir ; (2) collaboration interdisciplinaire ; (3) échanges avec les milieux économiques ; (4) positionnement sur le plan international. La recherche d'accompagnement en procéda en cinq modules. Les modules 1 à 4 traitent des quatre champs thématiques évoqués ci-avant, alors que le module 5 porte sur la coordination et comprend une synthèse. Les résultats et recommandations ci-après se fondent sur les rapports relatifs aux modules 1 à 4.

2. Les quatre champs thématiques couverts par la recherche d'accompagnement : résultats

Lacunes thématiques et institutionnelles, lacunes dans la chaîne de production du savoir

Les priorités thématiques institutionnelles définies par les SCCER sont appropriées compte tenu des objectifs thématiques du plan d'action pour les années 2013 à 2016 et compte tenu des moyens financiers à disposition. Relevons cependant que la mission des SCCER en termes d'axe technologique prioritaire n'est pas suffisamment bien définie. Si on leur demande de fournir rapidement des contributions concrètes qui permettront d'atteindre les objectifs de la Stratégie énergétique 2050 (niveau de maturité technologique TRL⁶ élevé), on leur demande aussi des solutions inédites et innovantes, dont la diffusion à large échelle sur le marché demande du temps (bas niveau de maturité technologique TRL).

Des lacunes importantes existent au niveau de l'organisation dans le domaine de la recherche appliquée en photovoltaïque et en thermie solaire, de la recherche socio-économique au sein des SCCER avant tout axés sur la technique, ainsi qu'au niveau du transfert de savoir et de technologie (TST). Les autres déficiences se situent au niveau de l'étude du potentiel d'efficacité de l'électricité, de l'intégration insuffisante des hautes écoles spécialisées, des universités et

⁶ „Technological Readiness Level“ (TRL).

des instituts de recherche privés (notamment en raison de modalités de cofinancement peu attrayantes), mais aussi de l'intégration insuffisante de l'industrie, des PME et des organes de décision politiques.

Durant la prochaine étape du plan d'action (2017–2020), il s'agira de combler ces lacunes en tenant compte des aspects prioritaires pour la réalisation de la Stratégie énergétique 2050, des ressources financières disponibles et de la nécessaire concentration sur des aspects précis de la recherche énergétique afin de garantir son efficacité.

Collaboration interdisciplinaire

La promotion des SCCER est synonyme d'encouragement de la collaboration interdisciplinaire dans le domaine de la recherche énergétique. La création des SCCER représente en effet le coup d'envoi qui permet d'entreprendre des recherches qui associent des chercheuses et des chercheurs de plusieurs disciplines et de plusieurs institutions. À ce jour, cette collaboration interdisciplinaire a eu pour effet de favoriser une compréhension plus aiguë des tâches communes et de mettre en place les premiers jalons d'une communauté de recherche dans le domaine de l'énergie jusqu'ici fortement cloisonnée selon les technologies.

La mise en place et le développement de la collaboration interdisciplinaire prend du temps. Par ailleurs, certains objectifs fondamentaux de cette collaboration ne sont pas encore définis explicitement (p. ex. effets à court terme ou effets à long terme). La collaboration interdisciplinaire dans la recherche énergétique n'en est qu'à ses débuts ; par conséquent, elle ne saurait produire des résultats significatifs avant un certain temps.

La promotion de la collaboration interdisciplinaire passe par une meilleure diffusion de l'information dans les SCCER, par la clarification du rôle du SCCER CREST⁷ ainsi que par la multiplication des incitations à mener des activités interdisciplinaires. Par ailleurs, il s'agit d'utiliser systématiquement les « feuilles de route de l'innovation » pour la planification stratégique des échanges interdisciplinaires et de les développer continuellement.

Échanges avec les milieux économiques

Les SCCER ont réussi à nouer un nombre important et croissant de contacts avec des entreprises privées. À l'automne 2015, les contacts formels étaient au nombre de 329 et impliquaient 250 entreprises de tailles diverses. Parmi ces contacts, nombreux sont ceux qui sont le résultat de la promotion des SCCER. Le renforcement des contacts informels entre chercheuses/chercheurs et entreprises constitue une méthode éprouvée pour créer des liens formels ; il reste pourtant de nombreuses entreprises déterminantes pour les champs de recherche respectifs

⁷ CREST: Competence Center for Research in Energy, Society and Transition.

que les SCCER sont encouragées à impliquer. Jusqu'à ce jour, 13 pour cent des budgets des SCCER sont couverts par les entreprises. Les SCCER entendent donc multiplier les contacts avec les entreprises. Quant aux contacts formels avec la Confédération, les cantons, les villes et d'autres organismes publics, ils sont au nombre de 125 ; ce sont eux qui assurent l'essentiel du financement des SCCER.

Malgré de nombreux contacts avec les entreprises et les institutions publiques, les SCCER semblent rencontrer des difficultés au niveau du transfert de savoir et de technologie (TST). Ces difficultés s'expliquent par le fait que les SCCER sont encore récents, mais aussi par l'immaturation des concepts de TST, par l'insuffisance des prestations TST et par la méconnaissance des prestations existantes dans les milieux de la recherche.

Pour encourager la création de liens avec l'économie et promouvoir le TST, il faut donc doter l'instrument de planification stratégique des SCCER, à savoir la feuille de route de l'innovation, de compétences et de leviers supplémentaires. Par ailleurs, il convient d'améliorer la conception, l'organisation et les performances des TST des SCCER. Enfin, on peut envisager de faire dépendre partiellement le financement des SCCER de leurs prestations TST.

Positionnement sur le plan international

Jusqu'à présent, le positionnement sur le plan international ne constituait pas une priorité des SCCER ; ces dernières ne disposent d'aucune stratégie internationale, à l'exception du module SCCER FURIES⁸.

Les partenaires du SCCER disposent, quant à eux, de réseaux internationaux performants et ont de multiples activités au plan international. Ils participent de manière plus ou moins systématique aux programmes de recherche internationaux. Durant la première période de financement, la contribution des SCCER à ces activités internationales était sans doute faible. Le rôle des SCCER consistait essentiellement à épauler les partenaires les moins bien positionnés qui souhaitaient nouer des contacts internationaux et à chercher des partenaires pour des projets internationaux. Les SCCER ont cherché par plusieurs moyens à accroître leur visibilité internationale, avec succès, selon les experts, qui confirment que les SCCER bénéficient désormais d'une meilleure visibilité. Toutefois, ce processus n'en est qu'à ses débuts.

En prévision des activités internationales futures des SCCER, les objectifs stratégiques qui sont visés avec les ambitions internationales devraient être définies de manière précise. Il s'agit en particulier de savoir dans quelle mesure l'internationalisation est un moyen pour atteindre les objectifs scientifiques des SCCER et dans quelle mesure il est opportun d'accroître leur visibilité internationale. Les SCCER sont invitées à définir puis à mettre en œuvre leurs

⁸ FURIES: Future Swiss Electrical Infrastructure.

stratégies et activités internationales en fonction de la réponse à ces questions. Il s'agira par ailleurs pour les SCCER d'être représentés dans les organisations internationales (avant tout à l'AIE) et dans les programmes de recherche (p. ex. Horizon 2020) déterminants.

Les programmes comparables de pays tiers (Grande-Bretagne, Suède, Autriche) se caractérisent par des périodes de financement plus longues, assorties d'une articulation flexible pour la reconduction ou l'interruption en fonction des objectifs atteints, ainsi que par des approches différentes de l'évaluation, qui misent davantage sur l'intensité que sur la fréquence de ces évaluations. Ces constats pourraient contribuer à piloter les SCCER à l'avenir.

3. Conclusions et recommandations

Les analyses menées dans les quatre champs thématiques conduisent aux conclusions suivantes :

- Dans les quatre champs thématiques, les SCCER sont sur la bonne voie. Les priorités adoptées sont adéquates, tout comme les conditions de base pour favoriser la collaboration interdisciplinaire, la création de réseaux avec l'économie a fortement progressé et des démarches ont été entreprises pour améliorer le positionnement au niveau international.
- Il reste d'importants progrès à accomplir dans tous les champs thématiques, notamment au niveau de la collaboration interdisciplinaire, de la création de réseaux qui impliquent les entreprises déterminantes, du transfert de savoir et de technologie et de la coopération internationale. Il convient de rappeler toutefois que les SCCER sont des organismes récents et que les développements souhaités nécessitent du temps et des efforts soutenus.
- Les objectifs stratégiques visés par les SCCER ne sont pas encore formulés explicitement. Il conviendra notamment de définir quel est l'apport souhaité des SCCER à la réalisation des objectifs de la Stratégie énergétique 2050 à court, à moyen et à long terme, en précisant les priorités en fonction des différents niveaux de maturité technologique.

La recherche d'accompagnement permet de formuler les recommandations ci-après à l'intention de la CTI et des SCCER :

1. La CTI est invitée à examiner la possibilité d'allonger les périodes de financement ainsi que d'assortir le financement de conditions relatives aux performances.
2. À la demande explicite de la CTI, les SCCER sont invités à formuler le plus explicitement possible leurs objectifs stratégiques pour chacun des quatre champs thématiques, à court, à moyen et à long terme, en ventilant si possible ces objectifs par thématiques internes des SCCER respectifs.

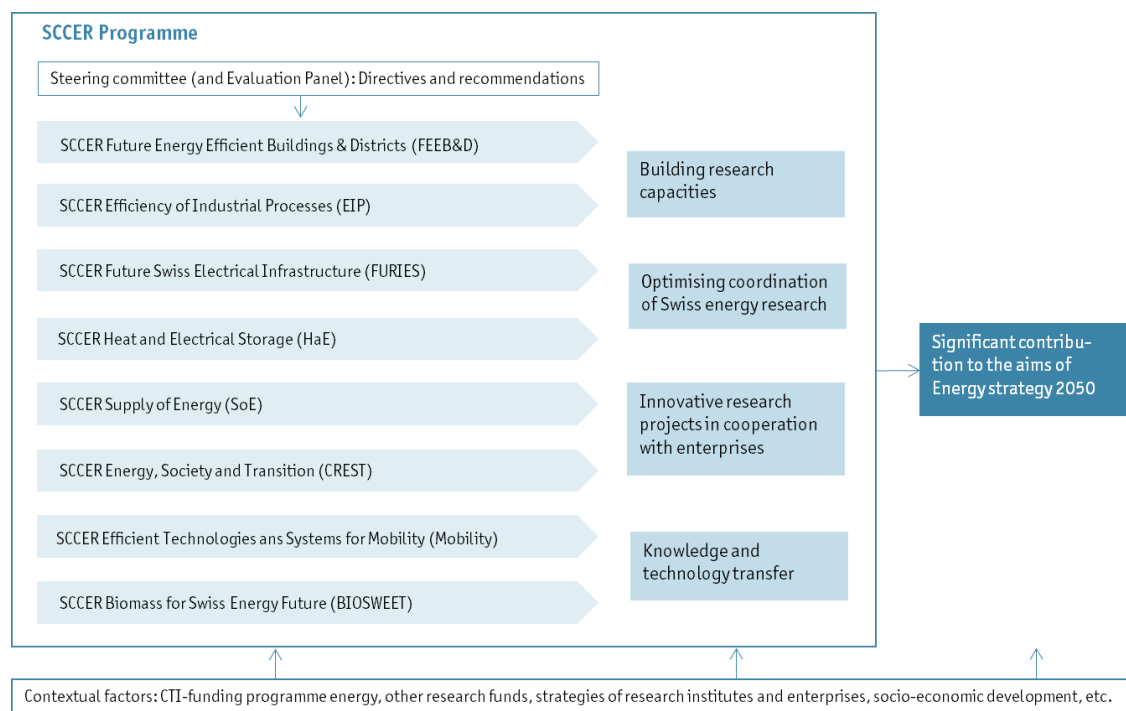
3. Les SCCER sont appelés à développer et à mettre en œuvre systématiquement les feuilles de route de l'innovation, à titre de référentiels pour le développement stratégique et le monitoring.
4. La CTI et les SCCER sont invités à étudier les possibilités de combler les lacunes thématiques et institutionnelles, dans le domaine de la recherche énergétique socio-économique surtout, en tenant compte des ressources disponibles et de la redéfinition nécessaire des priorités et des points forts. Il convient pour la CTI de reconsidérer les modalités de financement actuelles dans le but de mieux intégrer les savoirs existants à la recherche énergétique.
5. Les SCCER sont appelés à renforcer la collaboration interdisciplinaire avec le concours de la CTI, par exemple en lançant des projets phares.
6. Les SCCER doivent sensibiliser la recherche énergétique aux exigences du marché, collaborer avec les entreprises (en premier lieu avec celles qui sont déterminantes pour les SCCER respectifs) et contribuer à établir le transfert systématique et efficace de savoir et de technologie.
7. Les SCCER sont invités à soutenir davantage les activités internationales de leurs partenaires, en particulier lorsque ces partenaires participent à des programmes internationaux.

1. Introduction

1.1. Swiss Competence Centers for Energy Research (SCCERs)

The Federal Council's 'Swiss Coordinated Energy Research' action plan (Federal Council 2012) aims to promote energy research through to 2020, and thereby support the implementation of the Energy Strategy 2050. A central element of the action plan is the establishment of eight networked inter-university Swiss Competence Centers for Energy Research (SCCERs). The call for proposals was issued in 2013 (CTI 2013). This resulted in eight SCCERs, which have been active in seven priority energy-related areas since mid-2014 (see impact model in Figure 1). The Commission for Technology and Innovation (CTI) devoted CHF 72 million to the establishment of the SCCERs during the 2013–2016 period, and also received a further CHF 46 million in targeted support for energy research and development projects. If the findings of the SCCER's performance review are positive, their funding will be continued for the period from 2017 to 2020.

Figure 1: Impact model



The funding is intended to initiate new and innovative research activities, with a particular focus on applied research. The SCCERs must supplement their CTI funding with their own capital. They are also expected to raise third-party funds from the business and public sectors in order to conduct their research and innovation projects.

1.2. SCCER Accompanying Research

The work of the SCCERs is managed by a Steering Committee. The monitoring information collected by the SCCERs, as well as the evaluations and recommendations of the Evaluation Panel, are the cornerstones of monitoring and control. The CTI also commissioned the Accompanying Research which is the subject of this report. This research analysed developments in four specific areas and drafted recommendations for action to be submitted to the Steering Committee. It was conducted in five modules between August 2015 and April 2016. While Modules 1–4 examined the four themed areas, Module 5 was responsible for coordinating the research and synthesising the outcomes (see Table 1).

Table 1: Modules of the SCCER Accompanying Research

Modules	Contents	Contractor
Module 1	Thematic, institutional and knowledge value chain-related shortcomings	econcept, Zurich
Module 2	Interdisciplinary collaboration	Prognos, Basel
Module 3	Contacts with enterprises	Ernst Basler + Partner, Zurich University of Neuchâtel, Neuchâtel
Module 4	International positioning	Technopolis [group], Vienna
Module 5	Coordination and synthesis	INFRAS, Zurich

The following questions were asked in the four areas covered by the Accompanying Research (see Table 2):

Table 2: Research questions

Modules	Research questions
Module 1: Thematic, institutional and knowledge value chain-related shortcomings	<ul style="list-style-type: none"> ▪ Which institutions and actors in Swiss energy research which are relevant to the coverage of the designated SCCER research areas are not involved in the SCCERs? Are there any relevant thematic or important value chain-related shortcomings ▪ For what reasons do certain relevant research actors not participate in the SCCERs? What are the reasons that certain topics and elements of the knowledge are not sufficiently covered? ▪ What recommendations can be drawn concerning the identified gaps and the need for improvement in certain aspects with regard to the next funding period?
Module 2: Interdisciplinary collaboration	<ul style="list-style-type: none"> ▪ How does interdisciplinary collaboration develop (particularly with regard to social sciences and natural/engineering and technical sciences within SCCER or between SCCERs)? ▪ Was there new collaboration across the scientific disciplines? Where did this arise? Are the partners always the same ones? Of which type(s) are the new working structures? ▪ Which aspects support or obstruct interdisciplinary collaboration? ▪ What expectations do researchers have with regard to other scientific disciplines? How and why do expectations change? ▪ What should be improved with respect to interdisciplinary collaboration?

Modules	Research questions
Module 3: Contacts with enterprises	<ul style="list-style-type: none"> ▪ How are the SCCERs linked-up with private enterprises and institutions such as cantons, municipalities and public-sector enterprises? ▪ Have the SCCERs led to researchers establishing contact with partners they did not know before? ▪ Do the SCCERs involve the most important partners in the economy? ▪ What is the nature of contact with small and medium sized enterprises (SME)? What factors hinder or favour contact with small and medium-sized enterprises (SME)? Is there a need for special measures to increase contact with SME? ▪ How is the formal knowledge and technology transfer (KTT) organised by the SCCERs? What lessons can be drawn for the next SCCER funding period? ▪ How should the SCCERs improve contact with enterprises and public-sector institutions?
Module 4: International positioning	<ul style="list-style-type: none"> ▪ How are the individual SCCERs positioned internationally? How well are they linked with partners abroad? To what extent do they cooperate with international energy and climate programmes? ▪ To what extent have the individual SCCERs managed to establish themselves as competence centres in their fields? What are their specific strengths/deficits? ▪ What strategies are effective? What recommendations can be drawn for the SCCER Steering Committee? ▪ What are the strengths and weaknesses compared to other international programmes? Are there specific lessons to be learned from similar programmes abroad?

The research teams used a variety of methods to answer these questions:

- Desk research, in particular SCCER monitoring documents, SCCER evaluation reports, applications made by the SCCERs and SCCER innovation roadmaps (all modules);
- Interviews with various experts (all modules);
- Online survey aimed at all researchers at the SCCERs (Modules 2 and 3);
- Focus groups with researchers and senior researchers at the SCCERs (Module 2);
- Three case studies of international programmes similar to the SCCERs (Module 4);

The findings of Modules 1–4 are summarised below on the basis of the individual module reports (Sections 2 to 5). Cross-thematic conclusions are then drawn, and recommendations formulated for the attention of the CTI (or the SCCER Steering Committee) and the SCCERs themselves (Section 6).

2. Module 1: Thematic, institutional and knowledge value chain-related shortcomings

Module 1 examined thematic, institutional and knowledge value chain-related shortcomings at the SCCERs. Based on the report produced by econcept (2016), the key findings and recommendations are presented below. The following aspects must be considered when interpreting these findings:

- First, the SCCERs have not been in existence for very long. It is thus very early to be evaluating shortcomings in the knowledge value chain, in particular.
- Second, in the process surrounding the call for proposals, the SCCERs were asked to determine their particular thematic and institutional focus. The aim was to ensure innovative and efficient research with high added value for the Energy Strategy 2050, which requires a critical volume of resources to be available per topic and research unit to pursue these targets.
- Third, many of the identified shortcomings are relative, depending on the targets the research is pursuing (here given by the targets of the Energy Strategy 2050) and on the available resources. Hence, the evaluation of the integration of research institutes, thematic coverage, and analysis of the knowledge value chain had to focus on 'relevant shortcomings' with respect to the framework conditions and the restrictions of the SCCER programme.

2.1. Key findings

General conclusions

The following general conclusions may be drawn from the analysis of the SCCERs' shortcomings:

- Considering the thematic objectives laid down in the call for proposals for 2013–2016 and the available financial resources, the SCCERs have, on the whole, set suitable thematic and institutional priorities for their work. Relevant gaps exist in particular in the fact that the organisation of applied research in photovoltaic and solar energy is unclear, that socio-economic research in the technical SCCERs is inadequate, and that there are shortcomings in knowledge and technology transfer (KTT).
- There is no clear definition of the technological direction that the SCCERs are expected to take. They are intended to make rapid, tangible contributions to the attainment of Energy Strategy 2050 targets (research with a high 'technology readiness level' TRL). At the same time, however, they are called upon to produce new and innovative solutions that will take time for the market to adopt (research with a low TRL).
- The terms of the call for proposals proved difficult for the universities and universities of applied sciences (UAS). Various UAS institutes and some universities decided not to participate

in the SCCERs owing to the short application period and the funding arrangements, such as substantial self-funding and in-kind contributions. Furthermore, non-academic private energy research organisations do not receive funding and are de facto excluded from direct participation. Therefore, not all of the corresponding expertise is integrated in the SCCERs, especially with respect to socio-economic, policy and implementation research in the area of energy research.

Main shortcomings

In view of the objectives laid down in the call for proposals for the SCCERs, the following thematically relevant shortcomings were identified (see Table 3):

Table 3 Thematic shortcomings

Thematic shortcomings	Explanations
Organisation of applied photovoltaics (PV) and solar energy research is not clear	<ul style="list-style-type: none"> ▪ PV was intentionally excluded from the SCCER bid. There is a distinct CSEM⁹-PV network, which is funded separately. Although some PV research is conducted in SCCERs FEEB&D and FURIES, PV does not seem to be integrated fully into the SCCER networks. In addition, the degree of collaboration with the CSEM network is not clear. ▪ As a consequence of current priority setting, the other solar research areas (solar thermal, etc.) are somewhat disconnected from the SCCERs. There is no systematic approach, taking into account all solar technologies, storage (reloading) technologies and smart control.
Use of electricity and its efficiency potential is not addressed	<ul style="list-style-type: none"> ▪ Efficiency in electricity applications is regarded a significant research topic, which could be dealt with in SCCER EIP
Lack of research on mid-sized/small hydropower	<ul style="list-style-type: none"> ▪ Mid-sized/small hydropower plants have a comparatively high relevance in the implementation of the Energy Strategy 2050 (1–2 TWh/a). Whether SCCER SoE should strengthen its efforts in this area, even though the topic is not first priority, must be clarified
No hydro-geothermal energy (HGTE) research	<ul style="list-style-type: none"> ▪ HGTE is regarded as a significant research topic. The partners within SCCER SoE already have most of the required competences. It is not clear whether the limited research funds are to be shared between petro-thermal and hydro-geothermal energy research.
Inadequate socio-economic research	<ul style="list-style-type: none"> ▪ There is an explicit focus on socio-economic research in the SCCER CREST. Only a few other SCCERs are doing sufficient socio-economic research in their thematic fields. ▪ CREST basically has its own agenda. Collaboration must be developed between the SCCERs and CREST on SCCER-specific socio-economic research topics. ▪ The relevance of socio-economic research will tend to increase the longer the SCCERs are in operation, and the higher the TRL of their research.

⁹ CSEM: Swiss Centre for Electronics and Microtechnology.

Thematic shortcomings	Explanations
Sufficiency topic not adequately addressed	<ul style="list-style-type: none"> ▪ The sufficiency issue is not addressed in current SCCER research roadmaps. In SCCERs CREST, MOBILITY and FEEB&D, the sufficiency issue is expected to become even more relevant in the future.
Insufficient support for pilot and demonstration projects	<ul style="list-style-type: none"> ▪ Several SCCERs claim that they do not get enough funding for pilots and demonstration projects, which are typically expensive. ▪ However, this problem may instead indicate that implementation and industry cooperation are not yet sufficiently developed. The question is whether or not it is appropriate to reallocate substantial funds away from SCCER research, application and implementation, and towards single pilots.

The most significant institutional and knowledge value chain-related shortcomings can be summarised as follows (see Table 4):

Table 4: Institutional and knowledge value chain-related shortcomings

Institutional shortcomings	Explanations
Insufficient integration of universities of applied Sciences (UAS) and universities	<ul style="list-style-type: none"> ▪ Several research institutions, and related researchers from UAS, were excluded during the SCCER tendering process. This was partly a result of unavoidable priority setting, which makes sense.
Insufficient integration of private research	<ul style="list-style-type: none"> ▪ To make use of existing expertise from established private research organisations – especially in the fields of socio-economic research as well as implementation, policy design and assessment research – the funding rules for private researchers would have to be changed to create a level playing field. ▪ With the rising TRL of technological research, the integration of private socio-economic research will be of increasing relevance to the Energy Strategy 2050.
Knowledge value chain-related shortcomings	Explanations
Insufficient involvement of industry, SMEs, practice partners and policymakers	<ul style="list-style-type: none"> ▪ Existing cooperation and collaboration with industry and practice partners should be extended, and new partnerships established. ▪ As TRL increases, this becomes more important, and easier.
Knowledge and technology transfer (KTT) is insufficient	<ul style="list-style-type: none"> ▪ KTT is still insufficient and not established in all of the technology oriented SCCERs. Some of the SCCERs do not yet have effective KTT concepts and staff. ▪ The proportion of research activities that the SCCERs devote to higher TRL projects will increase the longer the SCCERs are active. KTT, as well as the development of market solutions and implementation, will therefore gain in importance.

2.2. Recommendations

The following recommendations for action to close the identified gaps can be made to the CTI and the SCCERs:

- Since it is up to the SCCERs to decide on the research strategy, the correspondent topics and the resources allocated to the different topics, the CTI should verify if the research topics

and the share of topics with low and with high TRL are adequate and promise to optimally contribute to the objectives of the Energy Strategy 2050.

- Funding conditions for UAS and universities, as well as for private non-academic research organisations, are complicating participation on the part of UAS and universities, and may even be excluding private research institutions. If high contributions to the Energy Strategy 2050 in the short and medium run are the objective, the funding conditions for UAS, universities and private research institutions must be reconsidered and modified to encourage their participation.
- Reconsider the relationship between the SCCER networks and the PV network for the second funding phase of the action plan. Solar energy in general (including solar thermal) should be given more attention, and efforts should be made to push a systemic approach to exploiting solar energy, combined with storage and smart control technologies.
- Reconsider the implementation of the topic of efficiency in electricity applications in the SCCER EIP in the second phase, bearing in mind the available resources and the prioritisation that are required. Check cooperation with CREST to overcome the main barriers to implementing known technologies.
- Foster socio-economic research within the technical SCCERs and foster joint projects between CREST and technical SCCERs in the second funding phase –at least in/with those SCCERs which have not yet developed adequate socio-economic research, namely EIP, HaE, MOBILITY and BIOSWEET.
- Existing cooperation and collaboration with industry and practice partners should be extended. Ensure that sufficient importance is attached to this requirement in the second call for funding and the subsequent assessment of applications.
- Ensure the continued development of KTT activities and ensure that there are dedicated KTT staff in the second funding phase.
- Reconsider
 - the integration of research on mid-sized/small hydropower in the SCCER SoE;
 - whether the sufficiency issue is adequately addressed in the SCCERs CREST, MOBILITY and FEEB&D;
 - whether pilots and demonstration projects truly need and deserve additional funding;
 - the feasibility and expedience of the integration of researchers from different UAS¹⁰, especially in the light of TRL tending to increase in the future.
- It makes sense to

¹⁰ Zurich University of Applied Sciences (ZHAW), University of Applied Sciences Western Switzerland (HES-SO), University of Applied Sciences and Arts of Southern Switzerland (SUPSI) and University of Applied Sciences and Arts Northwestern Switzerland (FHNW)

- focus on petro-thermal geothermal electricity and combined heat production. Hydro-thermal geothermal energy might profit from possible synergies from this research;
- waive wood combustion research within the SCCERs as long as there are other (non-SCCER) wood combustion research funds.

3. Module 2: Interdisciplinary collaboration

Module 2 analysed the development and status of interdisciplinary collaboration within and between the SCCERs. Based on the report produced by Prognos (2016), the key findings and recommendations are presented below.

First of all, it must be said that the overarching objectives that interdisciplinary collaboration is intended to achieve are defined in relatively open terms. Specifically, it is not clear how this collaboration should contribute to the short-term aims of (1) promoting the division of work and scientific collaboration in research and development and (2) covering the whole innovation chain and technology readiness level (TRL), or the long-term objective of (3) developing holistic innovations (scientific, technical, socio-economic, and energy policy). Second, it must be remembered that it takes time to set up and to develop interdisciplinary collaboration.¹¹ In the experience of the SCCERs, creating a common understanding of the task at hand and establishing resilient and useful partnerships takes at least a year. That is when the partners can begin to develop shared approaches and to work together on producing outcomes. Since interdisciplinary collaboration on the SCCERs' research work is still at a very early stage, it is too soon to expect the partnerships to produce any major findings.

3.1. Key findings

Development of interdisciplinary collaboration

Backing for the SCCERs should be understood as a means of stimulating interdisciplinary collaboration in energy research. The establishment of the SCCERs created a favourable framework for a concerted energy research effort involving researchers from a variety of disciplines and research institutions: the SCCERs not only provide an institutional framework for collaboration,

¹¹ This is also confirmed by experience at the international level (see the experience of the UK Energy Research Centre UKERC, Section 4).

but themselves are made up of a mix of different disciplines.¹² Furthermore, all of those concerned display openness and a willingness to cooperate with colleagues from other research areas.

By working together to determine the focal points of research, and to develop and plan research projects, researchers gradually acquire a common understanding of what their work is intended to achieve. This approach also educates an energy research community (within the SCCERs) which at present is still heavily biased towards the actual types of technology rather than their practical application. The natural consequence of this is that researchers acquire a systemic perspective of their own field of work. The development of joint research and development strategies under the aegis of the SCCER-specific innovation roadmaps is regarded as one of the key outputs of interdisciplinary collaboration to date.

New interdisciplinary collaboration

The establishment of the SCCERs has led to new partnerships both internally and externally. Two thirds of the new partnerships are interdisciplinary in nature, with this horizontal factor particularly marked in one third of all cases. With the latter, more than half of the new partners are drawn from other scientific fields. Almost all interdisciplinary collaboration projects involved new partners. All in all, the new partnerships are broadly based and do not concentrate on a small number of partners. Informal contact and the contact networks of other SCCER partners is very important in attracting new collaboration partners.

In the great majority of cases, new partnerships are motivated by pragmatic, research-related reasons. Raising the level of scientific excellence, accelerating research, securing the required specialist capabilities and access to scientific infrastructure are seen as particularly important. By contrast, comparatively little significance is attached to covering the whole value chain or transferring research to the market.

Most of the new partnerships have been formalised by being attached to an SCCER or via the corresponding work plans. Joining forces to produce outcomes in certain sub-areas, the transfer of methods and instruments, and working together on formulating shared research strategies are all important objectives for this collaboration. This is another indicator that most of the partnerships designed to be interdisciplinary.

¹² It should be added here that social sciences are concentrated within SCCER CREST, but remain a niche area in all other Centers. However, this makes sense in view of the aim of making CREST a crystallisation point for social scientific research, and encouraging the other SCCERs to cooperate with CREST when tackling research issues in the social sciences field.

Success factors, barriers and expectations of interdisciplinary collaboration

A critical mass of committed and motivated energy researchers, working within the research, networking and reciprocal learning framework that is offered by the SCCERs, is one of the factors in the success of interdisciplinary collaboration. The development of innovation roadmaps is a further crucial aspect because this work helps to create a common understanding of the task at hand and supports the development of a systemic perspective. The networks with other researchers that are built up on the strength of personal relationships are a further important success factor. The main barriers are funding criteria that are geared to technology projects (or, more accurately, the financial restrictions that result), the fact the SCCERs concentrate on immediate results and effects (i.e. they are very output-focused), and the size of the SCCERs. The latter factor often means that information is not distributed as it should be, and that the Centers lack the project management skills to coordinate several strategic and operational projects at once.

Almost all of the researchers who are active within SCCERs regard interdisciplinary collaboration as necessary for their own work. They expect it to open up new opportunities, to foster the transfer of methods or theories, and to lead to the development of shared research strategies. Collaboration should also improve the quality of research and development, as well as its findings. While those in natural sciences have relatively high expectations in terms of the transfer of methods and instruments, those in social science fields expect other disciplines to have less of an influence on research strategies, methods and tools.

3.2. Recommendations

From the point of view of its general objectives, interdisciplinary collaboration can be improved as follows (see Table 5).

Table 5: Recommendations for improving interdisciplinary collaboration

	Recommendations
General recommendation	<ul style="list-style-type: none"> ▪ The overarching aims that interdisciplinary collaboration is intended to pursue should be defined in more explicit terms. It should be clear whether the interdisciplinary approach is to generate project-level results as quickly as possible, or whether the goal is to have more of a long-term effect, such as the gradual coalescence of a comprehensive energy research community to promote holistic innovation.
Recommendations to improve the division of work and scientific collaboration in research and development (objective 1)	<ul style="list-style-type: none"> ▪ The dissemination of information within the SCCERs should be improved to make researchers more aware of the uses and added value of interdisciplinary collaboration, and to encourage a systemic view of the technological field in which the individual SCCER works. ▪ The role of SCCER CREST, which is somewhere between an independent research and a service-only unit, must be defined in clearer detail. Furthermore, the other SCCERs must be better informed about CREST's specific skills and capabilities. ▪ Since funding for interdisciplinary collaboration tends to be rather short-term and

Recommendations

technology-oriented under the present funding criteria, the SCCERs should be used as a test platform for new forms of collaboration, including the financial aspects.

- Greater use should be made of SCCER lighthouse projects to present and communicate the added value of interdisciplinary collaboration. These 'lighthouses' may serve as an inspiration and model for further interdisciplinary work.
 - Project management capabilities should be strengthened in specific areas. This might also encourage the strategic application and further development of project outcomes.
-

Recommendations regarding coverage of the whole innovation chain, and technology readiness level (TRL)

- The innovation roadmaps have a strategic role in the development, planning and management of research projects along the entire innovation chain. These roadmaps should thus be revised and enhanced on a regular basis in a process which includes interdisciplinary dialogue within the SCCER. They should also be distributed actively, as a means of motivating researchers and educating the energy research community, in addition to their strategic management function.
 - Interdisciplinary approaches should also be used to implement more effectively the roadmaps' systemic view of the different technological fields. The role of pilot and demonstration projects (e.g. 'Living Labs'), the way in which they are integrated into research and development planning, and how they might be funded should be examined in particular.
-

Recommendations regarding holistic innovations

- Where holistic innovations over a longer time horizon are concerned, it is important to draw up strategic plans for the individual research and development phases which include the necessary interdisciplinary requirements. These plans should be sufficiently flexible to adapt appropriately to the unforeseeable factors of the innovation process.
 - It might be helpful if each SCCER were to develop its own identity, which would then encourage the researchers to identify with its particular objectives.
-

4. Module 3: Contacts with enterprises

The central task of the SCCERs is to conduct applied research in collaboration with enterprises. In addition, research results generated by the SCCERs are to be shared with private enterprises and public-sector institutions for use in the development of commercial applications. In order to facilitate these tasks, the SCCERs are required to network with enterprises and public-sector institutions and to pursue knowledge and technology transfer (KTT). In return, the enterprises and third partners are expected to contribute at least 20% of the SCCERs' total funding.

Module 3 analysed how successful the SCCERs were in establishing contacts with enterprises and public-sector institutions. In addition, it assessed SCCER-specific KTT concepts and organisations. Contacts with enterprises and public-sector institutions might be formal or informal:

- Formal contact takes the form of contractual agreements that define a shared goal and the corresponding obligations.

- Informal contact takes place at a personal level between researchers and representatives of enterprises or public-sector institutions.

Based on the report from EBP and the University of Neuchâtel (2016), the key findings from and recommendations on Module 3 can be summarised as follows.

4.1. Key findings

Formal contact with enterprises

By the autumn of 2015, the SCCERs had succeeded in establishing 329 formal contacts with 259 domestic and foreign-based enterprises of various sizes. Many of these were new ones for the SCCER leaders. Except for one SCCER, all SCCERs had more formal contact with enterprises in 2015 than they had planned to establish in 2013. Within three years, the SCCERs were thus able to establish a substantial number of formal contacts, in many cases with new partners, and the number is still growing.

The high number of contacts nonetheless contrasts with the finding that less than 40% of all respondent SCCER leaders have been able to involve all or at least most of the key enterprises in their specific field. The main obstacles are the difficult economic circumstances of the corporate sector, existing partnerships with other SCCERs or universities, and the desire of the companies concerned to have an exclusive arrangement.

The corporate sector collaborates with the SCCERs in many different ways. The most frequent form of support is financial. More than 35% of all formal contacts contribute funding for the SCCERs' research, and enterprises and third parties have accounted for 13% of the total SCCER funding so far. Other important forms of support include the provision of data and models, as well as the use of infrastructure (with or without additional funding).¹³ Expectations with regard to contributing market experience to research and joint technology development could not be met, however. In addition, 56 enterprises only signed a letter of intent, without any subsequent contribution in kind or cash.

Of all the enterprises with which the SCCERs have contact, half are small and medium-sized (SMEs). Whereas large enterprises more often offer funding than contributions in kind, it is the opposite for SME. That said, it is not possible to generalise about which size of enterprise is generally best for the SCCERs. Depending on the thematic field, the research targets and the

¹³ This finding is in line with that concerning enterprises' participation in the outputs of the SCCERs. Most outputs are models and data (around 100 products in two years). In around 40% of the cases, enterprises helped to create these models or were able to use research data for their product development. More than half of the 80 or so prototypes were developed and installed in cooperation with enterprises. In contrast, patents and licences as well as spin-offs are rarely reported.

economic sector, an SCCER might find large companies or SMEs the more suitable cooperation partner. More than two-thirds of SCCER leaders would like to involve more SMEs. Obstacles are the lack of sufficient financial and human resources for cooperation, differing opinions on how research and development processes should work, and uncertain economic prospects for many SMEs.

Two-thirds of the SCCER leaders rate contact with enterprises as significant or even highly significant for their work. The main reason for initiating this contact is to obtain (1) technical expertise and patents; (2) process and production skills; and (3) additional funding.

Personal (i.e. informal) contacts are the most important way of establishing formal contact between the SCCER leaders and enterprises. This is followed by previous experience working together on joint projects and publications. Surprisingly, almost half of the SCCER leaders state that it was the enterprises that initiated contact. However, the findings also show that the SCCERs are using only a small number of typically academic approaches to contacting enterprises.

More than half of the SCCER leaders believe that contact with enterprises needs to be expanded and intensified to reach the goals of the SCCERs.

Formal contact with public-sector institutions

The SCCERs have established 125 formal contacts with the Confederation, cantons, cities and other public-sector institutions. Most contacts (over 80%) are related to funding. Two-thirds of the SCCER leaders state that these contacts are significant or highly significant for their work. In consequence, many SCCER leaders would like to expand contact with public-sector institutions (64%) and to improve existing relationships (54%).

However, in view of the relatively low number of contacts and their clear focus on funding, KTT experts doubt that the SCCERs are really aware of the importance of the public-sector institutions. They thus suggest, in addition to increasing and intensifying the contacts, that the SCCERs consider the importance of public-sector institutions as political actors and as users of new technologies.

Informal contact with enterprises

Almost two-thirds of all SCCER researchers maintain regular informal contact with enterprises. Most of the other third has at least selective informal contact with firms' representatives. However, most of the researchers do not have more than ten such contacts.

Informal contacts are an important means of establishing formal contact: 80% of researchers say that at least some of their informal contacts have turned into formal ones. Hence, a large majority of the researchers rate informal contacts as significant or highly significant for

their work, and many would therefore like to step up existing relationships and establish more informal contacts.

Knowledge and technology transfer (KTT)

Research results generated by the SCCERs should be shared with enterprises and public-sector institutions for use in the development of commercial and institutional applications. However, almost two-third of research results have yet been put to use by these bodies. Although the inherent transferability of the research results was not been assessed, this could indicate that the SCCERs face difficulties with KTT. The reason for this appears to be a lack of KTT concepts, weaknesses in the organisation of the KTT unit and an lack of awareness among researchers of KTT services:

- Most of the KTT concepts are not state-of-the-art and, and are supply-side-driven. Hence, they take only limited account of possible business needs. Some KTT concepts are a poor fit with the innovation roadmap.
- KTT does not appear to be a priority within the SCCERs. Not all KTT managers work full time, and there is only one SCCER that combines its KTT services with those of existing KTT organisations and networks. One-third of the SCCER leaders and half of the researchers are not familiar with the KTT concept (or the services their SCCER provides to support KTT).
- The SCCERs lack professional sales methods to link up with private enterprises and to respond to enterprises' demands.

4.2. Recommendations

The following recommendations are to be submitted to the SCCERs with the aim of improving the effectiveness of their networking and KTT activities in the short term (i.e. by the end of 2016):¹⁴

- Scale up efforts to establish new formal contacts and transfer existing research results, for instance by (1) information campaigns in the context of existing formal and informal contacts, and (2) initiating joint projects with informal contacts.
- Promote and increase the visibility of KTT services and develop strategic plans for promoting transfer in the context of each research project.
- Advertise SCCER services in a manner geared to reach representatives of enterprises and public-sector institutions.

¹⁴ The findings of Module 1 also indicate that collaboration with industry and practice partners, as well as KTT concepts, resources and activities, should be strengthened (see Section 2).

The following measures are recommended for the continuation of the SCCER programme in 2017:

- Seek to enhance the significance, standards and implementation of the innovation roadmap as a strategic planning instrument. The advantages of the innovation roadmap must be communicated internally and externally. Its implementation should be strictly monitored and reported.
- Restructure SCCER KTT-units with
 - a clear strategy for sales in accordance to the innovation roadmap;
 - hiring of professional KTT-managers with a market background;
 - offering trainings for researchers about basic KTT-knowledge;
 - external information about SCCER and its success stories.
- Introduce partially performance-based funding by taking into account SCCER specific research areas.

5. Module 4: International positioning

Module 4 aims to assess the international position of the SCCERs and to compare the SCCER programme with similar programmes in other countries. Based on the report from Technopolis (2016), the key findings and recommendations are as follows.

5.1. Key findings

International positioning of the SCCERs

First of all, it must be stated that the objectives with regard to the SCCERs' international positioning have not been formulated in explicit terms. However, it has been possible to derive them as follows from programme documents and interviews: (1) participation in international programmes; (2) increased effectiveness and efficiency of research; and (3) the international visibility of the SCCERs. Internationalisation is one of the many elements in the SCCERs' objective of helping to implement the Energy Strategy 2050.

With the exception of SCCER FURIES, which has a written internationalisation strategy, internationalisation is not currently a priority for the SCCERs. However, most have set themselves objectives in this area now the basic capacity-building stage is over.

All SCCERs – or rather their members – undertake international activities and have international links:

- Participation in international programmes is an effective way of accessing knowledge-generation abroad, pooling resources, creating synergies, learning from each other and avoiding

duplication, thus boosting the effectiveness and efficiency of research. The research projects that have been launched since the SCCERs' establishment include Horizon 2020 projects, national projects with the participation of international universities or firms (NRP 70¹⁵, CTI innovation projects), contract research paid for by industry, and a number of projects in the context of the International Energy Agency (IEA), etc.

- SCCER partners are involved in international programmes to varying degrees. In some instances, greater efforts should – and presumably will – be made in the future now that the SCCERs have been consolidated. It must be remembered that the SCCERs have only been in existence for two years, and that they will benefit in different ways from participating in international programmes because they work in different fields. SCCERs are also quite involved in the IEA.
- Being integrated in international networks is generally essential to participate in international programmes. Experts have confirmed that many of the individual researchers and research groups that form the SCCERs have excellent international links. This is particularly true of the universities and the ETH domain. However, most of these networks go back to before the establishment of the SCCERs. SCCER partners that have good international links do not need the SCCER to internationalise. The role of the SCCERs might nonetheless be to provide SCCER members that have fewer international contacts, such as young researchers or universities of applied sciences, with a network that they can use.
- Another way in which the SCCERs add value in terms of internationalisation is that they permit a coordinated approach to conference attendance, and participation in panels and committees (e.g. at the IEA) and international calls for proposals, while also facilitating joint EU and other international proposals involving several SCCER partners.
- Overall, SCCERs have built up significant energy research capacity in the past two years. This will presumably translate into more (international) project applications and projects, and eventually into conference papers and publications in the coming years. These research outputs will all be due to – or have close links with – the SCCERs.

All of the SCCERs have undertaken a range of activities to increase their international visibility. These have included presentations at international conferences, organising international workshops and conferences, and presenting the SCCER in international newsletters. SCCER heads report that they are accorded a higher standing in national and international communications because, as the head of an SCCER, they represent the whole of Swiss energy research in a given area. Indeed, the SCCERs consist of partners with a high reputation in their own right. Experts

¹⁵ National Research Programme (NRF) 70 – Energy Turnaround.

have confirmed that SCCERs have gained a degree of international visibility, but the process is only beginning. It will take time, and a systematic effort on the part of the SCCERs, for them to be perceived as organisations in their own right – in particular at the international level. Whether or not international visibility is actually desirable, given that the SCCERs are funded only for a defined period and consist of partners with a good to world-class reputation, is a valid question. It may be enough for SCCERs to focus on participating in international research and innovation projects, thus improving the effectiveness and efficiency of research.

Given that the SCCERs have not been in existence for very long, and taking into account that internationalisation is not currently a priority for most of them, it is too early to assess the effectiveness of any strategies or activities. Nevertheless, it is evident that certain activities help increase international visibility and networking, such as presenting the SCCER and its research agenda at international conferences, the consistent use of the SCCER logo in external communications and, last but not least, participation in the IEA and other international programmes.

International comparison of programmes

To learn from international experience, the SCCER programme was compared with the UK Energy Research Centre (UKERC), the Swedish competence centre programmes, and the Austrian competence centre programme (COMET). The main results can be summarised as follows:

- The UKERC, which resembles the SCCERs most in its set-up, shows that coordination in a decentralised network of research organisations is time-consuming and requires sufficient funding. Similarly, interdisciplinary work needs time, effort and dedicated resources, and must be integrated into structures. An important success factor is to include people who are bridge-builders and are motivated to work in an interdisciplinary setting.
- Swedish and Austrian competence centres differ from the SCCERs in that industrial partners are much more closely integrated. Rather than participating on a project basis and being part of the (advisory) board, industry partners are an integral part of the competence centre together with the university partner. They also co-fund the centres, providing a third of the total in the case of Sweden, and half in the case of Austria (part of it in kind). The danger of a network structure consisting solely of research organisations (such as the UKERC and the SCCERs) is that it is very much focused on (basic) research, following the logic and incentives of the academic system to the detriment of industrial relevance. Hence, it is important for the CTI to insist on the involvement of industry and other users, such as relevant public-sector institutions and NGOs.

- In all three countries, funding periods are longer than for the SCCERs, for which the first was effectively three years (2014–2016)¹⁶ and the second will be four (2017–2020). At the UKERC the funding period is five years, with the Centre now in its third funding period. In Sweden, the first competence centre programme ran between 1995 and 2005. The funding period for the current generation of competence centres run by the Swedish Energy Agency is four years. The Swedish Energy Agency's competence centres have no maximum funding period, however. Centres will continue to be funded as long as there is a need for their results, and as long as they are in line with the Energy Agency's strategy. In Austria, the funding period is eight years, but an evaluation is conducted after four years to decide whether or not to continue funding. After eight years, competence centres can re-apply for support.
- While the monitoring arrangements are similar across all countries, the evaluation regime in Switzerland differs from that in the other countries. In Switzerland, SCCERs are evaluated once a year. The evaluation consists of a site visit by an evaluation panel, based on the annual monitoring reports provided by the SCCERs themselves (informed peer-review). In the other countries, evaluations normally take place at the end of the funding period, and they tend to be more comprehensive.

5.2. Recommendations

The following recommendations emerge from the analysis of the international positioning of the SCCERs and the international comparison of programmes:

- The starting point for an SCCER is an attractive research agenda which credibly underpins Swiss energy transition with international activities as a means to achieving this end. Against this background, it is important to establish what strategic internationalisation objectives are relevant for the SCCERs, and why. Since SCCERs are temporary and composed of internationally well-known Swiss institutions, a national format may perhaps be sufficient. SCCERs would thus take the form of national centres (1) linking the major actors in their fields; (2) creating a broad and coordinated research agenda; and (3) executing it in a coordinated fashion.
- If and when the SCCERs sets explicit internationalisation objectives, they should develop their own international strategies and activities in line with the objectives and the SCCER's own field. The CTI should hold them accountable for their internationalisation objectives.
- If the SCCERs set internationalisation objectives, it is important for them to harness their value added to a greater degree. The SCCERs should support their members in their international activities, e.g. providing them with international contacts if they do not have them,

¹⁶ The first funding period was 2013–2016. However, since the SCCERs did not begin until 2014, it was reduced to three years.

coordinating international conference and programme participations, and facilitating international proposals.

- Irrespective of the above, SCCERs will need to be represented in certain international policy/advisory forums, in particular those of the IEA, and in certain research programmes (e.g. Horizon 2020) and initiatives, as appropriate for the individual SCCER. This is important for the SCCERs (and Switzerland) to access complementary knowledge, integrate into international networks, and simply be aware of what is going on, in terms of both energy policy and research.
- As the international examples have shown, longer funding periods may be desirable in the case of SCCERs, to allow them to focus on their work and fulfil their objectives. It may also be worthwhile considering a flexible approach to continuing or stopping funding for SCCERs, depending on the achievement of objectives. If such an approach is chosen, it is important to use the evaluation results as evidence-based policy intelligence.
- In the light of international experience, the CTI might consider commissioning a comprehensive evaluation before the end of the second funding period. This evaluation should focus on benefits for centre participants (outcomes) and stakeholders in the broader sense, such as universities and industry (impacts).

6. Conclusions and recommendations

6.1. Conclusions

The findings on the four areas of the Accompanying Research led to the following conclusions:

- Where the four areas examined are concerned, the SCCERs are on the right track. They have set suitable priorities, created a good basis for interdisciplinary collaboration, achieved considerable progress on networking with business and public-sector institutions, and made efforts with regard to their international positioning.
- There is still (substantial) room for improvement on all four areas, however. This is particularly true of the need to:
 - close relevant thematic and institutional gaps, especially with regard to the organisation of applied research in photovoltaic, the inadequate socio-economic research in the technical SCCERs and the integration of UAS and private research organisations;
 - reinforce interdisciplinary collaboration by means of better dissemination of information, the clear definition of the role of the SCCER CREST, the use of the SCCERs as a

test platform for new forms of cooperation (including the financial aspects), encouragement for lighthouse projects, efforts to strengthen project management skills, and moves to foster a systemic perspective;

- intensify collaboration with existing enterprises and establishing new formal contacts with others, especially with major companies in the SCCER's specific fields, the primary aim being to conduct joint research projects;
 - step up efforts to strengthen knowledge and technology transfer through improvements to KTT concepts, services and organisation;
 - foster international cooperation, especially with regard to participation in international networks and programmes.
- It must be remembered that the SCCERs have not been in existence for very long, and that progress in the areas covered here will take time and systematic effort. This is particularly true of reinforcing interdisciplinary collaboration and international cooperation. To strengthen efforts in the four areas, the innovation roadmaps should be developed further and used even more as a strategic planning instrument. Moreover, they could be combined with performance-oriented elements in financing. In addition, international experience indicates that it might be worthwhile considering a longer funding period with a flexible approach to continuing or stopping funding.
 - The strategic objectives that are to be pursued in the four areas have still not been formulated in specific terms. In particular, there is a need to determine what contributions the SCCERs should make towards Energy Strategy 2050 targets in the short, medium and long term – including priorities between the different technology readiness levels (TRLs) of research outcomes. Individual priorities between TRLs and the timing of expected contributions must be set for each SCCER and the topics addressed by that SCCER.

6.2. Recommendations

On the basis of this Accompanying Research, the following general recommendations for action can be made to the CTI and the SCCERs.

1. The CTI should consider longer funding periods (with a flexible approach to continuing or stopping funding) and performance-oriented elements in financing.
2. In response to a specific request from the CTI, the SCCERs should set out as clearly as possible the strategic objectives that are to be pursued in the four areas in the short, medium and long term, possibly differentiating between the topics within their particular SCCER.
3. The SCCERs should systematically refine and implement the innovation roadmaps as a framework for strategy development and monitoring.

4. The CTI and SCCERs should investigate whether or not the thematic and institutional gaps that have been identified (especially regarding the organisation of applied research in photovoltaic, the inadequate socio-economic research in the technical SCCERs and the integration of UAS and private research organisations) can actually be closed, bearing in mind the available resources and the prioritisation and focus that are required. The CTI should verify current funding terms to further integrate existing energy research knowledge.
5. With the support of the CTI, the SCCERs should strengthen interdisciplinary collaboration (inter alia by means of better dissemination of information, clear definition of the role of the SCCER CREST, encouraging lighthouse projects and fostering a systemic perspective),
6. The SCCERs should strengthen awareness about their market approach, involve business – especially major companies in the SCCERs’ specific fields – more closely and foster the establishment of effective, systematic KTT.
7. The SCCERs should lend their partners greater support with international activities, especially regarding participation in international programmes (e.g. providing them with international contacts if they do not have them, coordinating conference and project participation and facilitating international proposals involving several SCCER members).

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