

Triple Helix Research Partnerships Evidence From Energy Research Organizations in Australia, Germany and USA

Andrea Hanebuth^{‡}, andrea.hanebuth@der.tu-freiberg.de*
Roh Pin Lee^{}, roh-pin.lee@der.tu-freiberg.de*
Technische Universität Bergakademie Freiberg, Germany
Chair of Management, Leadership and Human Resources &
German Centre for Energy Resources
Lessingstrasse 45, 09599 Freiberg, Germany
Phone: +49 (0) 3731-39-4423, Fax: +49 (0) 3731-39-4555

[‡] *Corresponding author*

**The authors contributed equally and are listed alphabetically*

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Author information:

Andrea Hanebuth is a researcher with the German Centre for Energy Resources (DER) at the Technische Universität Bergakademie Freiberg (TU Freiberg). She studied Business Administration and Mechanical Engineering (TUM-BWL) at the Technische Universität München (TUM) and completed her degree as Diplom-Kauffrau. A doctoral candidate at the Chair of Leadership, Management and Human Resources at TU Freiberg, her research interests include research and innovation management, especially the management of intellectual property, research cooperation models as well as collaborative research management in the context of virtual organization, teams and networks. Current research areas include investigation of alternative models for sustainable research cooperation involving government, industry and science partners, as well as research into management of research groups and organizations characterized by decentralization and under the influence of virtualization.

Roh Pin Lee is a researcher with the German Centre for Energy Resources (DER) at the Technische Universität Bergakademie Freiberg (TU Freiberg). She has a Bachelor in Psychology from the National University of Singapore and an MBA in International Management of Resources and Environment from TU Freiberg. A doctoral candidate at the Chair of Leadership, Management and Human Resources at TU Freiberg, her research interests include behavioral decision-making, research and innovation management as well as collaborative research management, in particular in the energy sector. Current research areas include investigation of alternative models for sustainable research cooperation involving government, industry and science partners, as well as research on affective rationality in energy judgments and decision-behaviors.

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Introduction

Energy research plays a key role in addressing global challenges relating to sustainability, global warming and climate change, in addition to addressing national challenges relating to competitiveness, energy supply security and sustainable development (EU, 2010). Though universities have historically been the core provider of research, the landscape of university research is changing as the scale and cost of research rise rapidly (Smith, 2001). Today, energy research is no longer the exclusive domain of institutes of higher education, whose main goals include the promotion of academic education and training in addition to basic research (often done according to scientific interest). Other research providers include 1) national/regional/governmental research centers, whose main aims are the promotion of the national research agenda which normally have a strong economic rationale as their basis (for example the Commonwealth Science and Industrial Research Organization CSIRO in Australia and the National Energy Technology Laboratory NETL in the USA); 2) Private research centers, which include private/non-profit research institutes, firms or universities pursuing research according to economic and non-economic interests of their organizations (for example the Fraunhofer Institutes in Germany); and 3) Industry, characterized by economic value driven research aimed at the creation of financial economic gains (Porath, 2010).

Unlike product research and development, energy research goals often involve achieving wider social, economic and environmental objectives (for example to encourage economic development and technology leadership, to reduce CO₂ emissions etc.) in addition to innovative research. Increasingly, societal and energy decision makers are realizing that to achieve real, sustainable energy technological breakthroughs and competitive advantage, cooperation between government, industry and science is essential. Such cooperation could also allow the reaching of new summits of economic growth through utilization of research capabilities linked to economic ventures and interests (EU, 2006). Recognizing this potential, energy research activities today are increasingly being conducted in various collaboration forms between government, science, and industry, so-called triple helix interactions (Etzkowitz & Leydesdorff, 2000), and are usually characterized by complex hybrid networks between different helix actors (Heimeriks et al., 2003).

However, collaboration is a complex phenomenon that is difficult to define. Though it serves many different purposes, it also poses difficult policy and organizational management problems (Smith, 2001). Helix research partnerships are highly challenging as they require cooperation between separate entities from different “cultural” backgrounds (i.e. governmental, scientific or industrial), with different aims and different sets of values (Porath, 2010). For example, a potential conflict point between scientific and industrial partners is the conflict between publication (academia) and confidentiality (industry), which is further complicated should the research project be both publicly and privately funded (i.e. financed through both government and industry partners) as placing the outputs of research into the public domain is one of the defining requirements of publicly funded research activities (Smith, 2001). If this is not resolved through well-defined contractual terms and management systems, it could lead to

premature termination or collaboration and/or failure to reach research objectives. In addition to the challenge of facilitating sustainable and successful cooperation between partners with different purposes and goals, energy research partnerships, in particular large research projects involving multiple partners, often involve (industrial) partners who are also market competitors. Hence, firms trying to collaborate under such an atmosphere where co-opetition issues are very strong will have to lay down a strict set of cooperation rules in order to avoid conflict (Porath, 2010). Such determination of cooperation rules becomes especially important as the number of collaboration partners increases. This is because the management of R&D cooperation becomes increasingly complex with growing number of (helix) partners. With the resulting multiplicity of interests, insufficient setting/clarification of “ground rules” could contribute significantly to the failure of helix research collaborations (for example Faems, Looy & Debackere, 2005; Link & Marxt, 2004).

As failure to address the significant challenges (of which some are mentioned above) faced by such collaborative partnerships could ultimately lead to project failure (for example Lhuillery & Galiab, 2006; Lhuillery & Pfister, 2009), faced with the potential for such (economically and socially) expensive failures, an urgent question for both scholars and practitioners is how energy research partnerships involving different partners can be designed, organized and managed to facilitate successful and sustainable collaborations.

Though much progress has been made in research management, even leading practitioners recognize that there remains much to learn (Kirkland, 2005). Especially in collaborative research, though there is wide consensus that collaboration offers powerful solutions to problems of scarce resources, excessive competition, quality control and scale of problem (Smith, 2001), the abyss between research management and organizational character of different partners are difficult to overcome as these are cultural differences which are harder to define and therefore harder to solve, hence making management of research partnerships even more challenging. Nevertheless, the development of collaborative research, its increased usage in particular for energy research and innovation promises great rewards to those able to understand its formation and function mechanisms, and the ability to control the cooperation in order to achieve the targeted goals (Porath, 2010). This leads us to the objective of our current paper, to provide an insight into successful research collaboration designs and identifying challenges associated with them, while highlighting the importance of the institutional environment following an intensive benchmarking process of leading energy research providers in different countries¹. In particular, our present paper presents issues relating to collaboration organization, research financing and intellectual property management in the field of energy collaborative research which are based on preliminary findings obtained through analysis of publicly accessible data and extensive semi-structured personal interviews with key personnel in selected leading energy research organizations in Australia, Germany and USA. In this way, we are able to obtain qualitative information and feedback which will be otherwise not possible through using the more familiar benchmarking process of gathering quantitative performance indicators on a range of issues (Kirkland, 2005). Note that the aim is not to present a representative sample.

Rather, our intent is to gain insights into a range of research collaboration approaches, and hence stimulate different examples of good practices.

Research Collaboration: General Forms

During our benchmarking processes, we identified different general forms of research collaboration. Research collaboration forms differ in their level of intensity. At its most basic level, research collaboration occurs between researchers, not organizations. However, societal and energy decision makers often refer to collaboration at other levels: between departments, disciplines, organizations, sectors, or between nations, which in its structure is more akin to a partnership, an alliance or understanding than traditional inter-researcher collaboration (Smith, 2001). Through our benchmarking process, we identified the following forms of research collaboration with differing levels of intensity and strategic significance (see Figure 1).

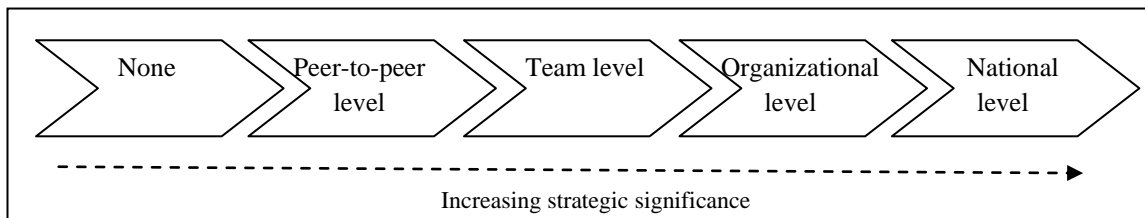


FIG.1: Research Collaboration Forms (Level of Intensity)

Peer to peer level research collaboration is pervasive in traditional university based research and is the essential building block of research activity, often originating from professor-research assistant/student relationships (Smith, 2001), as well as between academic and/or industry researchers with similar or complementary research interests.

Increasingly, with the growing demand for interdisciplinary capabilities to solve multidisciplinary issues, team level collaboration are being encouraged and promoted as the creativity essential to new knowledge production and innovation is frequently the outcome of the collectivity – the sum is greater than the individual parts (Smith, 2001, p. 135). Hence, bringing together research expertise from appropriate areas provides a competitive edge (i.e. bringing together researchers from different departments to solve multidisciplinary challenges). As such, such team collaboration is often encouraged through funding initiatives by the government and public agencies in numerous countries. An example is the directed funding of collaborative research centers in universities by the German Research Foundation (DFG, 2011).

Organizational level research collaboration (for example between scientific and industry partners) enable research partners to secure access to resources otherwise unavailable to the organizations working in isolation (Smith, 2001). Such organizational level research collaboration offer significant benefits to collaboration partners. In a time where public funding

has been scaled back in numerous countries, such collaborations allow scientific partners to obtain the financial resources necessary to carry out its research activities, and engage in knowledge transfer and in providing a pool of knowledge and expertise on which the economy can draw on. For the industry partners, collaboration with scientific partners allows them access to a free flow of basic knowledge, and the academy also provides a good support basis for further work and solving applied problems. Moreover, there is reduced strategic risk as the academy is not going to compete with the firm in the market. Additionally, there is also a reduction of risk and costs faced by being involved in a research or by investing in research infrastructure (Porath, 2010).

National level collaborations are often highly strategic in nature and set the stage and provide support for other forms of collaboration and technology transfer. An example is the cooperation of Germany with other European countries in the European Research Zone, where the German government promotes national level collaborations through creating the necessary framework conditions, supporting joint measure for the establishment and extension of international research alliances, initiating new collaboration initiatives, as well as helping to solve individual collaboration problems, if and when they arise (BMBF, 2011).

Research Collaboration: The Institutional Environment and the Role of the Government

Like firms (Lin, Peng, Yang & Sun, 2009), research providers and how they design and manage collaborations differ across institutional frameworks. Strategy scholars have increasingly highlighted the importance of institutional environments (for example Oliver, 1997; Peng & Heath, 1996) as being more than background conditions in which decision making and management processes take place. Following the contingency approach they argue that institutions directly determine the resources that an organization has access to in its struggles to formulate and implement strategy (Ingram & Silvermann, 2002). Considering that institutions differ profoundly between different economies, be it formal institutions (such as laws, rules and regulations) or informal institutions (such as cultures, norms and values) (Peng, Sun, Pinkham, & Chen, 2009), different institutional environments would have a significant influence in shaping research organizations, the direction of their research activities and the modes of research collaborations.

As a key helix player, the government shapes the institutional framework of the energy research landscape in which collaborative research activities take place. Its most fundamental role is the reduction of uncertainty for different actors by conditioning the ruling norms of behaviors, defining the boundaries of what are legitimate and setting strategic directions (Peng et al., 2009). Today, government and its agencies have developed new expectations of publicly funded research, as research is expected to make an explicit contribution, either socially, economically or environmentally. Through policy intervention, directed funding and other incentives, it significantly influences the direction of energy research to address the nation's energy priorities by placing funding with those research providers most likely to address the

relevant issues (Smith 2001), as well as creating the environment and conditions for collaborative research between different research providers. This is illustrated for example through the directed funding of energy research and collaboration projects by the German government in its Energy Concept 2010 (BMW, 2010) and its 5th Energy Research Program (BMW, 2005), and by the USA government in its Advanced Energy Initiative (Li, Jenkins-Smith, Silva, Berrens, & Herron, 2009). Though it is an important player in promoting energy research collaborations through the creation of the collaborative research environment, the government does not necessarily have an active role in the managing of the project, often playing at most a supervisory role as it has a specific interest to show that fair play and transparency regarding public funds and their allocation has been maintained (Porath, 2010). As mentioned earlier, its main interest is in promoting the research to match the nation's needs and priorities, to meet its social, economic and environmental objectives, as well as to stimulate economic growth through linking research capabilities to economic ventures and interests.

In the following section, we will address issues relating in particular to triple helix research collaboration in the energy context.

Research Collaboration: Triple Helix Collaboration in the Energy Context

In addition to innovative research, energy research goals often involve achieving wider strategic social, economic and environmental objectives. Societal and energy decision makers are realizing that to achieve such goals and address a nation's energy challenges, cooperation between government, industry and science is essential. This is because bringing together a mix of different disciplines and cultures from these three different players can lead to a "bigger bang for the buck" and the multiplier effect from this synergy can achieve more than organizations working independently (Alcock & Woodley, 2002, p. 28). As a result, energy research collaboration increasingly involves all three helix players (i.e. public agencies and multiple industry and scientific partners), with the government playing a key role in promoting such organizational level collaborations between industry and science. Advantages include a reduction of research costs as research is shared between multiple partners. Furthermore, it allows partners to continue with other research projects and to spread their risks (Porath, 2010). Additionally, the scope of research covered in such research collaboration will also be wider than would optimally be expected from a single research provider (Kamien & Zang, 2000). However, despite its potential, the growing importance of collaborative research involving multiple partners from different backgrounds aggravates the problem of research management. Main problems, as mentioned in the introduction include: 1) If firms are technologically close enough to cooperate, they are close enough to be competitors in various ways, leading to co-opetition issues, 2) partners from different backgrounds have different sets of goals and values, as well as organizational and management cultures, 3) potential conflicts relating to publication versus confidentiality and intellectual property rights (Porath, 2010).

To address the above challenges in research collaboration, leading research organizations have developed alternative forms of research partnership programs. As organizational level research collaboration is fast becoming the norm in energy research, in the following sections, we will present insights drawn from three selected energy research organizations in Australia, Germany and the USA respectively on how they address organization, financing and intellectual property issues in such research partnerships, and illustrate the corresponding challenges facedⁱⁱ.

Australia

Concerned that there was not enough ready uptake of research innovation by the industry, the cooperative research centers (CRCs) program was established in 1990 by the Australian government to improve the effectiveness of Australia's research and development. CRCs are devoted to strengthening collaborative links between industry, research organizations and government agencies to achieve outcomes of national, economic and social significance. CRCs aim not only to resolve national challenges. Their goals also include the transfer of knowledge between researchers and industry, and the development of industry ready graduates. As such, it is a form of research collaboration actively utilized by the Australian national science research organization.

Organization: CRCs are based on strategic collaboration between multiple partners. They aim to bridge the gap between scientists, research institution, government agencies and private industries. CRCs are accountable for their own direction, progress and outputs. Each CRC is given a seven-year life span and is reviewed regularly (after one, three and five years) to ensure that they are meeting their key objectives.

CRCs are like virtual organizations, with researchers dispersed throughout the country depending on the location of research partners. As such, one of the biggest challenges in collaborative projects is a lack of clarity about who does what. Research objectives which are too broad and which change along the way further complicate the matter. Additionally, due to its virtual nature, researchers' loyalties often lie with their home institutes, even though they know that their funding comes from the CRC. Furthermore, with multiple stakeholders and interests in a CRC, another main challenge is the management of intellectual property (IP) issues (for example the question of who's going to own what, and who can use what).

To overcome the above challenges, a CRC is set up as a complete separate company, much like a small-medium enterprise (SME). All partners are in the company with rights to IP and technology transfer. Each CRC has a board with an independent chairman, and each company/group of companies and each research organization/group of research organizations are represented on the board. However, non-research organizations are usually the majority on the board so as to ensure industry focus in the research undertaken. Board members are required (by law) to operate in the best interests of the CRC.

Furthermore, a CRC also tries to employ some independent employees who do not have divided loyalties. These include the CEO and core management and support staff. They will be employed directly by the CRC and are not from any participating scientific institutions or

companies. Moreover, to avoid conflict of interest, the CEO reports directly to the board, and not to anyone else. 100% of the funding goes to the CRC and the CEO is responsible for distribution of funds according to delivered results. In this way, the CEO has control over the funding and hence a lot of leverage in “encouraging” partners to cooperate with each other and to deliver research objectives as planned.

To ensure research quality, an international panel of experts (the research advisory committee) carries out periodic review of research results delivered by each CRC (for example every 2-3 years). However, though the panel of experts works with the CRC board to resolve research issues, they give their report directly to the government. This external review process thus encourages the CRC virtual team members to bind together.

Additionally, as different partners have different motivations for joining the CRC, there is a need to balance the different motivations and avoid conflict of interests. Each CRC thus works hard in separating research objectives from commercial objectives, and structuring relationships according to objectives.

Financing: CRCs are unincorporated joint ventures consisting of multiple partners. Competitive funding rounds are held by the government every 12 months, with the federal government funds seen as the “glue” attracting contributions from participants - approximately one-third from government and two-thirds from participants. There is upfront industry commitment of funds and resources based on legally binding agreements. This, together with government funding, represents a significant united funding base for each CRC. On average, each CRC has an annual budget of AUD\$7 million to cover operating costs and wages for staff (Alock & Woodley, 2002), which include cash and in-kind contribution by other core participants including companies, government agencies and universities.

Intellectual Property Management: Intellectual property is one of the main issues in CRCs as there are multiple stakeholders and interests. In general, intellectual property belongs to a CRC which is set up as a separate company and is recognized as a legal entity. However, as mentioned above, not only are most employees in CRCs (ranging between 100-200 employees per CRC) not employed directly by the CRC, most research work are also carried out by partner institutes and universities sitting in different locations. Hence, to avoid and/or reduce potential intellectual property interest conflicts, the intellectual property produced in a CRC collaboration belongs to the CRC. Furthermore, CRCs strive to separate research objectives from commercial objectives in order to further reduce conflict potential between participating partners (see FIG. 2).

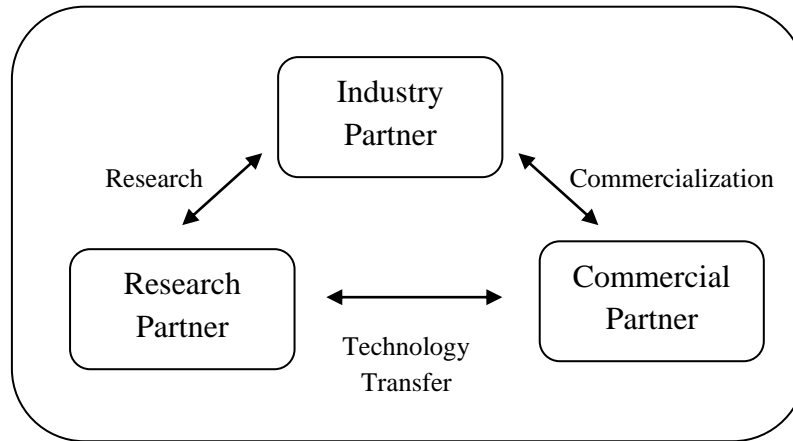


FIG.2: Separation of Objectives (source: CSIRO)

Germany

A country with a different institutional environment is Germany, where sustainability and energy are regarded as one of the strategic research focus by the Federal Ministry of Education and Research (BMBF). To address the challenges of competitiveness, energy supply security, climate change and sustainable development, the BMBF invests approximately 400 million € yearly into sustainable energy research under its “High-Tech Strategy Initiative” (Schavan, 2010). Recognizing that triple helix interactions is key to innovation in increasingly knowledge-based societies (Etzkowitz, 2008), the BMBF actively encourages and facilitates research collaborations between government, science and industry partners to address strategic energy challenges through its various funding programs. One such program is the funding initiative “Innovation Initiative for the New German Länder”, through which the BMBF aims to boost the innovative strengths and economic success of the East German states through promoting top-notch research and science activities in innovative clusters linking research capabilities to industry interests, in addition to enhancing the international profiles and visibility of participating scientific organizations. Under the framework of this particular program, an energy research center is established in 2010 as a strategic research innovation alliance between triple helix partners to address fundamental and applied energy issues and to develop key energy technologies. With 18 partners from government, science and industry (including two energy giants and leading scientific organizations such as Fraunhofer and Helmholtz institutes) across the country, this research center has a pilot character in Germany. Insights obtained so far into this young research collaborative center are presented below.

Organization: In addition to the BMBF and the industry (both industry leaders and SMEs), partners in the collaborative research center include multiple institutes from the “host” university, institutes from external universities, public funded as well as semi-private research

organizations. Strategic research direction in the research center is provided by a board consisting of representatives from (four) funding companies as well as leading professors from participating scientific organizations. Scientific direction and management is provided by the project leaders (leading professors from the “host” university). As the research center brings together multiple partners from different backgrounds and motivations, the potential for a destructive conflict of interests is relatively high. To ensure that no/minimal such conflicts occur while taking full advantage of the innovative cluster, the board meets at least once a year to discuss research priorities and progress. In this way, the board ensures a balance of interests between different partners.

Similar to the CRCs in Australia, the collaborative research center is essentially virtual in nature. Although the headquarter of the center is established at the institute of the project leader, it was not possible for all researchers to relocate there due to space and resource constraints (e.g. equipment, laboratory at home institutes/organizations). As such, cooperating partners work in a decentralized manner, with two research coordinators planning, coordinating and managing the research process and progress. Research coordinators report directly to the board of the research center (see next paragraph) as well as to an independent position deployed by the BMBF (a “*Projekträger*”) to supervisor the research center over the funding period. However, virtualization of the research center brings with it significant coordination challenges as the researcher coordinators have limited influence over research partners spread across the country. Additionally, as the research center is not a legal entity, it cannot employ the researchers itself. Its forty researchers are employed by their home universities, research organizations or companies and “assigned” to the research center. So although researchers are essentially employed through the research center, their loyalty and sense of identity remain strongly directed towards their home institutes/organizations/companies. To further complicate matters, the different administrative systems employed by different helix partners further challenge the managerial accounting of the project.

To overcome the coordination and identity issues mentioned above, regular meetings are held every three months for the presentation of research updates and discussion of research progress. Additionally, workshops and various events are organized to intensify interactions and exchanges between all partners (i.e. government, industrial and scientific partners). Management researchers are also integrated into the research center to investigate as well as to promote the success of the research collaboration.

Financing: In its initial phase (2010-2014), the research center has been granted 5 year funding under the BMBF’s funding program ProSIN. Approximately 60% of its funding comes from the BMBF while the remaining 40% is provided by four industry partners (with remaining industry and scientific partners participating as non-financing partners supporting the research center in other complementary ways). The whole research budget is controlled and supervised by an independent position deployed by the BMBF (a “*Projekträger*”), and significant parts of the budget can only be “unlocked” for use following an explicit and comprehensive application process. Moreover, research partners are discouraged from “over-budgeting” their planned annual expenditures through a high penalty interest rate levied on money which has been

approved and “unlocked” by the *Projekträger* but remains unused for that particular year (i.e. remains in the bank account of the research organization at the end of the financial year).

Intellectual Property: In general, the German law states that intellectual property generated by employees belongs to the employer. In the multi-partner collaboration project presented here which is essentially virtual in nature, employees are being employed by their “host” organizations. It is thus essential to clarify the property rights situation at the very beginning of the collaboration with a cooperation agreement/contract. This includes a regulation for the rights of use for all the research partners for the duration of the cooperation. Under the regulations and agreements, the rights of the intellectual property belong to the host organization of the inventor; shared inventions belong to host organizations involved, depending on the contributions their employees made to the invention (unless they waive their rights). Special licensing conditions for industry partners (i.e. sponsors) are also part of the contract provisions. However, it is necessary to note that as the government is a key sponsor of the research cooperation, it has a keen interest in ensuring that transparency regarding public funds and their allocation has been maintained (Porath, 2010), and that its social, economic and environmental objectives are met. Hence, in such a context, no exclusive property rights could be given to any single partner institution in the cooperation project.

USA

The USA is the largest energy consumer in the world. The Advanced Energy Initiative, unveiled in 2006, aims to reduce the country’s dependence on foreign energy and to promote the use of clean-energy technology (Li et al., 2009). However, despite calls from various sources for increased commitment to energy R&D to reach the above goals (Friedman, 2007), there has been a general historical decline in federal funding (Nemet and Kammen, 2007). Together with the deregulation of electric utilities following the Public Utility Regulatory Policies Act (PURPA) of 1978 (Russo, 2001) and the Energy Policy Act of 1992 (Li et al., 2009), these developments in the institutional environment have led to different forms of research collaborations between helix partners as they restructure and strategically position themselves in the energy market. The insights obtained through our research and interview with a leading non-profit energy research provider are presented below.

Organization: The research organization has developed a mechanism for a group of interested companies (especially local small-mid size energy distribution companies) to engage in research collaboration to address common issues using a consortium approach. Such a collaborative approach allows the participating companies to leverage their investments (in terms of funds and personnel) to minimize risks and improve the potential for success. Moreover, as each company has limited resources, this approach ensures minimized administrative and transaction costs while enabling them to address their most critical needs. Furthermore, it facilitates consensus building on projects that will impact regulatory issues (Snedic, Bernstein & Fiore, 2008).

In this form of collaboration, a group of interested companies come together to form a not-for-profit corporation. The board of directors consists of one member from each participating

company. Its role is to provide strategic guidance on program priorities and set long-term goals and objectives, in addition to establishing procedures and program oversight. A technical project committee, comprising of representatives from member companies who typically meet in person twice a year, works closely with the research organization to identify challenges and issues that are to be addressed in the program, as well as specific topics that will be the focus of individual research projects.

The not-for-profit corporation formed in the consortium approach has no employees. It is a virtual organization. The research organization is contracted to be the administrator of the partnership. Hence, in addition to providing research capabilities, its role includes the overall program management, back-office activities (for example financial accounting and contract administration), and commercialization activities (for example manufacturer identification and selection). However, research projects decided upon by the partnership are given out on a competitive basis. Hence, external research providers could also bid for research projects given out by the partnership (though the research organization remains the main research provider for the partnership).

Financing: Research funding is provided by the companies in the consortium. The number of customers that each company has determines the funding level for each participating company in the partnership. Funds received by the partnership from a member are held in trust by the partnership until the member directs the partnership to allocate a specific dollar amount to a specific project. As such, a participating company has the option to fund or not fund an individual project which the partnership will undertake. Each member will invest in the projects they wish to fund. Once participating companies elect to move a project forward and the scope of work is finalized, the project participants may elect to seek additional and/or leveraged funding outside the partnership (for example from public agencies).

Intellectual Property Management: Intellectual property is negotiated on a project-by-project basis. In the consortium approach, to avoid conflicts between member companies, the corporation formed attempts to retain the intellectual properties for projects they fund (which are then typically monetized later on through licensing arrangements).

Furthermore, in research collaboration with multiple partners, there are certain sensitive “secret-source” information and equipment parts which are kept secret by industry partners from the research partner/provider (due to proprietary concerns), and which are removed from the research premise at the end of the project. To prevent leakage of such secret-source information, there is thus differentiated network and physical access to different parts of the database and lab facilities for employees and partners, depending on their clearance levels.

Conclusion

Innovative energy research and development plays a key role in addressing global challenges relating to sustainable development and climate change, in addition to national challenges of competitiveness, energy supply security and sustainable development. Increasingly, decision makers are recognizing that to meet the energy challenge, cooperation

between government, science and industry is necessary. Today, energy research is often conducted in various collaboration forms involving government, science, and industry partners. However, such collaboration is a complex phenomenon which is difficult to define. Though it serves many different purposes and brings with it significant synergies and benefits, it also poses difficult policy and organizational problems as well as research management challenges. Through an intensive benchmarking study of research collaboration forms practiced by selected energy research organizations, we seek to identify factors which contribute to sustainable and successful research collaborations involving multiple partners, highlighting the importance of the institutional environment in which collaboration takes place. In the current paper, we share insights on different research collaboration designs as practiced by three energy research collaboration forms in Australia, Germany and USA and discuss the corresponding challenges faced. Bear in mind that research management is an activity which has grown rapidly over the past two decades (Kirkland, 2005). Though our benchmarking exercise provides a snapshot and overview of current collaborative practices, we expect collaborative research management practices to continue to evolve as they react to changes in institutional environments and other challenges.

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End Notes

ⁱ This paper is based on preliminary findings from a wider study of collaborative research approaches in different countries in 2010, conducted by the Chair of Leadership, Management and Human Resources and the German Center for Energy Resources (Technische Universität Bergamademie Freiberg, Germany).

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ⁱⁱ The insights and information presented in the following sections are based on preliminary findings obtained through analysis of publicly accessible data and extensive semi-structured personal interviews with key personnel in these research organizations. Responsibility for any flaws and interpretative weaknesses in the present paper are, of course, due solely to the authors.