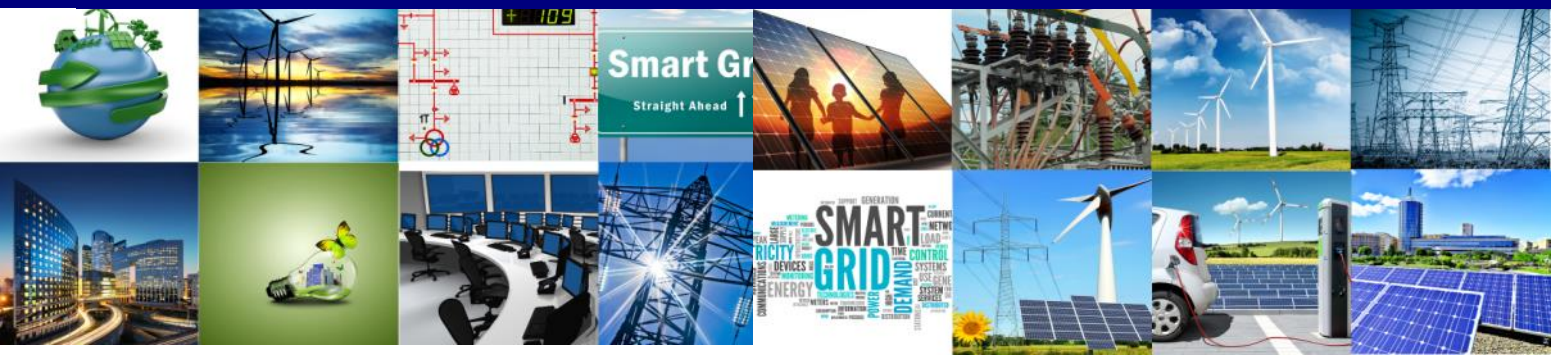
Project No. 609687

FP7-ENERGY-2013-IRP

ELECTRA

European Liaison on Electricity Committed Towards long-term Research Activities for Smart Grids



WP 9

Researcher Exchange

Deliverable 9.4

Final report on exchange programme outputs on the IRP website

14/04/2018

ID &Title	**D9.4** Final report on exchange programme outputs on the IRP website	**Number of pages:**	85

Short description (Max. 50 words):

The deliverable D9.4 presents the final results from the ELECTRA Researcher Exchange Program, a part of the ELECTRA Integrating Research Programme. The document explains in detail all the information concerning the preparation and operation of the Researcher Exchanges.

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V0.1	04/04/2018	First Draft
V0.2	10/04/2018	Second Draft
V0.9	11/04/2018	Version sent to internal review
V1	14/04/2018	Final version for submission

Accessibility

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Executive summary

The ELECTRA Integrated Research Programme (IRP) on smart grids brings together the partners of the EERA Joint Programme on Smart Grids (JP SG) to reinforce and accelerate Europe's medium to long term research cooperation in this area and to drive a closer integration of the research programmes of the participating organizations and of the related national programmes. ELECTRA's joint research activity and collaborative support actions build on an established track record of collaboration and engagement. The project consortium of leading research organisations from 17 different European countries aims to reinforce the EERA JP SG in strengthening coordinated European research, and building support for realizing the European SET Plan objectives in the area of smart grids. The project's joint research activity is establishing and validating proofs of concept that utilise flexibility from across traditional power system boundaries in a holistic fashion using a new control concept, the Web-of-Cells. At the same time, a programme of dedicated actions are being undertaken to accelerate existing coordination efforts established through EERA – and a significant element of this relates to researcher mobility through the ELECTRA Researcher Exchange Programme, ELECTRA REX.

ELECTRA REX provided assistance to support transnational and international researcher exchanges to or from ELECTRA partners and EERA Joint Programme members, that complement and enhance the collaborative smart grids research undertaken within the joint programme. Through a series of managed REX Calls, applications were invited for one of three types of exchange: Global Exchange, European Exchange, Intra-ELECTRA Exchange. The successfully selected applicants were provided funding for the additional costs of travel, accommodation, subsistence and modest laboratory costs associated with the exchange visit, and support for participation in a conference or workshop. A number of international ELECTRA REX workshop have been additionally organised alongside technical conferences, for the sharing of exchange experiences and dissemination of results through co-authored papers. The smart grid focussed exchange programme has been further complemented by an international questionnaire across the energy domain, which provided some confirmation of the opportunities of exchange and the barriers to participation.

Overall targets for the volume of exchanges have been met by the programme, valuable new research and professional engagement achieved, and a strong pipeline of quality co-authored publications has been established. Moreover, these successes have stimulated the adoption of the ELECTRA REX methodology by other projects and by EERA, and it has been integrated within the CSA actions of a number of proposals.

This report provides a succinct outline of the approach taken by this exchange programme, reflecting on key features and achievements, as well as lessons learned. This provides guidance and insight to those considering the introduction of an exchange programme to better support international cooperation in research and innovation. It furthermore outlines the nature and value of the workshops that have been organised by the exchange programme, these proving valuable in the sharing of mobility best practice and cooperative research ideas.

Further information on the ELECTRA IRP, with description of the consortium partners, is available at the Website http://www.electrairp.eu .

Terminologies

Definitions

Exchange Researcher	The person who is participating in a hosted researcher exchange experience.
Exchange Programme Management Committee	The committee of ELECTRA IRP responsible for managing the administration and selection of researcher exchange proposals
Home Organisation	The institute of which the Exchange Researcher is a normal member of staff or PhD student
Host Organisation	The institute at which a researcher exchange experience takes place, responsible for looking after the Exchange Researcher
Strathclyde University	Coordination body for Researcher Exchange Programme
REX Coordinator	Strathclyde University
ELECTRA IRP Coordinator	The person responsible for the whole ELECTRA IRP, Luciano Martini of RSE S.p.A

Abbreviations

EPMC	Exchange Programme Management Committee
ELECTRA	European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme
EES-UETP	Electric Energy Systems – University Enterprise Training Partnership
INCO	International Cooperation
IRP	Integrated Research Programme
MS	Milestone
REX	Researcher Exchange Programme
EERA	European Energy Research Alliance
ISGAN	International Smart Grid Action Network

Table of contents

List of Figures and Tables

1 Introduction

Deliverable D9.4 reports on the results of the ELECTRA Researcher Exchange Programme (ELECTRA REX), a smart grid researcher mobility scheme that was created and operated during the four year operation of the ELECTRA Integrated Research Programme. The first year of the project was dominated by setting up the rules and structures of the exchange programme, while the subsequent three years saw the programme in operation. The document has been structured to provide: (1) a summary report of the key features and results of the exchange programme that provides readers with an appreciation of what was developed and achieved, and (2) a fuller account of the programme methodology, its operation, and the results and impact achieved. A conclusions section completes the report.

ELECTRA REX gave opportunity for European or International researchers (especially those early in their career) to work closely together with leading smart grid research partners from the ELECTRA project and EERA Joint Programme on Smart Grids through an exchange of staff to reinforce and accelerate Europe's medium to long term research cooperation on smart grids. The scheme supported high quality applicants from research organizations as well as industry, including SMEs. This report explains how the resulting 39 exchanges were established and supported over seven Calls, and the results achieved.

This deliverable is based on the preparation and operation of a total of seven calls for exchange proposals. In particular, the deliverable provides sections dealing with:

- a summary outline of the exchange programme and its key features, providing an accessible report for those interested in the approach adopted and results achieved;
- a description of the ELECTRA REX methodology, explaining the multi-stage and cyclic approach that provided for the efficient and effective operation of the programme.
- an account of the operation of the ELECTRA REX programme, describing the changes introduced and outlining the exchanges that have been supported
- a review of the results and wider impact achieved through ELECTRA REX, including the steps being taken to support continuity in the provision of future researcher exchanges.

These demonstrate the strong profile that the exchange programme has attracted, show the impact provided to individuals their organisations and the coordination efforts of the ELECTRA IRP and EERA Joint Programme in Smart Grids, and prove the wider value generated in the energy community. The document is supported in this by a number of relevant appendices of generated materials.

2 Key features and results from the exchange programme

The following provides a summary of the key features and results achieved from the ELECTRA REX smart grid researcher mobility programme.

2.1 Purpose

Effective coordination and support action requires the commitment and dedication of people working to develop better, deeper understanding and shared research goals, and the ELECTRA project has facilitated this for smart grid research through the creation and operation of a new researcher exchange programme, “ELECTRA REX”. This programme provided funding for researchers to work together in another’s facilities over a number of weeks, enabling collaboration beyond mere participation in meetings that sees cooperation in research deliberation, debate, development, modelling, simulation, analysis and experimental work. The resultant value from the mobility experience has been reportedly felt by the participating individuals themselves, their organisations, the ELECTRA project and wider EERA Joint Programme in Smart Grids, and ultimately the wider research community who have benefited from the advancement and dissemination of the web of cells concept.

People are at the heart of international collaboration, and researcher mobility is an effective way to stimulate better understanding, shared effort, and new lasting cooperation. The experience of ELECTRA REX has brought value to the individuals, and to the host and sending research teams. Some images of exchange are included in Figure 1

Figure 1 ELECTRA REX researchers on exchange

2.2 Design

A new seven stage methodology was developed for the ELECTRA REX programme, and initiated by a sequence of multiple calls for applications. Three exchange "products" (see Figure 2) were designed to support the ambition of the programme: Intra-ELECTRA exchanges to encourage deeper cooperation across the project and JP team; European exchanges to stimulate wider involvement from the research community in new decentralised smart grid controls; Global exchanges to establish new cooperations in shared research challenges across the globe. Each of these exchange opportunities were offered for between 2 weeks and 12 weeks (with co-funding encouraged for those at the upper end of the scale), and made available to PhD students and staff from both research and industrial organisations. The scheme offered funding for travel, subsistence, dissemination, and some laboratory costs.

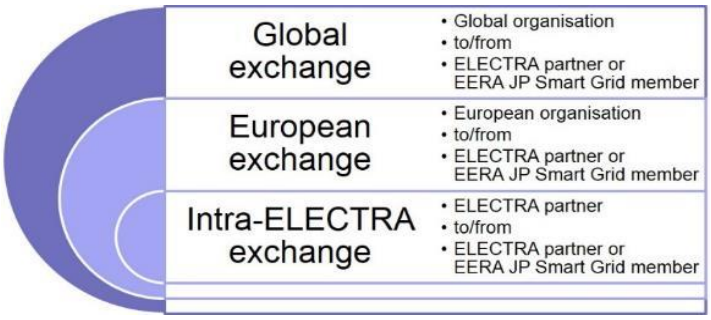


Figure 2 ELECTRA REX mobility "products"

The deliverables designed for these exchanges targeted quality dissemination and insightful feedback, and the scheme has been recognised by other groups as providing an exemplar to be followed.

The ELECTRA REX methodology is based on the operation of multiple calls for applications, and management through a seven stage cycle. This methodology is illustrated in Figure 3. This process permitted multiple calls to be managed at different stages, thus enabling new calls to be issued on a regular basis.

Each individual call for applications was developed in accordance with priority topics for collaboration, however applications in other areas were also considered. In each case a public forum at conference or project event was used for the global launch of the call – the first being at IRED'14 in Kyoto. The online portal for applications supported efficient handling of the submission and review process, the latter being commenced soon after deadline to enable rapid turn-around. An Exchange Programme Management Committee gave the programme oversight and was responsible for the independent reviews, and operated under the direction of the Exchange Coordinator, Professor Graeme Burt.

In each case of a successful applicant, a three-way contract was established between the coordinator, host and home institutions, and this commissioning stage ensured adequate institution support to the applicant and focused the team's attention on the common mobility deliverables: home and host questionnaires, abstract for web dissemination, and joint publication. These outputs not only supported effective reporting and dissemination of the results of the exchange, but also provided feedback that was valuable in drawing out lessons learned and making further improvements to the benefit of the subsequent calls and their applicants.

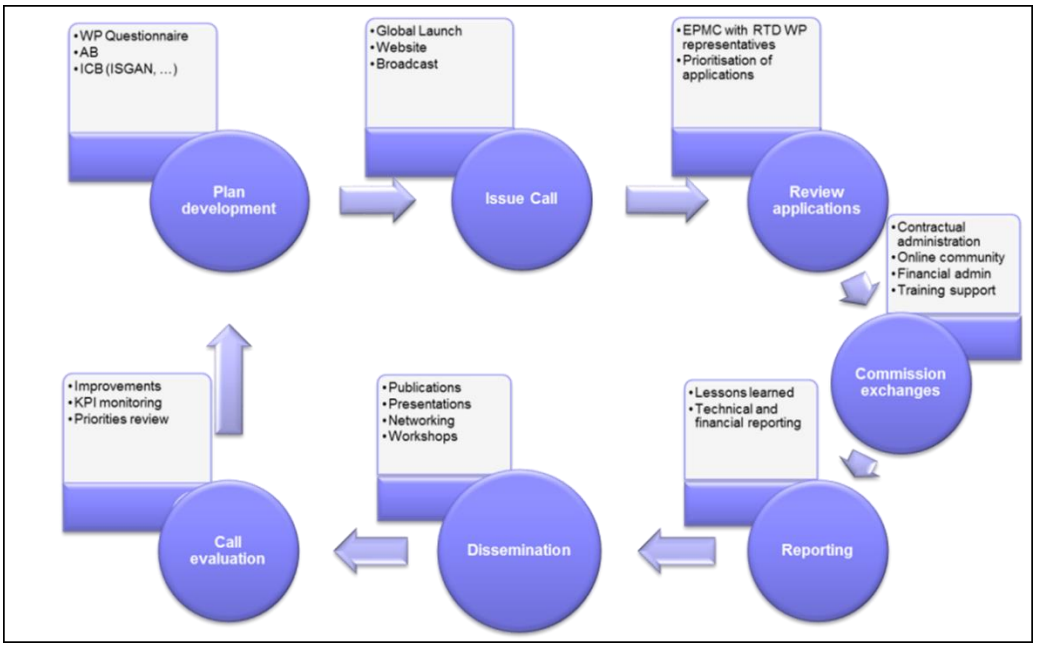


Figure 3 7 stage methodology for managing ELECTRA REX

2.3 Operational experience

A wealth of experience has been gained through the operation of the ELECTRA REX programme, to the benefit of the researchers, the participating organisations, and the wider smart grid research community. The 39 exchanges conducted under ELECTRA REX are documented on the project web page through short abstracts, and these are complemented by the co-authored papers that have been published.

This experience has further been shared through a series of four international ELECTRA REX workshops that had been organised to share mobility experience and results to wide ranging audiences. These took the form of special sessions at the following:

1. Special papers session at EDST'15, 8th-11th September 2015, in Vienna, Austria.
2. Special papers session at IEEE PES Innovative Smart Grid Technologies, Europe (ISGT Europe) 2016, in Ljubljana, Slovenia.
3. Presentation session and discussion forum at the First European Energy Research Alliance Conference, 2016, in Birmingham, UK. This was conducted in partnership with the EERA Mobility Task Force.
4. Special papers session at IEEE PES Innovative Smart Grid Technologies, Europe (ISGT Europe) 2017, in Turin, Italy.

In addition, these were complemented by a poster session for mobility participants at the final ELECTRA project meeting in Milan, in February 2017.

The EDST and ISGT hosted workshops gave opportunity for the exchange researchers' peer-reviewed and co-authored papers to be presented, as well as sharing their personal experience of mobility. For example, five of the recipients of Call 2/3 exchanges had their papers successfully accepted for presentation at ISGT Europe 2016, while a further six recipients of the later Calls had their papers successfully accepted and presented at the special session at ISGT Europe 2017 (Figure 4). These events proved successful, reaching out to new and different audiences, as well as enabling an exchange of individuals' experiences.

Figure 4 ELECTRA REX researchers participating in ELECTRA REX Workshop 2

The ELECTRA REX team actively sought feedback from recipients of mobility awards through the exchange questionnaires, feedback sessions, and from a survey developed and used in cooperation with the EERA Mobility Task Force. The latter provided useful insight as to the broader experience of mobility from over 70 respondents from 16 countries. Figure 5 shows one example from the analysis of reported mobility schemes, that shows training and personal development to be by far the top ranking reported benefit of mobility, while the next most valuable being highlighted were international experience and professional networking. It is perhaps telling that a high ranking benefit reported in private has been the opportunity to extract oneself from daily management tasks and obtain valuable focused thinking time!

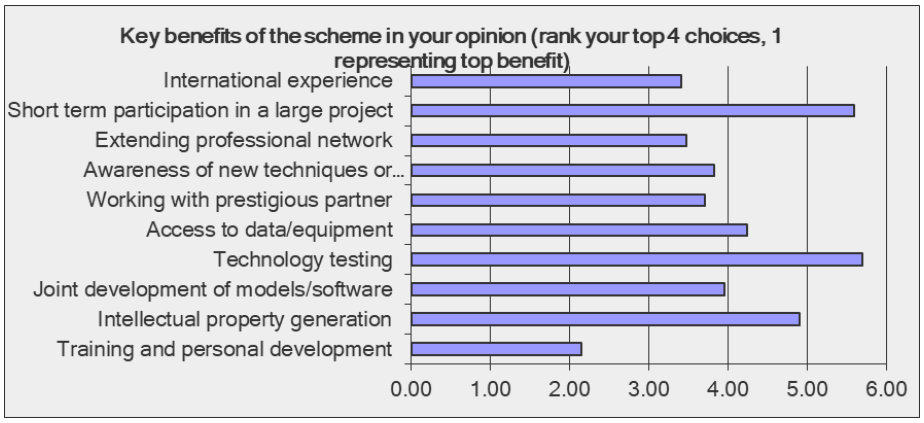


Figure 5 Example from the analysis of mobility survey results

2.4 Results

The ELECTRA REX programme has supported a total of 39 exchanges, involving researchers from Europe, North America, South America, Asia and Australasia. Of those who have participated in the exchanges, 69% have been early career researchers, many of whom have benefited from the inclusion of training during the period of exchange. 26% of the exchanges were conducted by female researchers. Over 4 person-years of exchange have been managed by the programme, and its dissemination efforts have included 5 international ELECTRA REX workshops, and a significant number of high quality co-authored publications. These statistics are summarized in the infographic shown in Figure 6.

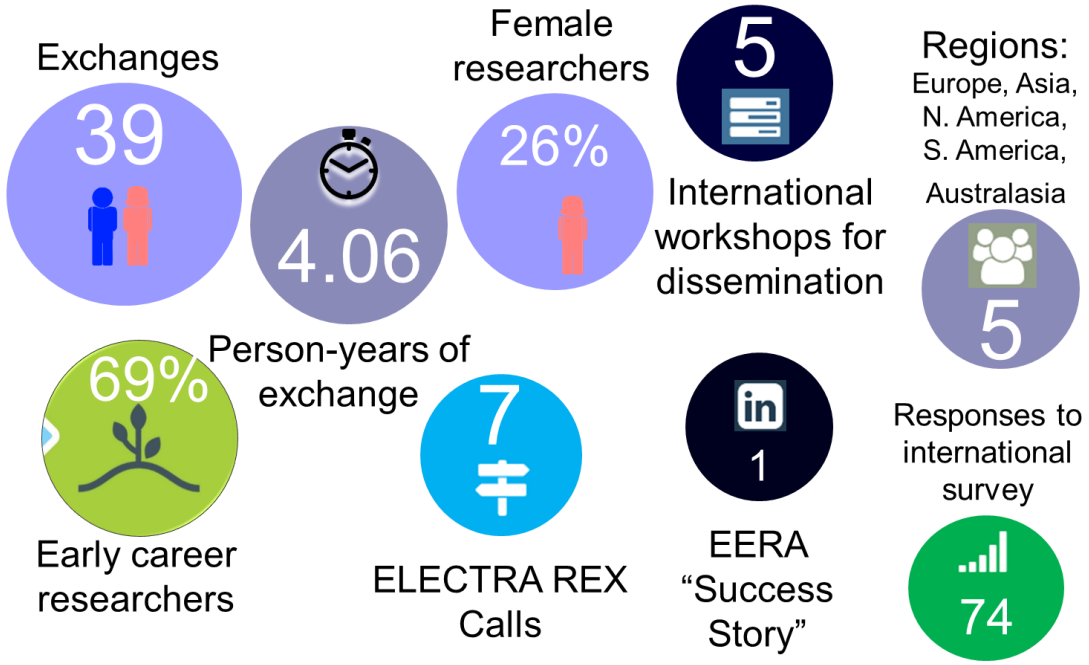
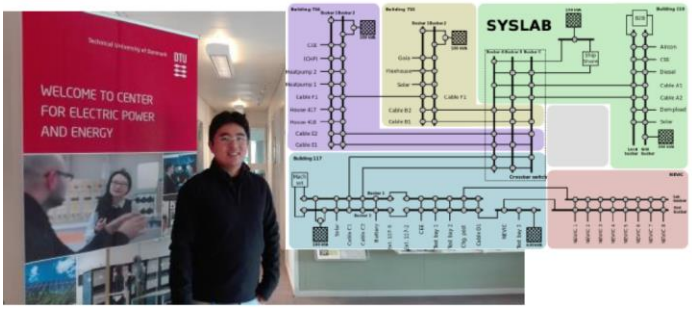


Figure 6 Summary infographic of programme statistics

The ELECTRA REX programme has delivered significant value into the research achievements of the ELECTRA project, which have been reported and disseminated in abstracts on the project web page, workshop presentations at international conference, and quality peer-reviewed publications. In many cases, research work has been completed that would otherwise have been impossible to complete in home organisations. Some examples follow.

2.4.1 Example exchange by Diego Issicaba, INESC P&D (Brasil) to DTU (Denmark)



This exchange gave opportunity for Belief-Desire-Intention (BDI) agents to be modelled to operate on DTU's Syslab experimental network in order to provide experimental validation of the agent control scheme operating under the web of cells philosophy.

The experiments demonstrated a group of cells negotiating to control tieline power flows, and being resilient to equipment failures. The impact of the exchange was to realise one of the earliest validation experiments associated with the web of cells concept.

2.4.2 Example exchange by Efren Guillo-Sansano, USTRATH (UK) to Florida State University (USA)

This exchange provided an opportunity for early stage evaluation of decentralised control algorithms for the web of cells concept. By using the FSU cyber-physical systems testbed, a fast integration of the prototype controllers was realised as controller hardware in the loop, and early feedback informed of the effectiveness of the controller performance under frequency events. This proved to be highly valuable in informing the later implementation of a distributed frequency control scenario in a WoC architecture on an innovative Power Hardware in the Loop validation platform at Strathclyde.

2.5 Wider impact from ELECTRA REX

The ELECTRA REX programme has been recognised for having developed good practice. The inclusion of post-exchange questionnaires and wider mobility survey have supported the project's assessment of good and best practice, and provided a useful assessment of the scheme's learning. This impact has been further complemented by reports of positive impact on the individual researchers who have participated in exchange. The line manager of an ELECTRA REX researcher has cited their global exchange as contributing significantly to their successful rapid promotion.

The ELECTRA REX programme has brought further benefit beyond the limits of the funded groups and ELECTRA project.

The successful operation of the REX programme has benefited the wider EERA community. Scheme experiences and results have been disseminated at the First EERA Conference in 2016, where it was presented as one of the Alliance's success stories (Figure 7), and summarized in the EERA Mobility Task Force Report.

The ELECTRA REX methodology and structures have subsequently been adopted as the basis of the EERA Mobility Programme, for use by the other Joint Programmes. The model has further factored in EERA strategy discussions, coordination meetings with other Joint Programme and IRP leads, and is also being used as the basis of CSA actions within other proposals.

Figure 7 ELECTRA REX presented as one of the "EERA Success Story" flyers

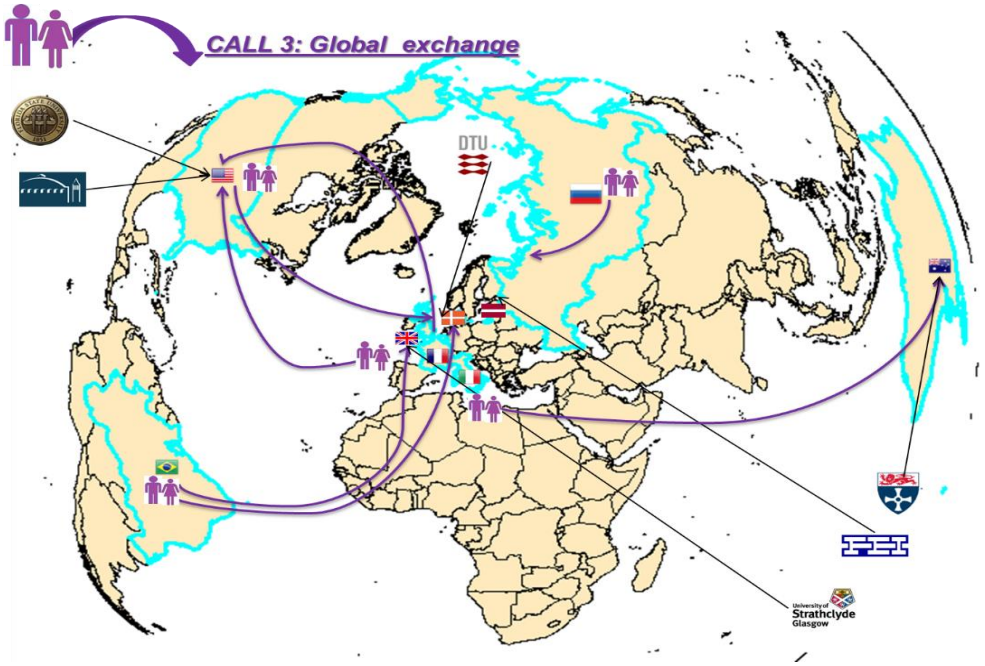


Figure 8 REX Call 3 global exchanges

The ELECTRA REX Global exchange offer has played a major part in supporting the EERA Joint Programme's international coordination (INCO) effort. The provision of mobility support is attractive to international teams, and a total of 13 Global exchanges were conducted over the project duration (e.g. REX Call 3 is illustrated in Figure 8). These encompassed exchanges between ELECTRA/EERA collaborators and research teams in North America, South America, Russia, Asia, and Australasia. In each case, co-authored papers have been produced, and in some instances new project collaborations commenced that will long-outlast the ELECTRA project and continue to support the EERA Joint Programme's INCO activities.

Looking further forward, the ELECTRA REX model is being applied in a number of ongoing activities. The European Energy Research Alliance have largely adopted the ELECTRA REX model for their mobility services, and it is anticipated that this will support better cooperation within and across a number of joint programmes. Furthermore, a number of research proposals have now been submitted with mobility tasks that incorporate the ELECTRA REX model, and it is anticipated that this will bring further benefit to the depth and breadth of collaboration in the smart grid and energy domains.

3 The ELECTRA REX methodology

3.1 Primary features and processes

The primary objectives of the ELECTRA REX remain threefold:

a. The proposed work is relevant to the goals of creating and demonstrating advanced voltage and frequency control as described by the ELECTRA IRP;
b. The Exchange Researcher will be capable of completing a quality body of work from the exchange and will gain useful personal development from it;
c. The value of the exchange is such that the host organisation and key individuals are willing and able to commit to producing valuable outcomes.

In order to achieve these objectives a programme of competitive calls was created supported by high quality publicity materials, and review and monitoring processes established. Project KPIs support the monitoring exercise, however successful outcomes from the exchanges are expected to include elaborated architectures, collaborative demonstrations and pre-standardization activities, as well as the monitored KPIs such as co-authored academic papers. In addition, best efforts are made to ensure that the exchanges offer a valuable and enjoyable experience to the individuals (Figure 9).

Figure 9 Early career researchers working together across countries and istitutes

The methodology of operating multiple REX Calls can best be summarised by the illustration in Figure 10. This shows the multiple stages involved in operating the ELECTRA REX programme, and indicates the status of multiple Calls at one snapshot in time: in the case shown, final evaluation and closure of Call 1-3, reporting of commissioned exchanges under Call 4, and operation of the call for applications for Call 5.

This approach supports effective monitoring that enhances the quality of experience and impact, and aided clear reporting to the project Technical Committee. The content of each step in the process is described in the following and was supported by the following roles:

- Exchange Programme Management Committee (EPMC) – a group of five individuals whose primary responsibility was the review and selection of successful applications.
- Exchange Coordinator – the leader of the exchange programme and chair of the EPMC.

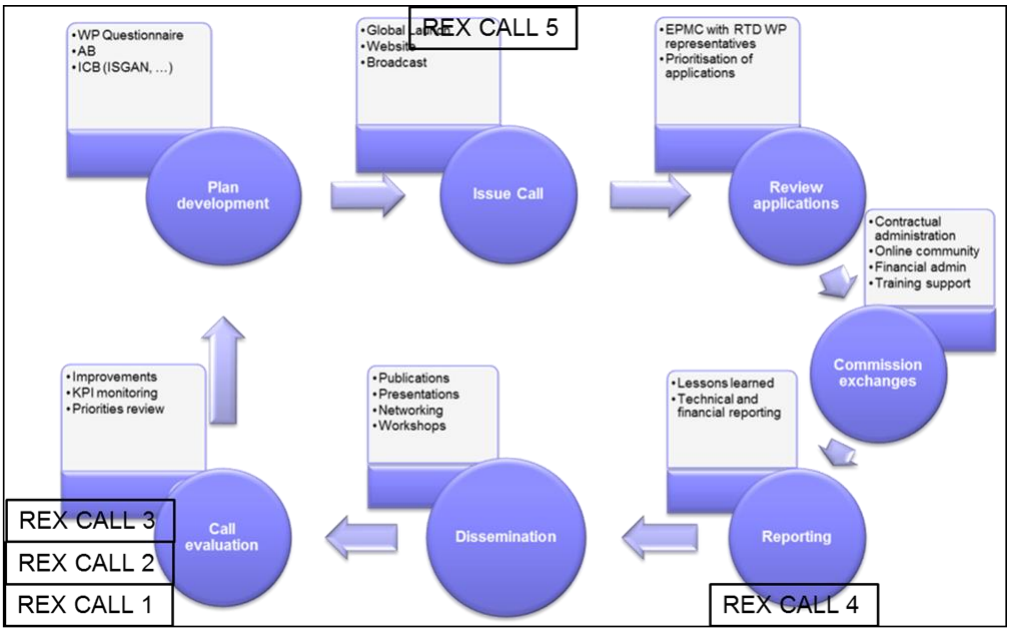


Figure 10 Methodology for managing ELECTRA REX, with a snapshot of multiple Call status

3.2 Stage 1: Development of the Call for Proposals

A Call for Proposals for researcher exchanges is developed for each Call in collaboration with the research project work package leaders. This encouraged proposed exchanges to be aligned with the project priorities for the forthcoming period. Completion of a questionnaire for work package leaders was complemented by direct consultation with individuals, including on occasion the International Coordination Board. The Calls identified priority topics, however were also designed to accommodate self-defined projects. ELECTRA REX exchanges take one of three forms, as shown in Figure 2: Intra-ELECTRA exchange, European exchange, Global exchange. On occasion, a particular focus on global exchanges was applied, in order to support ELECTRA's internationalization agenda and promote collaboration outside of Europe (e.g. Call 3).

3.3 Stage 2: Issue of the Call for Proposals

A Call for Proposals for research exchanges was launched on a regular basis by the ELECTRA Exchange Programme Management Committee (EPMC), with these following a cycle of approximately 6 months. Applicants were invited to submit through an online portal, and to identify their application with one of the Call priority topics or as a self-defined project. Each exchange opportunity was advertised through a global launch (typically at an international conference), the dedicated ELECTRA website [1], via personal contacts, and through other relevant channels (including social media, posters, conference flyers, workshops, partner web pages, etc.).

The web site provided the tool for submitting online applications, and the relevant programme documentation and guidance (including the programme rules and procedures [3]). The host facility had to be located outside the country that the exchange researcher works in, and the proposer was encouraged to engage with the host (or potential hosts) prior to submission. Evidence of this was required in the application.

3.4 Stage 3: Reviewing the Call Applications

Each application was reviewed by independent members of the EPMC, with a total of three independent reviews being conducted for each. A common set of scoring criteria was adhered to, judging aspects of the proposal against both quality of ambition and credibility of impact, as well as a set of non-technical matters (the so-called qualitative criterion). The latter reflected the programme's ambition of particularly welcoming the involvement of new organisations, early career researchers, and female applicants.

The Overall Scores from each assessor were averaged and this score used to rank the applications. The resulting order set of applications were then considered in an EPMC web conference, providing an opportunity for further clarification and debate. Decisions for acceptance or rejection were thus agreed. On a number of occasions, acceptance was conditional on further refinements or improvements by the applicant, and this also gave opportunity for more detailed discussion with work package leaders in order to maximize the impact from the work. Where lengthy exchanges were requested, the applicants were invited to provide co-funding. Review decisions and feedback were provided in a timely fashion to support effective host and researcher dialogue and rapid planning.

3.5 Stage 4: Commissioning the Accepted Exchanges

Following notification of the successful applicants, and completion of any requested changes or clarifications, an ELECTRA REX template agreement, with the proposal application appended, was shared with the applicant and the identified responsible person at the host organisation. A three way contract was then negotiated between the Hosting Organisation, the Home organisation, and the Exchange Coordinator's organization (University of Strathclyde). This therefore defined the responsible individuals, the description of work, the duration and budget of the exchange, the associated deliverables, and typical contractual obligations. Following signature of the agreement, each exchange could commence.

3.6 Stage 5: Reporting the Exchange Results

A number of standard deliverables were included within the template agreement, such that effective reporting was provided on completion of each exchange. This included an abstract for inclusion on the project web site, a researcher questionnaire, a host questionnaire, and commencement of a co-authored paper. The questionnaires provided a route through which feedback for improvement of the scheme could be identified and enacted upon. Completion of deliverables was the trigger for the processing of the invoices for the travel and subsistence costs of the exchange – a claim was typically made from the home organization to the Exchange Coordinator's organization (who held the exchange programme budget), however on occasion alternative means were required to process this.

3.7 Stage 6: Dissemination of the Exchange Results

The requirement for dissemination of the exchange results was included in the contract deliverables, taking the form of an extended abstract and joint paper, with the former conforming to a common format and being lodged on the ELECTRA web site. This was a valuable dimension of the exchange programme, stimulating new publication collaborations that might not otherwise have happened. The publication of the abstracts therefore provided a rapid route for sharing exchange achievements, and added to the richness of the project site.

A significant number of co-authored papers have already been published by the teams involved in exchange. This was supported by the organization of a number of international ELECTRA REX workshops, scheduled as special paper sessions at international conferences. A number of these

were reported previously [4]. In addition to providing a valuable platform for disseminating the results of the exchange, these sessions brought the individual exchange researchers together and provided an opportunity for them to share their respective experiences of exchange.

3.8 Stage 7: Evaluation of the Call

The end of the Call cycle provided an opportunity to reflect on the completed Call and its associated exchanges, reflect on the experiences, and make relevant improvements. These were then reflected in subsequent Calls as appropriate.

3.9 Integrating results into the ELECTRA IRP and EERA Program

A number of key aspects were put in place throughout the program in order to facilitate the integration and output from the REX exchanges within the ELECTRA IRP. This was established via the call design and application process:

- Research topics for each Call were established by Research WP leads to facilitate and further the work being carried out by ELECTRA partners and to ensure they were aligned with work already being undertaken.
- Applicants were asked to specify and detail which WP's their planned work would contribute to as part of the application and its relevance reviewed by the ELECTRA committee
- Engagement of the exchange researcher with the relevant work package leader was often encouraged and facilitated prior to the exchange in order to better align the work for maximum impact.
- The compulsory requirement of a joint publication for each and every applicant ensured integration between the works carried out at both the home and host organisations.
- Following the completion of an exchange the message of continued collaboration was portrayed to the applicants through a questionnaire. The questionnaire contained questions and messaging to encourage continued collaboration between the researcher and the host organisation.

4 Operating the ELECTRA REX programme

In this section the experience gained from operating the ELECTRA REX is described. The timetable that the programme actually followed is shown in Figure 11.

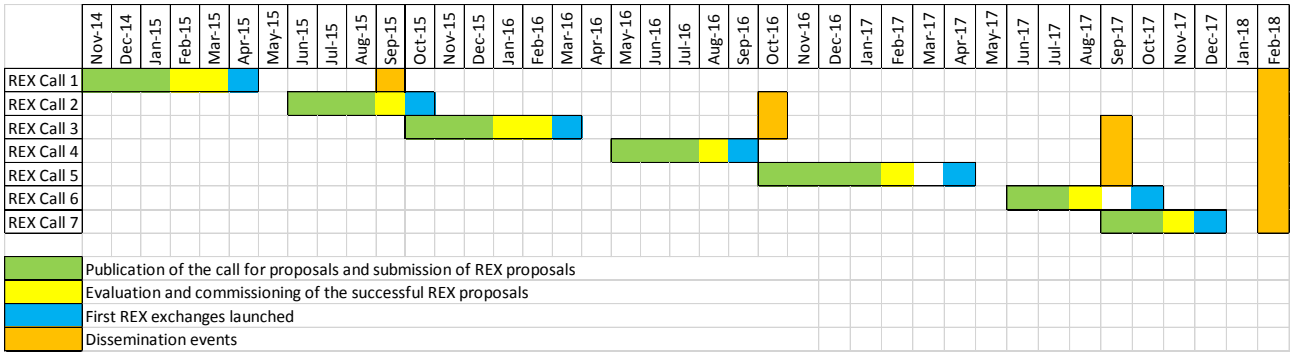


Figure 11 Timetable showing operation of the ELECTRA REX Calls

4.1 The First Researcher Exchange Call

This section describes the implemented steps during Call 1, starting from the development of the call of proposals, until the acceptance and commissioning of the selected exchange projects.

4.1.1 Implementation and publication of the REX 1 Call for proposals

The first call for proposals for researcher exchanges has been developed in collaboration with the research work package leaders of the ELECTRA Project. The WP leaders had been asked to fill out a questionnaire, detailing their priorities for the next period to allow the Call for Proposals to be suitably focused. The questionnaire used for this process is attached as Annex 1.

The topics identified for this Call were (in no particular order):

- Voltage control
- Frequency control
- Experimental demonstration
- Ancillary services provision
- Electro-mobility

The first Call for Proposals was launched by the ELECTRA Exchange Programme Management Committee on November, 2014. The Call was advertised through the dedicated ELECTRA website, under the page “Mobility”, via personal contacts and through conferences and special events. Indeed the global launch of REX Call 1 was made at the conference IRED 2014 on November 17th, 2014, Kyoto, Japan, where a dedicated ELECTRA side event was organized. Publicity for the Call was aided by a range of flyers (see Annex 2). The Call expired on February 5th, 2015.

4.1.2 Submission of the REX 1 proposals

The submission of the proposals was conducted electronically following earlier registration at the ELECTRA website, through the assisted tool. The proposal template was available on the ELECTRA website (see Annex 3), along with an online procedure which facilitated the preparation of the proposals and the electronic submission. The proposal template required evidence that the proposers and Host Institute had agreed in advance of the application. The ELECTRA team introduced this requirement at the outset in order to avoid the challenges and delays experienced on other exchange and transnational access projects in the past.

Eleven (11) proposals were submitted:

1. Six (6) Intra-ELECTRA exchange applications, in which a researcher from an ELECTRA Partner proposed undertaking collaborative work at the site of another ELECTRA partner;
2. Four (4) European exchange applications, in which an ELECTRA Partner and other European organization collaborate on an exchange;
3. One (1) Global exchange application, in which a researcher from an ELECTRA Partner proposed undertaking collaborative work at the site of an Extra-EU organization.

4.1.3 Evaluation of the REX 1 proposals

4.1.3.1 The Exchange Programme Management Committee

The evaluation of the submitted proposals has been undertaken by the EPMC, which is composed of representatives of each of the research work packages, along with the leader and deputy leader of WP9, WP9 partners and the coordinator of ELECTRA. The EPMC has been chaired by the leader of WP9.

The evaluation process has been completed in one month and a half from the deadline of the call of proposals.

Each EPMC member has evaluated the proposals following the application assessment, and assigned a score as follows:

- A for Excellent (75+/100)
- B for Good (65-74/100),
- C for Fair (60-64/100)
- D for Poor (55-59/100)
- E for Irrelevant (0-54/100).

The individual scores were collated to give average scores and ranked, and the resulting ordered list and individual scores reviewed by the EPMC. Each application was then considered and a final decision made. The IRP Coordinator did not participate in the voting to be able to adjudicate in the event of a dispute.

4.1.3.2 Evaluation Criteria

The voting has been based on three sets of criteria, the quality of the ambition of the research proposed, the credibility of the team proposing to complete the research, and if the first two are met, a qualitative criteria which is to do with some of the non-technical aspects of the exchanges, as already described in Deliverable D9.1 (paragraph 2.4).

In order to show an overall framework of all the proposal's scores, a simple table with the three sets of criteria (quality of ambition, credibility of impact and qualitative criterion) and the total scores has been prepared, following the Table 1.

Table 1 Table for final scores of REX Call 1

Application number	Applicant name	Quality of Ambition	Credibility of impact	Qualitative criterion	Final mark

4.1.4 Selection of REX 1 proposals and notification to the exchange researchers

The submitted proposals have received different evaluations, six of them have been positively evaluated (Excellent score - A) and accepted, as summarized in Table 2.

Table 2 Accepted proposals following REX Call 1

N	Home organization			Hosting Institution		
1.1	Fraunhofer IWES	Germany	ELECTRA partner	CSIRO, Energy Centre	Australia	Extra-EU organization
1.2	University of Strathclyde	United Kingdom	ELECTRA partner	TNO	Netherlands	ELECTRA partner
1.3	VITO	Belgium	ELECTRA partner	University of Strathclyde	United Kingdom	ELECTRA partner
1.4	DTU	Denmark	ELECTRA partner	OFFIS	Germany	ELECTRA partner
1.5	DTU	Denmark	ELECTRA partner	University of Strathclyde	United Kingdom	ELECTRA partner
1.6	CENER	Spain	European organization	CRES	Greece	ELECTRA partner

Several research institutions have been involved in REX Call I, both ELECTRA partners and other organizations from European and extra-European countries, as shown in Figure 12.

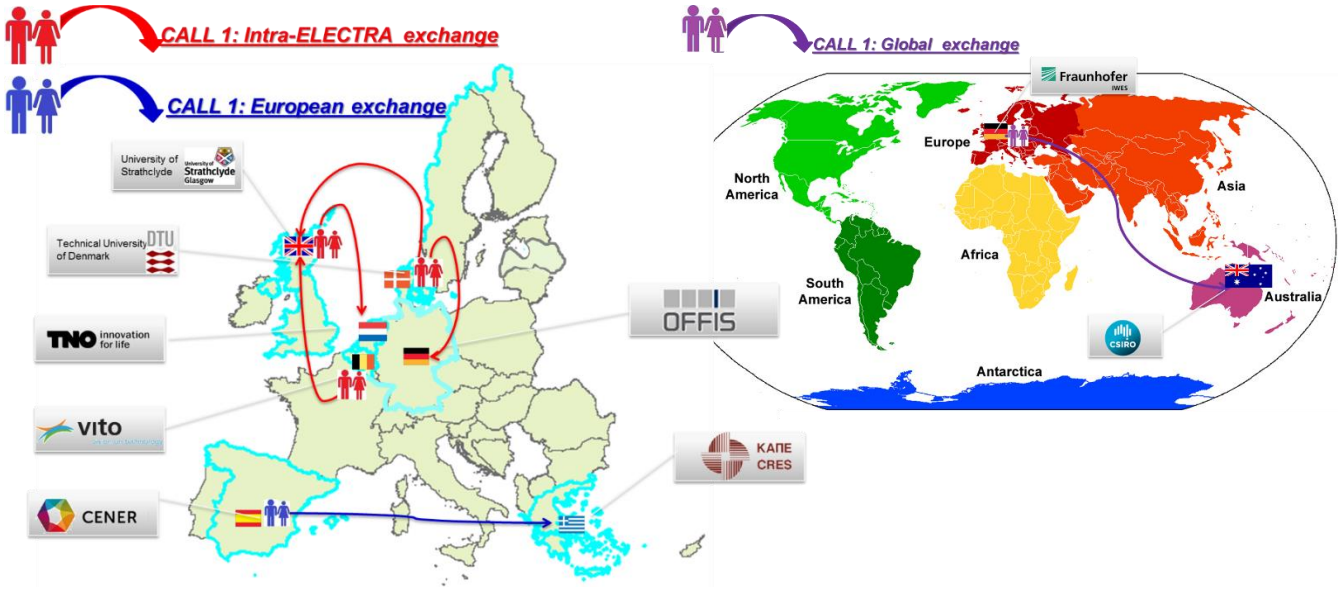


Figure 12 Diagram showing the research institutions involved in REX Call 1

The accepted proposals covered different research topics, as shown in Table 3 and Figure 13.

Table 3 Research topics of REX Call 1

N	Title	Duration	WP
1.1	Novel voltage control schemes and ancillary services provision from DER A comparative assessment for Australia and Germany	12 weeks	WP6, WP2, WP3, WP7,WP5
1.2	A methodology for the validation of Ancillary Service Provision by Demand Side Management through the use of a Real-Time Power Hardware-in-the-Loop Co-simulation Platform	4 weeks	WP6, WP7
1.3	Integrating Sequential Decision Making Bussiness Agents in the PowerMatcher multi-agent communication framework for inter-cell coordination	2 weeks	WP6
1.4	The architectural approach to controller conflict - Part I of Mutual Exchange: Control Case Modelling in SGAM	2 weeks	WP4 ,WP7
1.5	Topology Recognition and Inference Experiments	4 weeks	WP5
1.6	Modelling and simulation of Virtual Inertia for mitigation of frequency fluctuations in microgrids	2 weeks	WP6

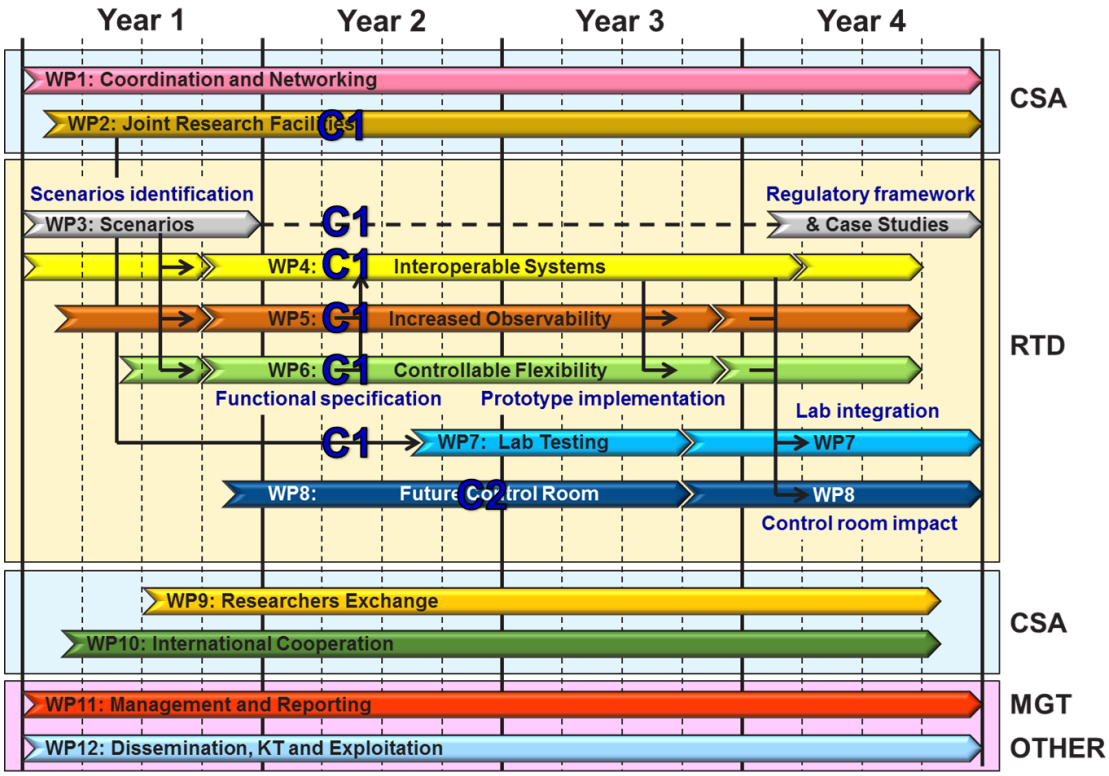


Figure 13 Research topics of REX Call 1 exchanges related to ELECTRA IRP work plan

The results of the evaluation process were then notified to the proposing researchers by the ELECTRA WP9 leader.

In each case the notification was accompanied with a short review with comments and suggestions for improvements. Where appropriate, borderline unsuccessful proposals receive suggestions to re-submit the proposal for the next Call. Notification was completed within two months of the call deadline.

4.1.5 Commissioning the REX 1 exchanges

Notification of acceptance launched a process of direct liaison with the exchange researcher and host, together with their contracts teams, was commenced by the REX coordinator. The following activities were conducted:

- Finalising the budgets requested by the successful applicants.
- Establishing three-way contact with contracts and legal teams
- Commencing with the template agreement (as included in deliverable D9.1), a process of negotiation was undertaken in order to reach an agreed exchange contract.
- Dealing with and responding to any queries from the involved parties concerning the exchange, budgets or the required outputs.
- Establishing a commitment to participate in the appropriate REX workshop.

The exchange researcher was instructed to proceed following signature of the exchange agreement.

4.1.6 Exchange activity for REX 1

The REX 1 exchanges were all conducted between April 2015 and August 2015. The operation of exchanges as a cohort is an important feature of the REX programme. Each exchange was completed at the respective host organization, with teams dedicated to the activity objectives.

Each signed contract clearly stated the requirement for dissemination of results by the researchers; the dissemination of results is considered a binding condition for the success of the REX programme. In each case the participants agreed to provide the following not more than 3 months after the end of the exchange period:

- An extended abstract of the research activity, to be published on the ELECTRA web page, submitted for the approval of the EPMC;
- A researcher and host questionnaire concerning the evaluation of the research activity;
- One jointly authored paper;
- Financial summary and invoice to support the review and conclusion of expense payments

At the end of the REX Call 1 exchanges, all the researchers fulfilled their commitment to supply questionnaires for review, abstracts for publication on the ELECTRA website (see Annex 4 for examples from across the REX Calls), and a co-authored paper with the host organization. The papers were prepared and submitted for review to the 2015 International Symposium on Smart Electric Distribution Systems and technologies, EDST'15 – this represents evidence of the soundness of the scientific work performed during the exchange period. EDST'15 was held on 8th-11th September 2015 in Vienna, Austria, and provided the venue for both a best practice review workshop and a special papers session for dissemination – these form part of the exchange support experience envisioned for the programme (Figure 14).

On completion of the exchange outputs, the parties are encouraged to invoice for the exchange costs incurred in keeping with the agreed budgets.

Figure 14 Summary of dissemination and publication of exchange results and learning

4.2 The Second Researcher Exchange Call

This section describes the implemented steps during REX Call 2, starting from the development of the call for proposals, until the acceptance and commissioning of the selected exchange projects, following the procedure defined in the Deliverable D9.1.

4.2.1 Implementation and publication of the REX 2 Call for proposals

The second call for researcher exchange proposals has been developed in collaboration with the research work package leaders of the ELECTRA Project. The WP leaders were invited to fill out a questionnaire, detailing their priorities for the next period to allow the Call for Proposals to be suitably focused. The questionnaire used for this process was the same as that used in the earlier Call, as attached in the Annex 1. A number of flyers were created for REX Call 2 and an online announcement prepared – see Annex 5 and Annex 6.

The identified topics for this Call were (in no particular order):

- Coding of distributed control solutions for real time voltage and frequency management
- DER management in support of low voltage network operation
- Detailed (functional) specifications of new smart grid control frameworks, such as microgrids or distributed cells
- Resilience of smart grid controls under disturbance conditions

The REX 2 Call for Proposals was launched by the ELECTRA Exchange Programme Management Committee on June 22nd 2015. The Call was advertised through the dedicated ELECTRA website, under the "Mobility" page, via personal contacts, invited keynote and conference flyer at IEEE POWERENG'15 (Riga), 11th-13th May 2015 [2], the DERLAB e-newsletter, and through an advertisement in the Latvian Journal of Physics & Technical Sciences. A number of improvements were incorporated into the application form and template agreement, reported in an update to Deliverable D9.1. The Call expired on August 22nd 2015.

In additional the team started to use the publicity mechanisms of national hubs to further advertise the exchange opportunities. A view of the example web page on the UK national academic hub for power networks, Hubnet, is shown in Figure 15.

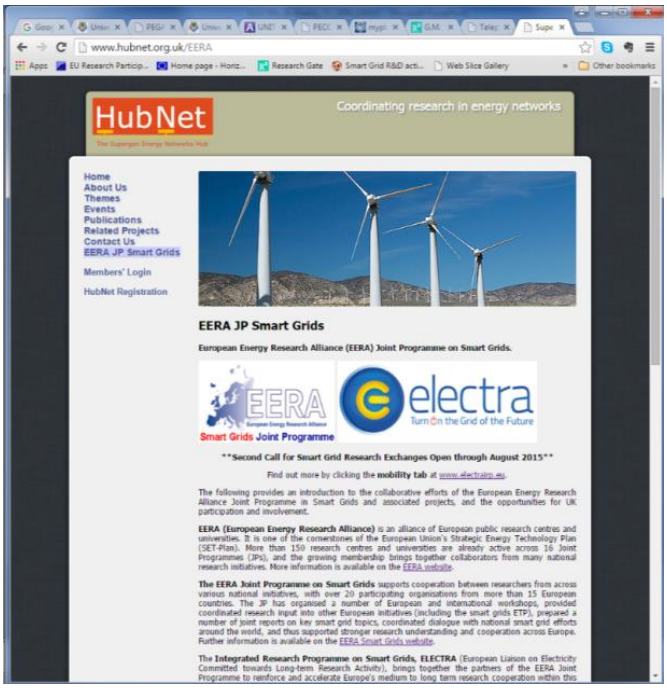


Figure 15 Hubnet web page to advertise ELECTRA REX and the EERA JP

4.2.2 Submission of the REX 2 proposals

The submission of the proposals has been done only electronically after previous registration at the ELECTRA website, through the assisted tool there available.

Seven (7) proposals were submitted again using the online application process, distributed as follows:

1. Four (4) Intra-ELECTRA exchange applications, in which a researcher from an ELECTRA Partner proposed undertaking collaborative work at the site of another ELECTRA partner;
2. Three (3) European exchange applications, in which an ELECTRA Partner and other European organization collaborate on an exchange.

4.2.3 Evaluation of the REX 2 proposals

The evaluation of the submitted proposals was undertaken by the EPMC, following the set procedure. While the basis of the review and voting procedure was the same, some improvements were introduced. This included adjustments to the weighting of the respective criteria to improve the spread and ranking of proposals. The updated evaluation table is attached as Annex 7.

4.2.4 Selection of REX 2 proposals and notification to the exchange researchers

The submitted proposals received their evaluations, and six of them were positively evaluated and accepted, as shown in Table 4.

Table 4 Accepted proposals in the II REX Call

N	Home organization			Hosting Institution		
2.1	TNO	Netherlands	ELECTRA partner	DTU	Denmark	ELECTRA partner
2.2	National Technical University of Athens	Greece	European organization	SINTEF	Norway	ELECTRA partner
2.3	University of Huelva	Spain	European organization	University of Strathclyde	United Kingdom	ELECTRA partner
2.4	OFFIS	Germany	ELECTRA partner	DTU	Denmark	ELECTRA partner
2.5	DTU	Denmark	ELECTRA partner	VITO	Belgium	ELECTRA partner
2.6	IPE	Latvia	ELECTRA partner	University of Strathclyde	United Kingdom	ELECTRA partner

Several research institutions have been involved in REX Call 2, both ELECTRA partners and other European organization, as shown in Figure 16.

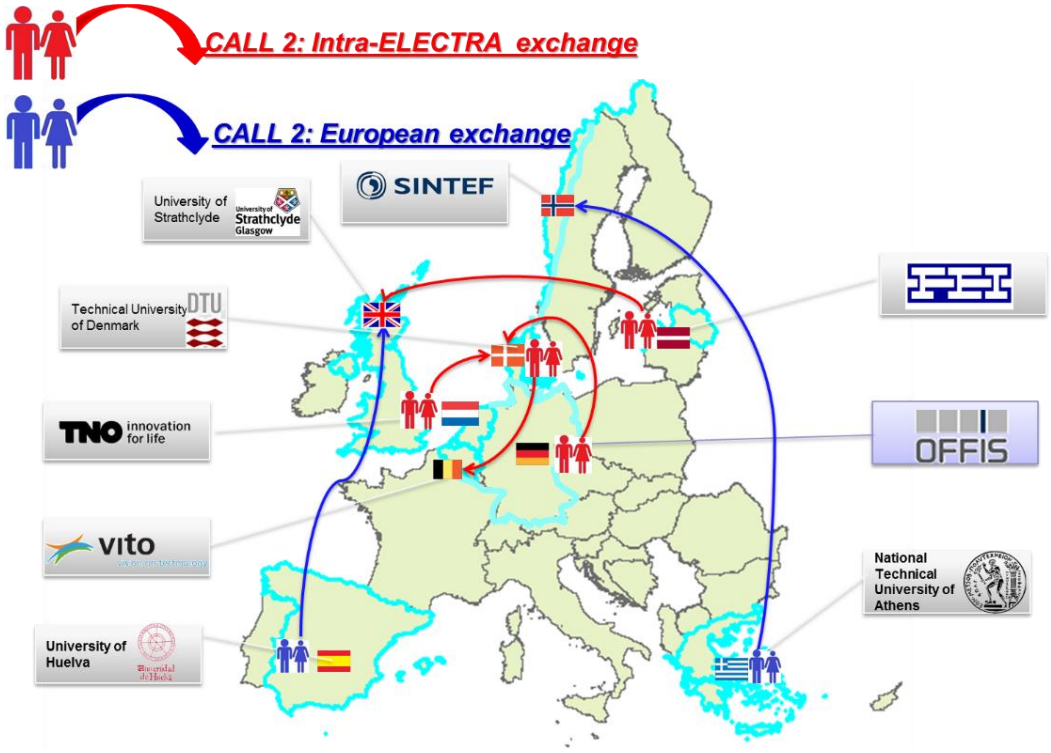


Figure 16 Diagram showing the research institutions involved in REX Call 2

The accepted proposals covered different research topics, as shown in Table 5 and Figure 17.

Table 5 Research topics of REX Call 2

N	Title	Duration	WP
2.1	Aggregation Flexibility Modelling for Balance Restoration Control	4 weeks	WP6
2.2	Coordination of Transmission and Distribution flexibility resources	3 months	WP5, WP6
2.3	Vectorial Control Strategy for a Photovoltaic Active Power Line Conditioner in Photovoltaic Systems (VCS for PV-APLC)	4 weeks	WP7
2.4	Adopting the UCMR and SGAM standards for security analysis for controller conflict analysis	14 days	WP4, WP8
2.5	Transactive Control for Managing Distributed Energy Resources to Support the Use Case of Balance Restoration Control between cell operators and aggregators	4 weeks	WP6
2.6	Smart grid control algorithms, measurement, and instrumentation technologies	2 weeks	WP5

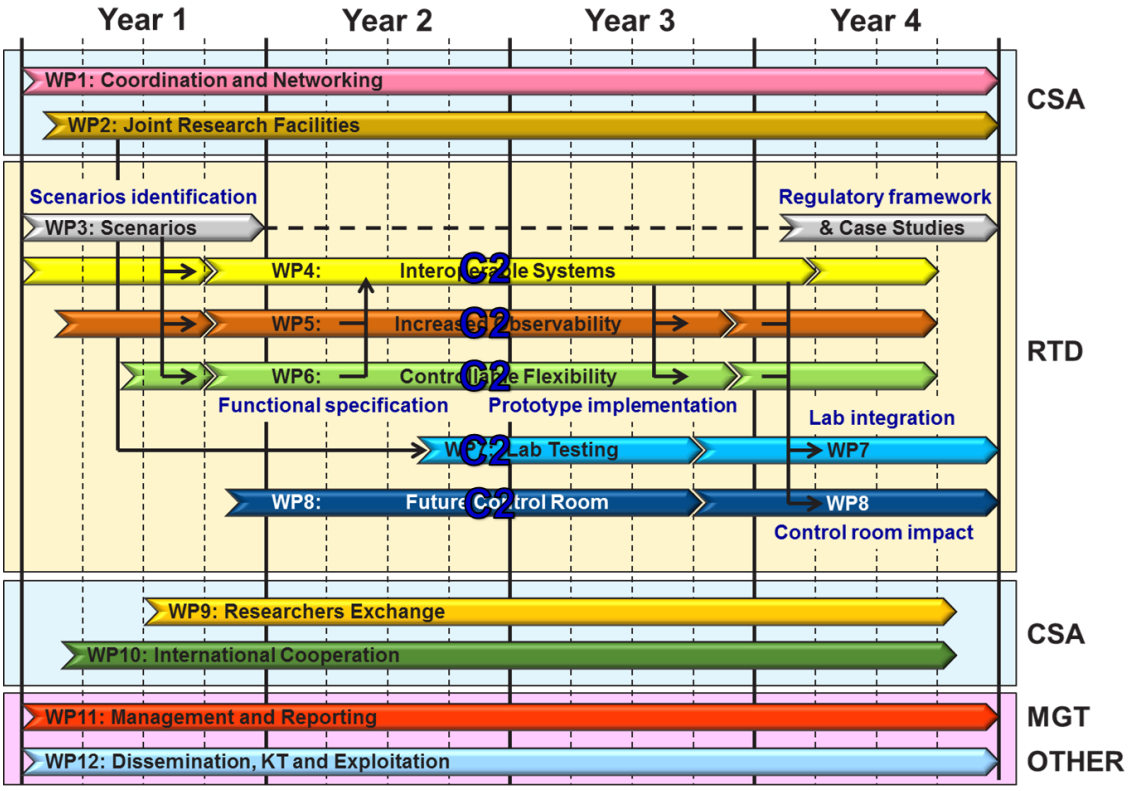


Figure 17 Research topics of REX 2 related to ELECTRA IRP work plan

Proposal number 2.3 was subsequently withdrawn due to staff availability challenges at the sending organization and was expected to be resubmitted to REX Call 4.

The results of the evaluation process were notified to the proposing researchers by the ELECTRA WP9 leader, through email. Again, this was accompanied with a short review report with comments and suggestion for improvements.

Notification was completed within one month from the call deadline, a significant improvement on the first Call.

4.2.5 Commissioning the REX 2 exchanges

The improvements to the application form template meant that the process of negotiation of contracts was significantly improved. Nonetheless this still required significant effort by the team at the REX coordinator. Exchange researchers were instructed to proceed as their corresponding agreements were signed. The REX 2 exchanges started in October 2015.

4.3 The Third Researcher Exchange Call

The decision was taken to dedicate the third Call to Global Exchanges between overseas organisations & ELECTRA partners, and the Call was strongly supported by the leader of ELECTRA's International Coordination work package. This has been shown to both deepen and broaden the international collaboration of ELECTRA. To further assist this broadening, the Call was also extended to allow EERA JP Partners and Associate Partners to participate. This is illustrated in the updated "product" list, shown in Figure 18, and by adopting this change the programme was intended to support stronger integration of the JP with ELECTRA.

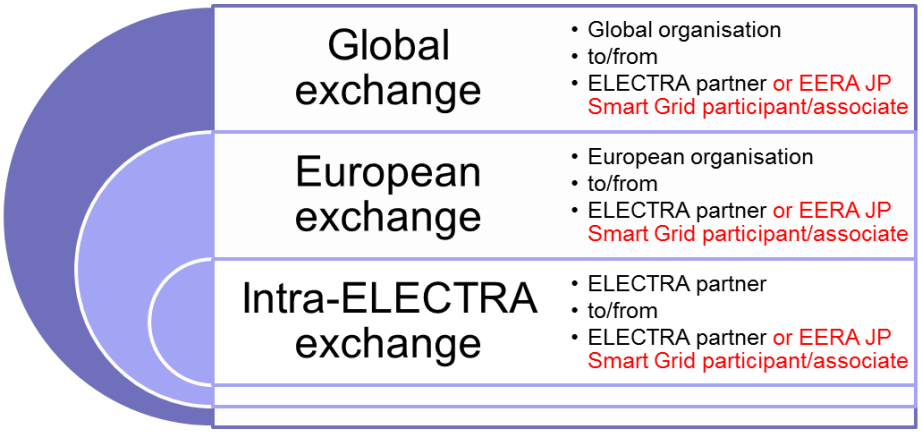


Figure 18 Diagram showing the extended exchange offering to include EERA JP Partners and Associate Partners

With this revision to eligibility, the ELECTRA REX methodology was again followed. The Flyer for REX Call 3 is attached as Annex 8, and applications were invited in relation to one of the following priority topics that emerged from the WP leader questionnaires and discussion:

- Assessment and control of system inertia
- Ancillary services for voltage and frequency regulation
- Power systems supervision & monitoring by considering smart meter data
- ICT & control system Interoperability: power & information flows with grid operators
- Integration of intelligent components such as IEDs and PMUs for wide area control
- Experimental investigation of DER control methodologies
- Definition of reference test networks

The third Call for Proposals was launched by the ELECTRA Exchange Programme Management Committee on October 5th, 2015. The Call was formally launched at an ISGAN workshop (Lecco) 14th-15th September 2015, and further publicized at EDST'15 (Vienna) 08th-11th September 2015, EERA JP Smart Grid General Assembly'15 (Bilbao) 05th October 2015, and the ELECTRA-Brazil conference (Florianopolis) 11-12th November 2015. It was further advertised through the dedicated ELECTRA website under the "Mobility" page, other Web announcements, the DERLAB e-newsletter, and via personal contacts. The Call expired on January 18th 2016, and the resultant successful applicants informed following the EPMC review. Figure 19 illustrates the exchanges successfully conducted under this Call, and the partners involved, and this demonstrates the global reach of researcher mobility supported. A broad range of topics were supported by this Call, with relevance to a number of project workpackages, and this is shown by Table 6.

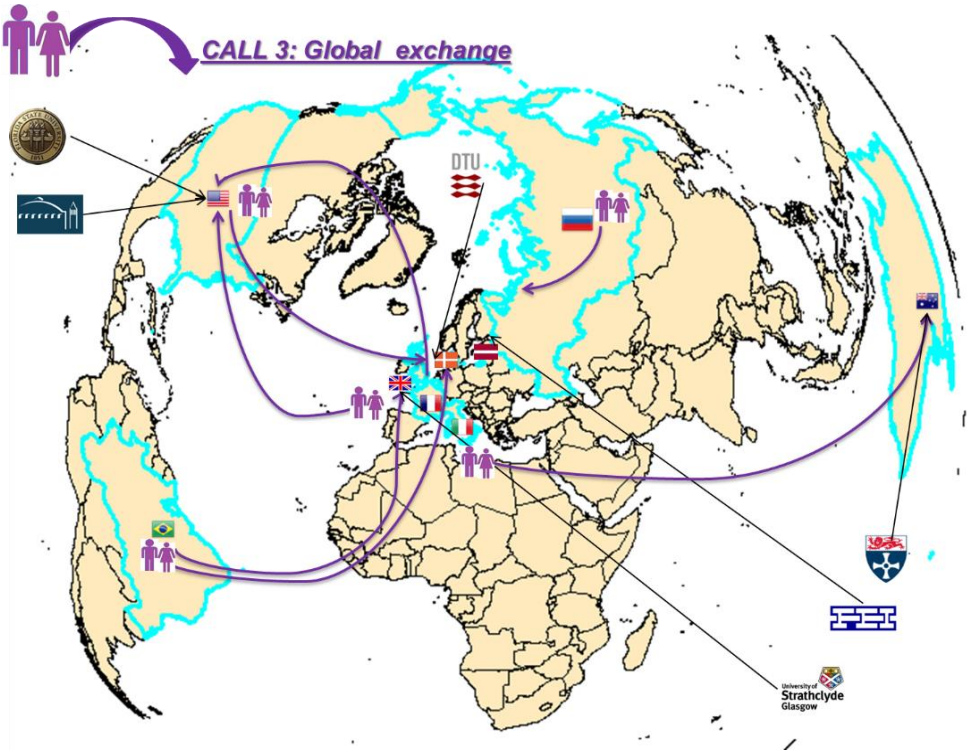


Figure 19 Diagram showing the research institutions involved in REX Call 3

Table 6 Research topics of REX Call 3

No	Title	Duration (wks)	REX product	WP relevance
3.1	Optimal PMU Placement in Smart Grid for Full System Observability	4	Global	WP5
3.2	Validation of a novel resource allocation method for frequency ancillary services	4	Global	WP7
3.3	Power hardware in the loop testing of distributed frequency control of a web of cells architecture	8	Global	WP7
3.4	Development of tools to support increased customer participation in provision of battery storage derived ancillary frequency control services	10	Global	WP3-WP7
3.5	Fiber Optic Sensors for Energy Transmission and Distribution Systems Control	2	Global	WP5
3.6	Agent-based Solutions to Web of Cell Management & Control	2	Global	WP6
3.7	Optimal sustainable energy grids	24	Global	WP6

4.4 The Fourth Researcher Exchange Call

The ELECTRA REX methodology was again followed under Call 4, with applicants for ELECTRA, European and Global Exchanges invited. The conference Innogrid 2020+ in April 2016 was used as the launch platform for this Call in order to support the raising of the scheme profile.

The applications were dominated by European and ELECTRA exchanges, however one successful applicant used the Global Exchange for a period of collaborative research in the USA. While this involved a different ELECTRA partner from that supported in Call 3, the same USA partner

organization was involved, Florida State University. The complete set of successful Call 4 exchanges are illustrated Figure 20 and the topics listed in Table 7.

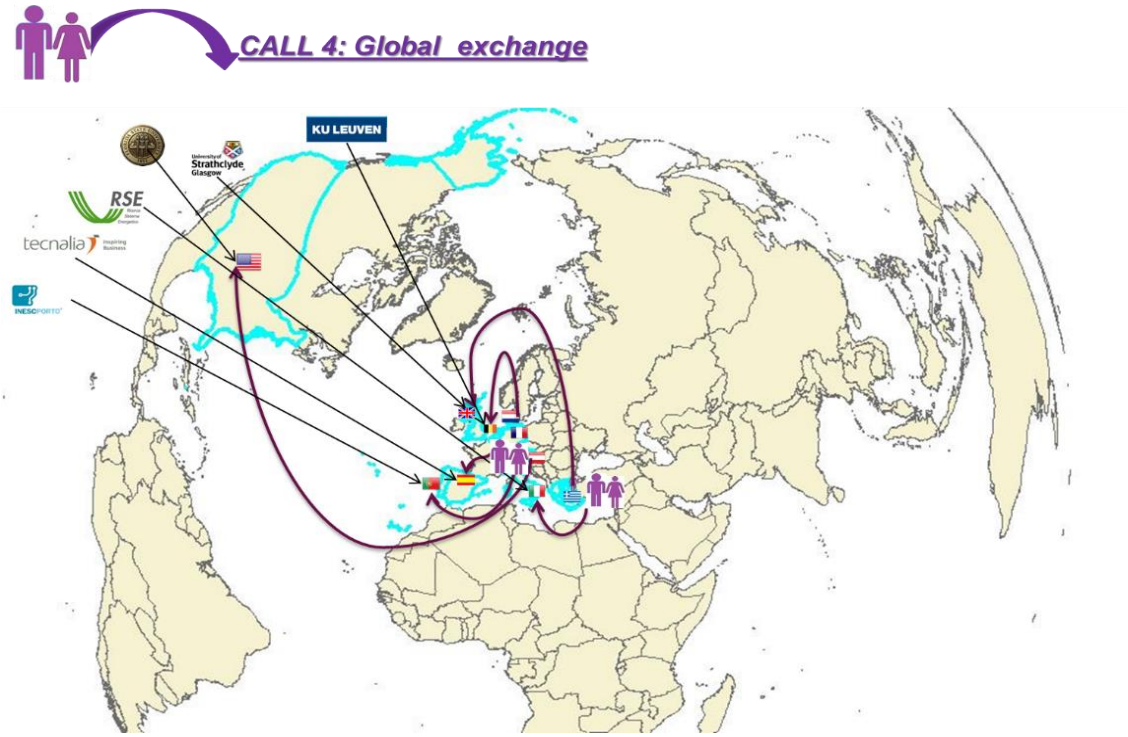


Figure 20 Diagram showing the research institutions involved in REX Call 4

Table 7 Research topics of REX Call 4

No	Title	Duration (wks)	REX product	WP relevance
4.1	Validation of Inter-cell Control Strategy for Smart Grid Services	4	European	WP7
4.2	MANAGe - Modeling of Active Networks And smart Grids	4	European	WP8
4.3	Modelling and analysis of the external behaviour of a cell implementing the ELECTRA proposed	2	ELECTRA	WP7
4.4	Validation of a protection scheme with distributed Intelligent Electronic Devices for the Web-of-Cells	4	ELECTRA	WP6
4.5	Increased Observability and Controllability by Distribution System State Estimation - Accuracy, Implementation, Applications and Validation of Advanced Data Driven Estimation Techniques and Topology Identification	12	Global	WP5
4.6	Dynamic Line Rating as a flexibility mean for intra-cell management and inter-cell coordination	12	European	WP6

4.5 The Fifth Researcher Exchange Call

The fifth ELECTRA REX Call has scheduled to coincide with ISGT Europe'16 at which a special papers session was organized. This gave the opportunity for conference delegates to hear firsthand of the research results from exchanges undertaken in Calls 2 and 3, as well as appreciate the value gained from exchange, and to consider the possibility of participating themselves. By

following the ELECTRA REX methodology, the EPMC was again able to approve and see launched a total of 8 exchanges, including 3 ELECTRA exchanges, 3 European exchanges, and 2 Global exchanges. Figure 21 and Table 8 present the successfully supported exchanges.

At the stage of launching Call 5, an increasing focus was being given to experimental validation within the ELECTRA research project, and this is reflected in a number of the exchanges undertaken. This brought a range of benefits to the work of validating the ELECTRA concept for decentralized control - the Web of Cells concept. ELECTRA exchanges proved a valuable way for extended stays for experimental work in partner laboratories, and this contributed to a deeper level of cooperation and delivered a marked acceleration in the establishment and conduct of experiments integrating partner algorithms within another partner's infrastructure. Global exchanges were also useful in this regard, either providing for the Web of Cells concept to be experimentally integrated with other emerging techniques or for lessons to be gleaned from other international experiences.

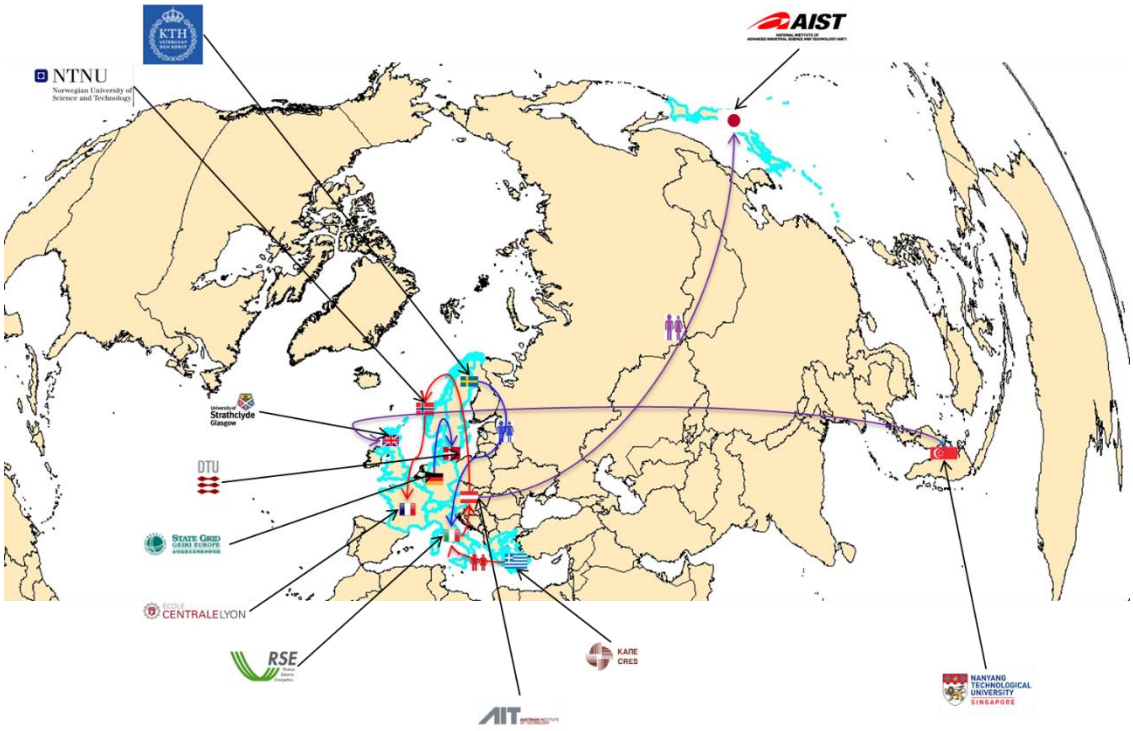


Figure 21 Diagram showing the research institutions involved in REX Call 5

Table 8 Research topics of REX Call 5

No	Title	Duration (wks)	REX product	WP relevance
5.1	KTH-RSE collaboration on Cyber Security Risk Assessment for ELECTRA	4	European	WP4
5.2	Simulation and experimental validation of voltage control use cases (PVC, PPVC)	4	ELECTRA	WP7
5.3	Validation of advanced interoperability functions for Battery Energy Storage Systems	4	Global	WP7
5.4	Frequency response estimation using ambient PMU-data	12	European	WP5
5.5	Lab validation: implementing the developed linear decision rule-based reserve control policy for balance restoration control in SYSLAB	3	European	WP7
5.6	Distributed Voltage Control using Energy Storage Systems for High PV-Penetrated Distribution Networks	4	Global	WP6
5.7	Power-hardware in the loop tests for electric vehicles smart charging strategies including inertial response at the Norwegian National Smart Grid Laboratory	8	ELECTRA	WP7
5.8	Experimental implementation and validation of FCC and BRC use cases	2	ELECTRA	WP7

4.6 The Sixth and Seventh Researcher Exchange Call

A sixth Call for applications was again scheduled to coincide with a major international event, in this case the CIRED'17 conference. The inclusion of ELECTRA REX flyers within delegate packs (see Annex 5), inclusion of ELECTRA REX pop-ups, and highlights in keynote and panel contributions, the mobility scheme has given a high profile.

It furthermore proved possible to operate an extra Call for applications, Call 7, to accommodate more exchanges at the end of the programme. This however did not attract a strong number of applications, and was also beset by the withdrawal of a successful applicant due to ill health. Nonetheless four exchanges were originally supported, including one repeat visit to further the experimental results of a previous exchange. Unfortunately, two exchanges subsequently had to be withdrawn due to ill health and visa delays.

The exchanges supported by the sixth and seventh calls were again managed in accordance with the methodology and are illustrated in Figure 22 and Table 9.

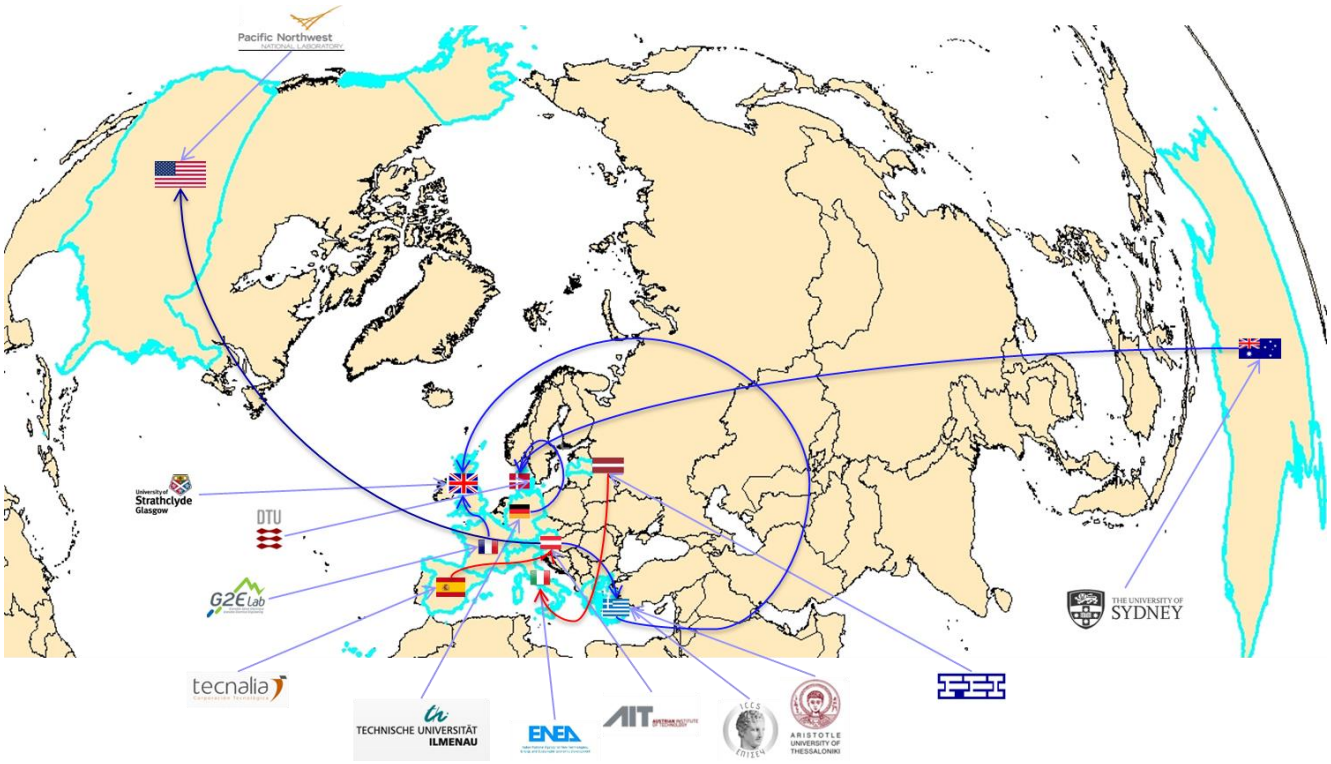


Figure 22 Diagram showing the research institutions involved in REX Call 6 & 7

Table 9 Research topics of REX Call 6 & 7

No	Title	Duration (wks)	REX product	WP relevance
6.1	Coupling of grid and PV-simulators to a communication middleware for HIL based validation of advanced smart grid control approaches	4	European	WP7
6.2	Description and design of a distributed decision process and control room implementation concept for enhanced inter-cell cooperation	4	European	WP6/8
6.3	Stability Monitoring of Active distRibuTion GRIDs – (SMART GRID)	4	European	WP8
6.4	Distributed control in microgrid - Implementation on a real platform	4	European	WP6/WP7
6.5	Analysis of market design for prosumers' flexibility in the U.S. in comparison to Europe/Austria	12	Global	WP3
7.1	Regulatory Rules for the Market Design Solutions within the Web-of-Cells Concept (ReMDeS)	3	ELECTRA	WP3
7.2	Extension of distributed control in microgrid - Validation on a real platform	2	European	WP7

5 Results and wider impact

5.1 Summary results and performance

The outputs achieved at project completion are summarized in the WP9 Key Performance Indicators (KPI). These indicators include joint publications and trained young researchers, as well as numbers of exchanges and partners as shown in Table 10.

Table 10 Key Performance Indicators for WP9 (*see text below)

Exchange KPIs	Target M24	Result M24	Target M51	Result M51
No. of exchange calls	2	3	6	7
No. of researcher exchanges	6	6	30	39
No. of researcher-weeks of international exchange	12	12	75	98
No. of extra-EU partners involved in exchange	2	1	15	11
No. of trained young researchers	4	4	21	25
No. of joint publications	6	6	45	24 (+28*)

Targets have been met and indeed surpassed in relation to the numbers of calls for applications, exchanges, and exchange duration. This has been achieved through the combination of an effective methodology, efficient processes for rapid turn-around, and extensive work in the dissemination and publicity of the mobility programme within the research community. International conferences have proved valuable for this. Nonetheless, the attraction of large numbers of applications proved elusive throughout the programme. The mobility questionnaire reported later in this chapter identified some of the key barriers to exchange engagement. While family commitments were cited amongst these barriers, there was only one case in which an ELECTRA REX exchange start date change was requested and accepted for family reasons.

The desire to provide rapid turn-around of the increased numbers of exchanges presented some challenges, not least in the negotiation of contracts for each exchange. However, the Exchange Coordinator with the support of the project coordinator brought in a subcontractor for contracts handling and this allowed the exchange commissioning to proceed effectively.

The extra-EU KPIs demonstrate significant success in achieving a greater number of international exchange-weeks than targeted while engaging with a lower number of extra-EU partners. Overall exchange support costs were at the same time lower than anticipated, this being significantly helped by the programme requesting co-funding in the cases of exchanges lasting more than 2 months. This additional funding, together with the coordinator's requesting of receipts, has contributed to a significantly reduced budget spend on exchange support. One extra-EU partner hosted two exchanges from different ELECTRA partners, and one of the later exchanges had to be cancelled due to visa delays. These contributed to the reduced result on the extra-EU partner KPI. Nonetheless, exchanges have involved collaborations with Asia, North America, South America and Australasia.

The target for early career researchers being trained through exchange has been surpassed. While not exclusive to those at the start of their career, the programme encouraged the consideration of training content during the exchange period. As a result, the experience provided to each of the researchers has been of significant value, contributing to PhD completion, additional high quality publications, training sessions, and personal career advancement.

The target for co-authored papers actually published has not yet been reached, however a significant number of papers are still in development or review, and it is anticipated that this will be surpassed before long. At the stage of writing this report, a further 5 co-authored abstracts have

been accepted and the papers are being finalised for submission, a further 8 papers have been published directly benefiting from the exchange, and 15 additional papers are in active preparation. At this stage a potential 52 papers have been identified.

These papers, combined with the extended web abstracts posted on the project web site (some of which are included in Annex 4), provides a detailed record of the technical results achieved through the exchange programme. The following value is included in that reported from exchange:

- Value has been brought to the research programme by the intimacy of ELECTRA colleagues working together for a spell in the same office or laboratory;
- Valuable contribution has been made to the Web of Cells concept, its development and validation, and to researchers' and institutions' shared understanding;
- The exchange has immersed new young PhD researchers into the collaboration and engagement of the ELECTRA IRP and EERA JP. This provided a boost to them aligning their research studies in contribution to work package effort;
- Improved understanding of partners' laboratories supporting comparative and collaborative working.

The infographic shown in Figure 23 complements the KPIs and provides a useful summary of the programme statistics achieved.

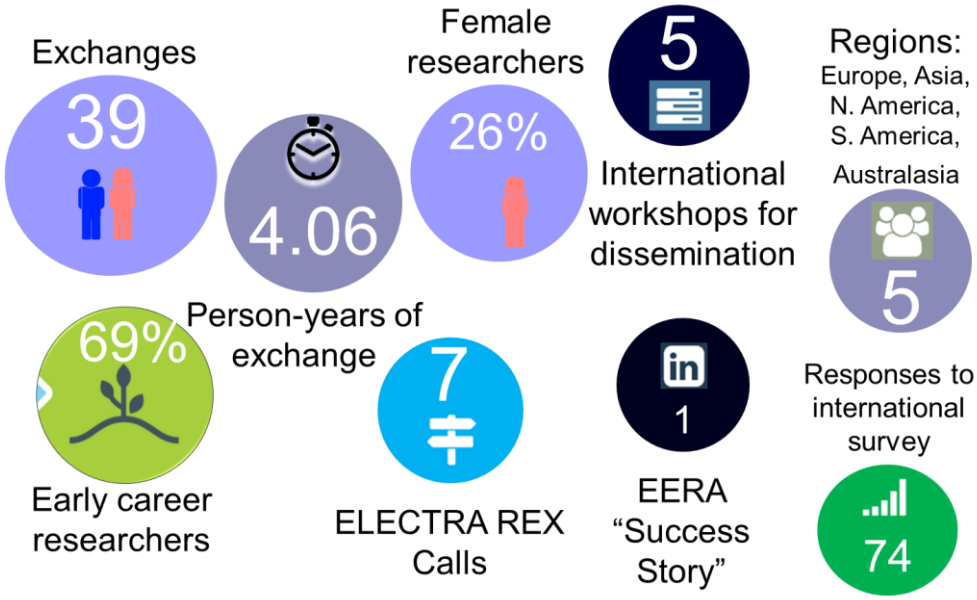


Figure 23 Summary infographic of programme statistics

5.2 Dissemination and publication of results

The research results obtained through the exchange programme are being disseminated through the publication of quality papers in journals and international conference. These co-authored publications are providing an insight to what was achieved through the exchanges, and are supporting ongoing dialogue and cooperation beyond the end of the exchange period. The lasting impact of these ongoing engagements should not be underestimated. Indeed, some new exchanges are already underway through other funding programmes as a direct consequence of an ELECTRA REX exchange.

A number of dedicated ELECTRA REX workshops were organised to support both dissemination and the sharing of best practice gained from the researcher exchange [4]. These were organised

alongside international conferences and workshops, and took the form of special papers sessions. In this way the reach and impact of ELECTRA REX was increased.

These workshops proved to be of value to the exchange researchers themselves. As well as publishing peer-reviewed and internationally co-authored papers, they:

- disseminated the results of their exchanges, their methods and experience;
- shared their experience of exchange working in leading global smart grid organisations;
- were encouraged to network and create a community of early career smart grid researchers.

In sympathy with the latter, the public workshops were supplemented with private meetings of the exchange researchers where any issues could be more openly aired.

The following sub-sections present a summary of the five workshops organized throughout the duration of the programme.

5.2.1 ELECTRA REX Workshop 1: Vienna, Austria, September 2015

The first ELECTRA REX Workshop on Smart Grid Researcher Exchanges was held in Vienna at the EDST2015 symposium, on September 8th and 9th, 2015. This event provided an opportunity for delegates to hear from the six successful participants in REX Call 1 and to be introduced to the wider work of the EERA Joint Programme in Smart Grids. The workshop took the form of a special papers session at the conference, and the dissemination efforts were significantly assisted by the co-authored papers published in the conference proceedings. Each exchange researcher gave workshop delegates a first-hand account of the value of their exchanges to prestigious smart grid centres.

Figure 24 includes some pictures of the workshop, which attracted nearly forty delegates. The agenda for the workshop is included as Table 11. The REX programme made good use of the ELECTRA news feeds to publicise the results of the workshop and to highlight the online posts of the presentations.

Figure 24 Pictures of the first ELECTRA REX dissemination workshop in Vienna

Table 11 Agenda of the first ELECTRA REX dissemination workshop

SS05	**Experiences from the ELECTRA IRP Researchers Exchange**
Wednesday, 9th September 2015, 14:10 - 16:10	
VF-005193	Sizing and grid impact of PV battery systems - a comparative analysis for Australia and Germany
	Jan von Appen, Julio H. Braslavsky, John K. Ward, Martin Braun

SS05	Experiences from the ELECTRA IRP Researchers Exchange
Wednesday, 9th September 2015, 14:10 - 16:10	
VF-005118	Frequency Restoration Reserves: Provision and Activation Using a Multi-Agent Demand Control System
	Reinhilde D'hulst, Jef Verbeeck, Chris Caerts, Mazheruddin Syed, Ammar Zaher, Graeme Burt
VF-005134	A Use Case Methodology to Handle Conflicting Controller Requirements for Future Power Systems
	Kai Heussen, Mathias Uslar, Carlo Tornelli
VF-005142	Implementation of a Fuzzy Logic Controller for Virtual Inertia Emulation
	Konstantina Mentesidi, Evangelos Rikos, Raquel Garde, Monica Aguado
VF-005126	Distributed Framework for Prototyping of Observability Concepts in Smart Grids
	Alexander Prostejovsky, Oliver Gehrke, Anna M. Kosek, Federico Coffele, Ammar S. A. E. Zaher
VF-005169	Demand Side Participation for Frequency Containment in the Web of Cells Architecture
	M. H. Syed, G. M. Burt, J. K. Kok, R. D'Hulst

5.2.2 ELECTRA REX Workshop 2: Ljubljana, Slovenia, October 2016

The dedicated ELECTRA REX workshop took the form of an “invited technical and industry sessions” at ISGT Europe’16. This session gave the opportunity for five of the exchange researchers (from Call 2 and Call 3) to share their experiences and results to around twenty delegates in a parallel conference session, Figure 25. Each of these presentations was based on their peer reviewed co-authored paper which was included within the conference proceedings, and covered a number of valuable aspects of the ELECTRA research programme. These papers are listed below, together with the collaborating institutions:

- Mathias Uslar, Kai Heussen, (OFFIS, DTU), Towards modelling future energy infrastructures – the ELECTRA systems engineering approach
- Junjie Hu, Kai Heussen, Bert Claessens, Lei Sun, Reinhilde D’ Hulst (DTU, ZheJiang University, VITO), Toward Coordinated Robust Allocation of Reserve Policies for a Cell-based Power System
- E. Guillo-Sansano, M.H. Syed, A.J. Roscoe, G. Burt, M.J. Stanovich, K. Schoder. (University of Strathclyde, Florida State University), Controller HIL testing of real-time distributed frequency control for future power systems
- M. V. Khokhlov, A. Obushevs, A.Mutule (Komi SC, IPE), Optimal PMU Placement for Topological Observability of Power System: Robust Measurement Design in the Space of Phasor Variables
- P. MacDougall, B. Ran, G. Huitema, G. Deconinck (TNO, University of Groningen, University of Leuven), Predictive control for multi-market trade of aggregated demand response using a black box approach

This programme provided the audience with results from a mix of Global Exchanges and intra-ELECTRA exchanges that covered the modelling, experimental testing, observability requirements and market structures for the project’s Web of Cells (WoC) distributed control concepts. The question and answer sessions provided a useful exchange of research ideas and enquiries. Publicity material was provided for all conference delegates to support the wider dissemination of

the mobility programme opportunities. This took the form of a two-fold flyer, whose cover sheet is shown in Annex 5. This attracted a number of discussions with possible applicants to future calls.

Figure 25 ELECTRA REX researchers participating in ELECTRA REX Workshop

5.2.3 ELECTRA REX Workshop 3: Birmingham, UK, November 2016

A special dissemination and review session was organised at the First European Energy Research Alliance Conference, 2016. The event held in Birmingham in November 2016 attracted over two hundred participants to a varied and interdisciplinary programme, all of whom learned of the ELECTRA REX mobility programme and the opportunities for interdisciplinary research collaboration by way of an EERA success story case study (see Annex 9). The conference programme also included special presentation and discussion sessions at the end of Day 2 under the theme of Joint Programme Development.

The dissemination session “Interacting with stakeholders” was used to share the ELECTRA REX approach and experiences with an audience of around thirty researchers from different energy fields. A joint presentation by the ELECTRA REX Coordinator and Massimo Busuoli (NTNU and EERA Mobility Task Force Coordinator) provided an insight to delegates of how mobility might help energy researchers cooperate more and better to solve existing challenges and come up with new solutions for the future (Figure 26).

Figure 26 Joint mobility presentation at the First EERA Conference

The presentation session was followed by a dedicated discussion forum that allowed the participants from a number of differing EERA JPs and backgrounds to consider the nature and needs of effective mobility programmes. The group considered the draft task force questionnaire, offering suggested changes and additions for inclusion prior to issuing.

5.2.4 ELECTRA REX Workshop 4: Turin, Italy, September 2017

The fourth ELECTRA REX workshop was held as part of the ISGT Europe'17 conference programme in Turin. The event attracted around forty delegates, who came to hear the results of six exchanges involving researchers from Europe and South America who participated in Calls 3-5. The presentations by the recipients of ELECTRA REX mobility awards highlighted interesting results from their collaborative research on advancing various aspects of the Web of Cells concept. These initiated some interesting discussion, and stimulated further interest in the final call for applications. The papers are listed below, together with the collaborating institutions:

- Antonio Del Giudice, Adrian Wills, Andrew Mears, (ENEA, University of Newcastle) Development of a Planning Tool for Network Ancillary Services Using Customer-Owned Solar and Battery Storage
- Evangelos Rikos, Mattia Cabiati, Carlo Tornelli, (CRES, RSE), Adaptive Frequency Containment and Balance Restoration Controls in a Distribution Network
- Maria Valov, Julia Merino, (Fraunhofer IWES, Tecnalia), A Case Study of an Adaptive Protection Scheme for the Web-of-Cells Concept
- Eleftherios Kontis, Mazheruddin Syed, Efren Guillo-Sansano, Theofilos Papadopoulos, Andreas Chrysochos, Grigoris Papagiannis, Graeme Burt, (Aristotle University of Thessaloniki, University of Strathclyde), Development of Measurement-Based Load Models for the Dynamic Simulation of Distribution Grids
- Diego Issicaba, Alexander M. Prostejovsky, Mauro Augusto da Rosa, Henrik W. Bindner, (INESC Brasil, DTU), Experimental Validation of BDI Agents for Distributed Control of Electric Power Grids
- Pamela MacDougall, Bob Ran, George Huitema, Geert Deconinck, (TNO, KU Leuven), Multi-Goal Optimization of Competing Aggregators using a Web-of-Cells Approach

The conference also gave opportunity for a keynote address by the Exchange Coordinator, and for publicity material to be made available to all conference delegates. The picture in Figure 27 was taken during the workshop.

Figure 27 The fourth ELECTRA REX dissemination workshop in Turin

5.2.5 ELECTRA REX Workshop 5: Milan, Italy, February 2018

The final REX workshop took the form of a poster session as part of the final ELECTRA project meeting. This provided an opportunity for twenty of the exchange recipients to share their research results and exchange experiences, and to appreciate more of the research context in which their work fitted.

At the same time, a number of videos of researcher exchanges were prepared to support dissemination of ELECTRA REX results and to encourage future interest in exchange opportunities. Some of the REX participants are already exercising other opportunities for exchange-based collaboration, such as available through ERIGRID Transnational Access [5]. This is now building and expanding on the work already completed under ELECTRA REX through follow-on experimentation.

5.3 Internal feedback and improvement

Throughout the programme operation, opportunities for feedback and improvement were created. Two primary routes for feedback were utilised, with the first of these being closed workshops with exchange researchers, and the second being through questionnaires. These were organised alongside the aforementioned dissemination workshops, with the first of these being hosted for REX Call1 researchers by AIT in Vienna on 8th September 2015 (see Figure 28). They provided an opportunity for the researchers from various home institutions to meet each other, to share experiences, and to gather lessons learned that might offer improvements for future participants.

Figure 28 REX Call 1 researchers with REX coordinator and ELECTRA technical coordinator

Exchange researchers thus offered the following highlights of their exchange experience:

- Learning about other infrastructures and workflows;
- Good networking with open minded people, and new insight into their working field;
- New understanding of grid integration challenges from different national situations;
- Brainstorming opportunities to the enhancement of research ideas;
- Following up on previous collaborations;
- Tangible research inputs/outputs;
- Valuable feedback on conducted work.

The feedback from the exchanges was generally very positive, and researchers were unanimously happy to recommend the scheme. Improvements are always possible, and amongst the areas of concern that were at times expressed by the researchers and offered as areas for improvement were the following:

- Call text has been too general and objectives set were very ambitious;
- Administrative difficulties experienced were mostly related to contract matters;
- The expectation of exchange start dates following shortly after the results being announced were at times too short, especially where a long term visa was required;
- Activities were, on occasion, not entirely well executed;
- Coordination in/between facilities was at times difficult;
- Not enough technical insight available for some of the proposed work;
- It took the same effort for an application for a 2 week exchange as for a 12 week exchange.

The workshop feedback was complemented by that obtained through questionnaires. Close-out questionnaires, a researcher questionnaire and a host questionnaire, were included as deliverables in every exchange contract. The analysis of the questionnaire responses solicited from the exchange researchers and hosts provides evidence to the positive experience obtained through the smart grid exchanges. This is summarised in Table 12 and Table 13 respectively, relating to the responses from Calls 1-7. These only show the non-null return fields, evidencing the positive nature of the feedback.

The feedback from the exchange researcher questionnaires was very positive, and in particular offered the following highlights:

- The hosting institution provided a value adding experience to the research activity and a unique experience to collaborate with open-minded experts with different background;
- The overall activity performed at the hosting institution was satisfying and gave valuable input from the interaction between different research topics;
- The exchange objectives and activities were performed as planned mostly in all REX proposals, adapting it according to discussion with the hosting institution; some critical constrains are referred to ELETRA project progress;
- The experience gained throughout the REX exchange was beneficial, and in particular the researchers highlighted: good collaboration with the hosting institution responsible person; enough time dedicated to the research activity; good exchange opportunities with other ELECTRA partners; possibility to continue the collaboration with the hosting institution also after the REX experience; additional knowledge gained beyond the project scope; suggestions for improving laboratory facilities and equipment; possibilities to prepare some peer-reviewed publications;
- The exchange contributed towards their personal development and training, developing new competencies and expanded problem comprehension;
- The results of the exchange were directly used for ELECTRA activities and motivated further developments of the proposed approach;
- Good intension to continue collaborating with the team at the host organization.

The feedback from the hosting institution questionnaires was very positive, and in particular offered the following highlights:

- The REX researcher respected the local rules of the hosting laboratory, and in one case the researcher had already been familiar with the rules and regulations governing the hosting organization before her visit, due to previous visits she had paid to the facilities in the frame of other European projects;
- The REX researchers were well prepared for using the test facilities;
- The effort dedicated for the preparation of the exchange was also strongly linked to the ELECTRA research activities;
- Good satisfaction by the overall activity performed by the REX researchers; some critical constrains are referred to the limited visit duration and because of that the test results were limited to some basic scenarios;
- The experiments carried out by the researchers were performed as planned and correctly;
- Good benefits hosting the exchange researchers, above all for results sharing and possibilities for scientific publications, experience exchange between hosting and hosted researchers, and establishment of a good collaboration between the two organizations so as to promote common research activities and project ideas.

Question	Results
1. The hosting institution responsible person(s) provided a value adding experience to my research	Strongly agree (25)
	Agree (10)
	No view (1)
2. I am satisfied by my overall activity performed at the hosting institution	Strongly agree (20)
	Agree (16)
3. My exchange objectives and activities were performed as planned in my REX proposal	Strongly agree (17)
	Agree (18)
	No view (1)
Critical constraints	Technical (9)
	Time (22)
	Economical (1)
	Other (dependency on ELECTRA project progress, administrative issue and confidentiality) (3)
4. The experience I gained throughout my exchange was beneficial	Strongly agree (25)
	Agree (11)
Related benefits	Suggestions for improving laboratory facilities and equipment (10)
	Results sharing and possibilities for scientific publications (28)
	Experience exchange between hosting and hosted researchers (29)
	Collaboration in research activities and projects (22)
5. My exchange has contributed towards my personal development and training	Strongly agree (25)
	Agree (10)
	No view (1)
6. The work I undertook during my exchange will generate valuable research outputs	Strongly agree (18)
	Agree (17)
	No view (1)
7. I intend to continue collaborating with the team at the host organisation	Strongly agree (24)
	Agree (12)

Table 12 Results from Researcher questionnaires

Question	Results
1. The REX researcher respected the local rules of my laboratory	Strongly agree (21)
2. The REX researcher was well prepared for using the test facilities	Strongly agree (9)
	Agree (9)
	No view (3)
3. How many hours of planning and preparation did you and your team commit prior to the exchange?	1 -10 hours (6)
	11 -20 hours (8)
	21 -30 hours (1)
	31 -40 hours (3)
	more than 40 hours (3)
4. I'm satisfied by the overall activity performed by the REX researcher	Strongly agree (16)
	Agree (5)
5. The REX researcher's exchange involved experimental activity	Yes (9)
	No (12)
6. The experiments carried out by the researcher were performed as planned and correctly	Strongly agree (5)
	Agree (4)
	No view (12)
7. Hosting the exchange researcher was beneficial to my research team / institution	Strongly agree (11)
	Agree (10)
Related benefits	Suggestions for improving laboratory facilities and equipment (3)
	Results sharing and possibilities for scientific publications (20)
	Experience exchange between hosting and hosted researchers (18)
	Collaboration in research activities and projects (13)
8. What value of additional costs did you incur in supporting the exchange?	€ 0-500 (4)
	€ 500-1000 (2)
	€ 5000-10000 (2)
	No additional costs (13)

Table 13 Results from Hosting Institution questionnaires

5.4 Wider impact beyond smart grids

The ELECTRA REX programme supported exchanges for smart grid researchers, however it was recognised that benefit could be gained from consultation and comparative analysis with similar efforts across the energy domain. This effort involved participation in joint workshops and cooperation through the EERA Mobility Task Force.

5.4.1 Workshops support wider impact

A special mobility session was organised at the EERA Summer Strategy Meeting, Trondheim, 28-29 June 2016. This provided a launch meeting of the EERA Mobility Task Force, and provided an opportunity to share the methodology and lessons learned from the ELECTRA REX programme with representatives from other EERA Joint Programmes and the EERA Secretariat. The most comparable scheme to ELECTRA REX was that developed by the IRP WIND project, and key differences were identified in the two approaches as indicated in Table 14.

Table 14 Comparison of ELECTRA REX and IRPWind mobility programmes

IRPWind	ELECTRA REX
• Only experienced staff, no PhDs	• PhD students and staff
• Intra IRPWind exchange, within the EERA JPWind partners	• Intra ELECTRA exchange, European exchange, Global exchange
• Different schemes- continuous call, different schemes were tried	• Multiple calls
• No max limit for funding	• No max limit (other than guidance) for funding but co-funding invited for longer exchanges
• From 4 weeks to 26 months	• From 2 weeks to 12 weeks +
• Freedom of topics (bottom-up)	• Topic calls with priority topics (top down) and self-defined
• From 2 weeks to 4 weeks (only for Managers)	• Call opened around twice a year
• Funding was moved to mobility under Infrastructures	• Exchange workshops organized as conference special sessions

An IRP Coordination Meeting was held in Brussels, 6 July 2016, which included mobility matters. This meeting of the EERA IRP leaders together with respective EC Project Officers provided an opportunity to share the experience to date with the ELECTRA REX mobility programme, and to share lessons learned together with the IRPWind Mobility scheme. This was further complemented by the aforementioned Workshop 3 at the First European Energy Research Alliance Conference in Birmingham in November 2016. This supported engagement with IRP and EERA Joint Programme leaders and participants from across the energy domain, and provided an opportunity to share the key features of ELECTRA REX and discuss the relative merits of alternative approaches and schemes.

5.4.2 EERA mobility questionnaire regarding energy domain mobility

The ELECTRA REX Coordinator led the development, conduct and analysis of a researcher mobility questionnaire as part of the EERA Mobility Task Force. The purpose of this was the collection of relevant information and experience concerning available national and international instruments, supporting researcher (academic or industrial) and student mobility in any thematic area within the energy domain. The combination of scheme information and participant experience

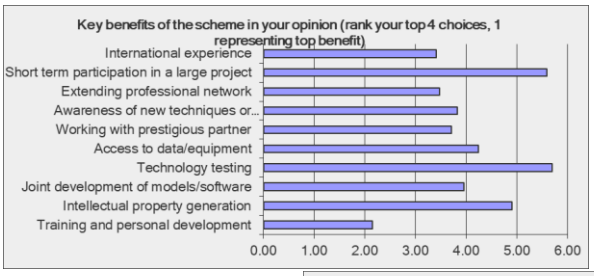
provides a useful insight for the recognition and discernment of best practice. This cooperation benefited significantly from the experience from operating the ELECTRA REX and IRPWind programmes.

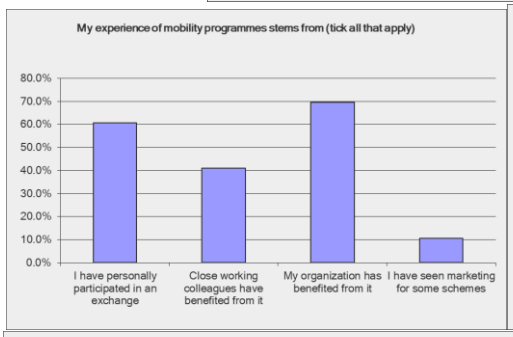
Hosted by the Survey Monkey platform, the questionnaire was circulated to a wide range of stakeholders including:

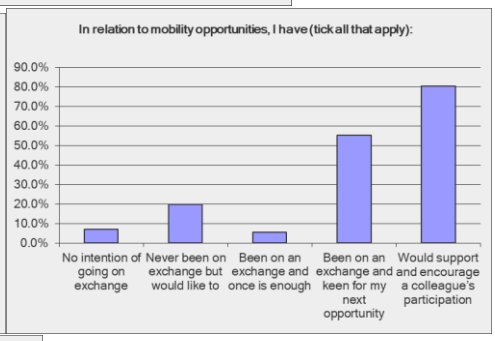
- University groups including: EUA – European University Association, CESAER – Conference of European Schools for Advanced Engineering Education and Research, N5T – Nordic Five Tech, EUROTECH UNIVERSITIES, THE GUILD, LERU – League of European Research Universities, YERUN – Young European Research University Network
- Industry groups including: BUSINESS EUROPE, ENERGY RELATED TECHNOLOGY PLATFORMS, Biofuels ETP, Photovoltaic ETP, Ocean energy Europe, Renewable Heating and Cooling, European Technology and Innovation Platform for Smart Network for Energy Transition, SNETP, ETP Wind, ZEP
- RTOs including: EARTO, EERA JPs, ERRIN, IGLO

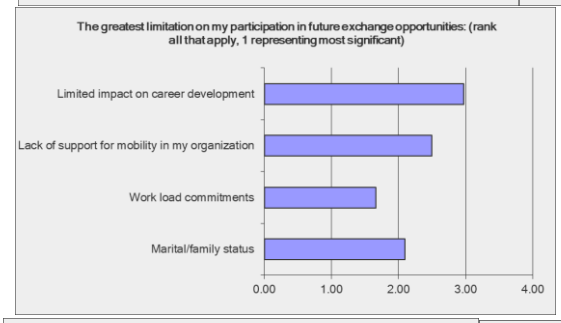
A total of 74 responses from 16 countries were obtained, and the questionnaire analysis included within the Task Force Report. Some summary results are listed below, with Figure 29 showing some example charts developed from the response analysis.

- The primary benefits of the mobility programmes identified by the respondents identified training and personal development as by far the top ranking benefit. The value of international experience and of professional networking are each showing as the next most valuable benefit of mobility.
- In terms of the respondents' own experience, the majority have personally participated in exchanges, report their organisations benefited, and would encourage others to participate. They do report work load and family status as the two greatest limiting factors, though some further limiting factors have been elaborated.
- The respondents felt that their own careers would benefit most from a mobility experience through the opportunity to extend their professional network and the opportunity to access specialist knowledge. This was followed by their expectation of personal development resulting from the experience. This is perhaps further reflected in the perception that exchanges are of greatest benefit to early career researchers.
- The respondents were further invited to reflect on the most desirable features they would like to see in a future EERA mobility scheme. The top choices highlighted were the respondents were, almost equally, the provision of laboratory access costs as well as travel and subsistence costs, and being responsive to rapid approval and quick starts using standard agreements. Of least significance from the choices given was the support for two way exchanges and the avoidance of a quality review process.

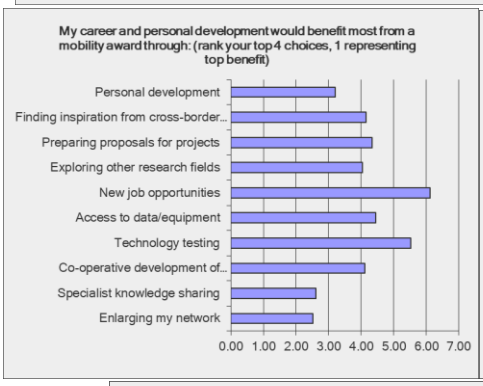


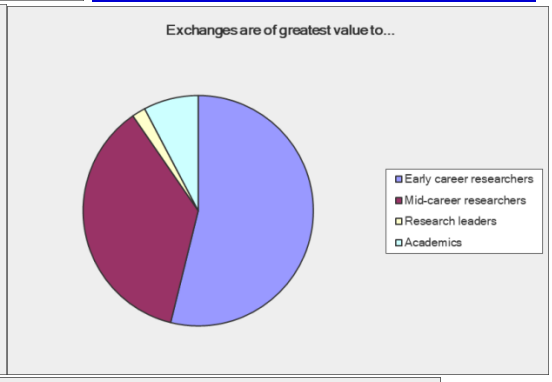






Number	Response Text
1	this scheme is ending, after a couple of years when I would like to participate next, perhaps no scheme to apply for
2	Suitable reason/topic: I don't want to go "just because I can"; should have a real net benefit.
3	2 weeks is too short for an impact on career development. longer stays sometimes desirable.
4	Other projects might suffer because of the lack of direct communication with colleagues
5	Difficult to transfer responsibilities at home when abroad for a longer duration For non-profit research institutes one will need a large R&D project to cover hour costs while on exchange since the usual work situation is to work on several projects and mobility will only cover direct extra costs for transport and subsistence
6	N/A
7	Support if partial funding needed. Age/career stage limitations.
8	The way of funding the researcher, who should collect and keep all receipts. Maybe a better way for funding, more efficient, should be found.
9	N/A
10	3- Not involved in public research any longer (industry).





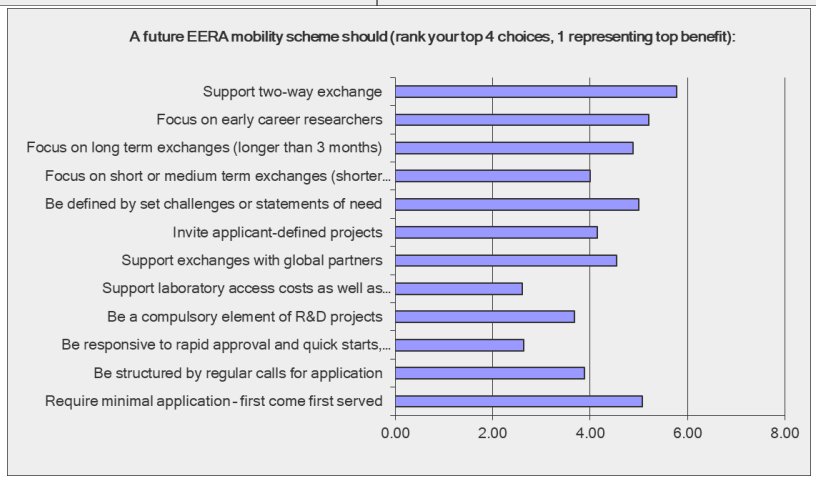


Figure 29 Selected results of the cross energy domain mobility questionnaire

While it has to be recognised that this survey includes a large measure of self-selection, given that non-responses were not included in the data, it does provide some insight on the characteristics of

exchange programmes that are currently available and a perception of their pros and cons. The enthusiasm for exchange is clear.

5.5 Ongoing impact and effort

The successes of the ELECTRA REX methodology and programme have been recognized across the smart grid community, at senior levels within the European Energy Research Alliance, and beyond. It is not surprising therefore that the model is being adopted in other projects and proposals. The EERA Mobility Programme is being modelled on ELECTRA REX, as is the mobility programme of the ECRIA project SMILES. Moreover, the mobility related task force of the DERlab association of distributed energy laboratories has benefited from the insight gained from ELECTRA REX, and is in the process of implementing actions suitable for promoting greater inter-laboratory cooperation as a result. The ELECTRA REX model has further been included as part of the CSA actions within at least two other proposals to date. Ongoing work in this area will provide the basis for further work to be undertaken to better improve both the volume of applications attracted and the active involvement of industry. Through these efforts, and with future funding success, it is purposed to continue to provide a coordinated offer of researcher mobility associated with the EERA Joint Programme in Smart Grids to the benefit of a deeper level of cooperation and accelerated realisation of SET Plan goals.

6 Conclusions

This document shares the results of the ELECTRA REX Researcher Exchange Programme. Most key targets have been met through implementation of the developed methodology, good levels of dissemination achieved, important value delivered to the ELECTRA project and the EERA Joint Programme, and wider impact achieved through engagement with the wider energy research community. Despite the successes, the attraction of high numbers of applicants and the active involvement of industry remained elusive, and further work is required here. The ELECTRA REX model is already being adopted in other projects, and further funding is being actively sought. Reported benefits from the exchange experiences supported through ELECTRA REX are broad, spanning personal development and advancement, research concept development and validation acceleration, research infrastructure enhancement, and new active research collaborations that continue beyond the duration of this project. As such the research outcomes resulting from the mobility programme continue and the associated number of joint publications continue to grow.

7 References

[1] http://www.electrairp.eu (ELECTRA IRP web site)

[2] http://www.ieei.rtu.lv/POWERENG2015/

[3] ELECTRA Deliverable D9.1, “Exchange programme procedures and documentation”

[4] ELECTRA Deliverable D9.3, “Workshop for exchange researchers to share best practice and cooperative research ideas”

[5] https://erigrid.eu/transnational-access/ (ERIGRID Transnational Access web site)

8 Disclaimer

The ELECTRA project is co-funded by the European Commission under the 7th Framework Programme 2013.

The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Commission.

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Annex 1: Questionnaire issued to ELECTRA Work Package leaders to identify the focus of a Call

This questionnaire has been prepared as part of the Researcher Exchange programme within the ELECTRA project (WP9). ELECTRA's Researcher Exchange (REX) programme offers the opportunity for ELECTRA partners and European or International collaborators to work closely together through an exchange of staff. The scheme is open to participants from research organisations and industry, including SMEs. Host organisations are encouraged to offer elements of training, and so this represents an excellent development opportunity, especially for early career researchers.

The following questionnaire is an example of those populated by WP leaders for a REX Call.

Work Package Number: XX **Work Package Leader: XXXX**
1. In what topic areas would you particularly welcome exchange applications in REX Call 2 (to be issued June '15) • Control room functionality in particular with respect to visualisation of internal state of cells e.g. amount of inertia, voltage control capabilities and inter cell state of operation e.g. exchange between cells and comparison with schedule. • Topics relating to observability of cells in particular in relation to their responsibilities i.e. exchange and voltage control.
2. Who in industrial organisations would you particularly welcome participating in an exchange to the benefit of the ELECTRA IRP programme? • Researcher/developers from SCADA system providers
3. Can you identify particular SME's that you can recommend participating in an exchange?
4. Which of the work packages should benefit most from the aforementioned topics and industry partners? • WP 8 and WP7
5. If you are a Work Package Leader, which aspect of the programme would particularly benefit from (a) intra-ELECTRA, (b) European, (c) Global exchanges? • a - intra-electra exchanges will be a valuable tool for ensuring coherence between the developed solutions and their implementability/validation; • b - integration of results from other EU-projects; c - control room operators from US and Japan.
6. REX Call 3 (to be issued September '15) will particularly focus on global exchanges - what topics and global partners would have the greatest impact on the realisation and testing of innovative smart grid controls?
7. What emphasis would you like to be made in the subsequent REX Calls: Call 4 (due early '16), Call 5 (due late '16) and Call 6 (due early '17)? • topics for demonstration of developed topics

Work Package Number: XX

Work Package Leader: XXXX

8. If you are a Work Package Leader, which of the following calls would you expect to make most use of in your work package:

☐ Call 2 (June'15)

☐ Call 3 (Sep '15)

x Call 4 (early '16)

x Call 5 (late '16)

☐ Call 6 (early '17)

If you are NOT a Work Package Leader, which of the following calls would you expect to be most interested in:

☐ Call 2 (June'15)

☐ Call 3 (Sep '15)

☐ Call 4 (early '16)

☐ Call 5 (late '16)

☐ Call 6 (early '17)

9. List exchanges you expect to apply and complete in each IRP year

	Sending organisation	Receiving laboratory	Description	Value to IRP
Call 2 (June '15)	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Call 3 (Sep '15)	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.
Call 4 (early '16)	1. increased observability 2. 3.	1. 2. 3.	1. 2. 3.	1. WP5 2. 3.
Call 5 (late '16)	1. improved visualisation of state of cells 2.	1. 2. 3.	1. 2. 3.	1. WP6 and WP8 2. 3.

Work Package Number: XX Work Package Leader: XXXX				
	3.			
Call 6 (early '17)	1. 2. 3.	1. 2. 3.	1. 2. 3.	1. 2. 3.

10. Are you personally aware of any benefit already achieved from an ELECTRA REX exchange? Please describe.

The two exchanges that DTU has participated in have contributed significantly to the progress of Electra. The one involving OFFIS are contributing to the clarification of controller conflicts between the various controllers contributing the safe operation of the cells. The exchange involving Strathclyde has contributed to a more basic part of the system in that some algorithms for dynamic topology detection has been tested on a different grid setup.

Annex 2: Initial flyer of REX Call 1

Call for Researcher Exchanges in the ELECTRA Project

The Exchange Programme Management Committee of the ELECTRA Integrating Research Programme is pleased to announce the first call for applications for Researcher Exchanges between ELECTRA Partners, and between ELECTRA Partners and International organisations.

This Exchange Programme will provide funding (travel and subsistence) for a researcher to work at another recognised research institute to enhance the effectiveness of the ELECTRA research programme.

The research to be conducted during the exchange must be agreed with the Host Institute in advance of the application.

Topics for researcher exchanges during this first call are (in no particular order):

- Voltage control
- Frequency control
- Experimental demonstration
- Ancillary services provision
- Electro-mobility

Applications must be made using the online form available on the ELECTRA website.
www.electrairp.eu .

www.electrairp.eu
An FP7 Integrating Research Programme

2007 - 2013

Annex 3: Template for proposal

Some example screens from the web based form.

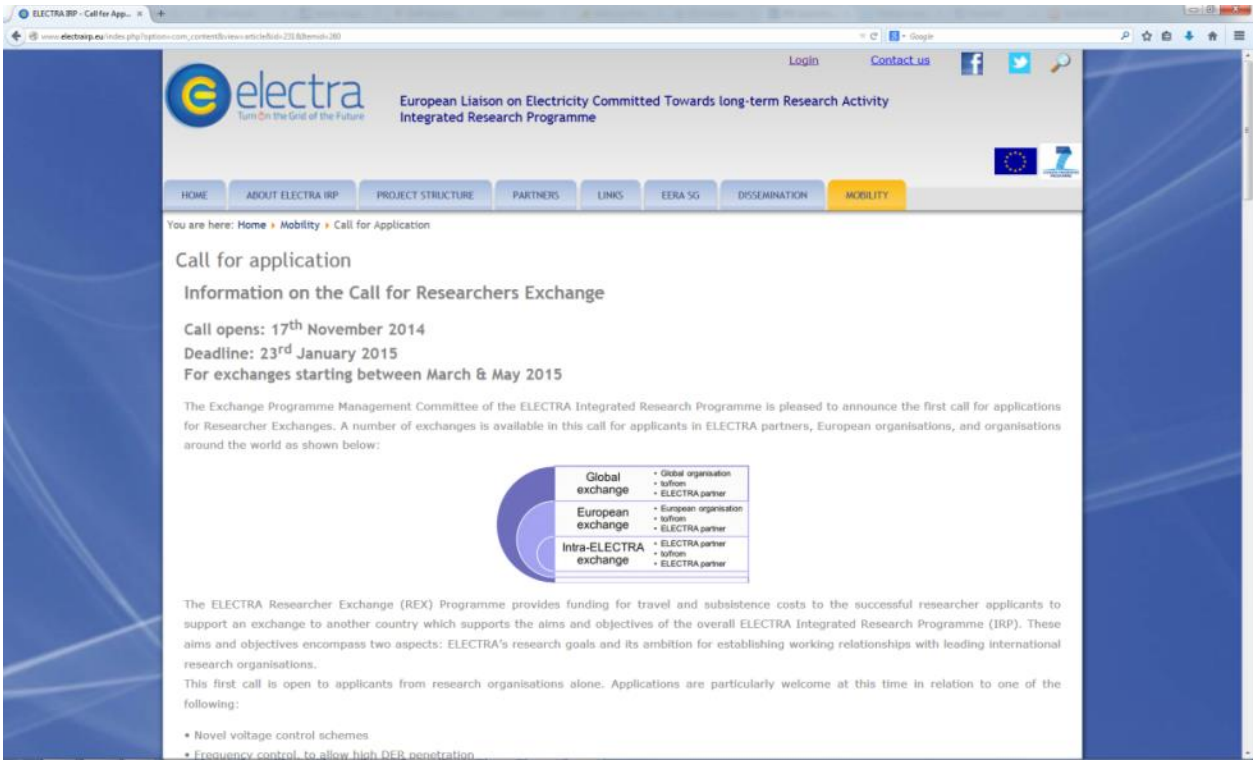

Figure 30 Website capture of call for exchanges details

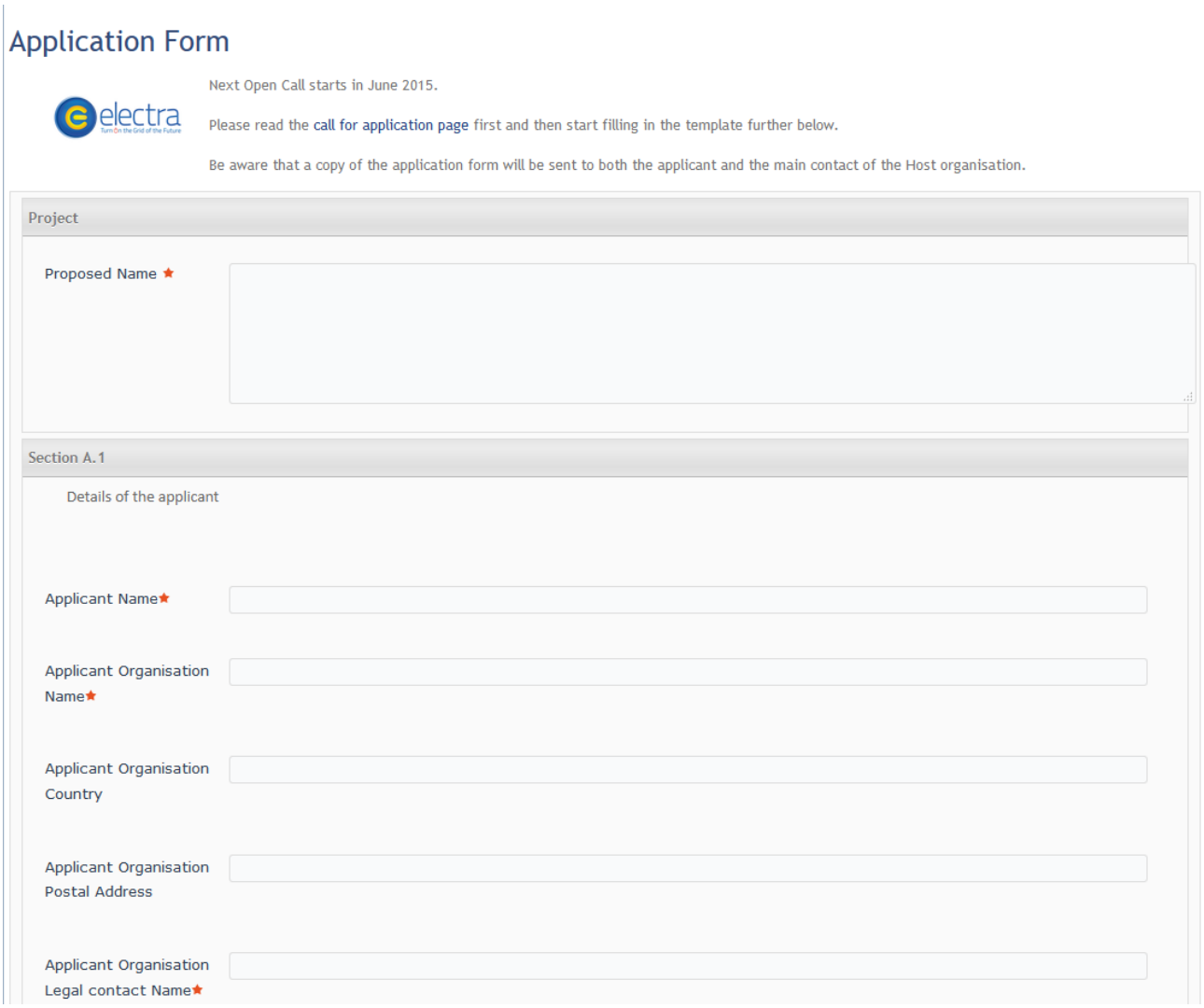

Figure 31 Part 1 of online application form

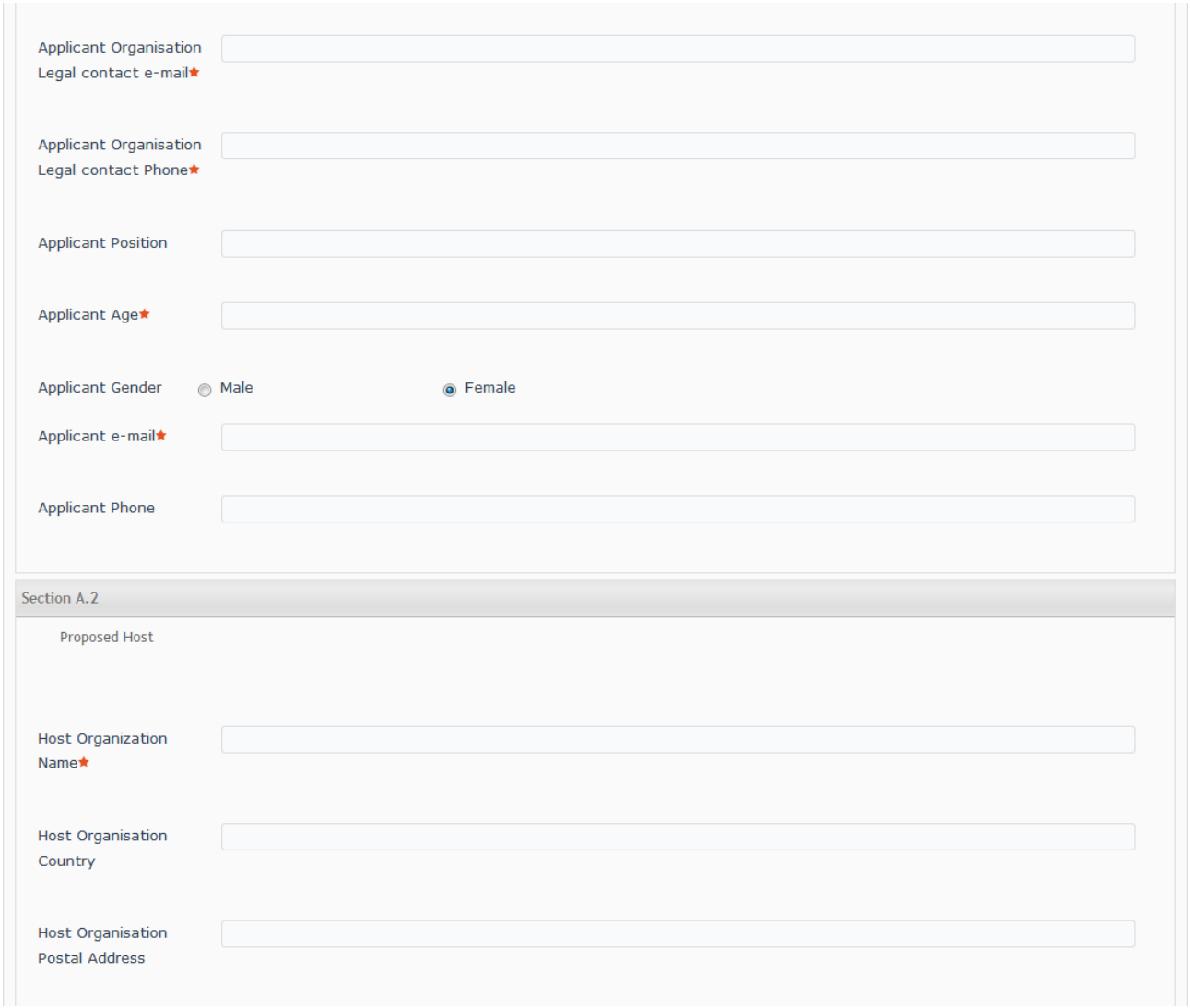

Figure 32 Part 1 cont. and 2 of application form

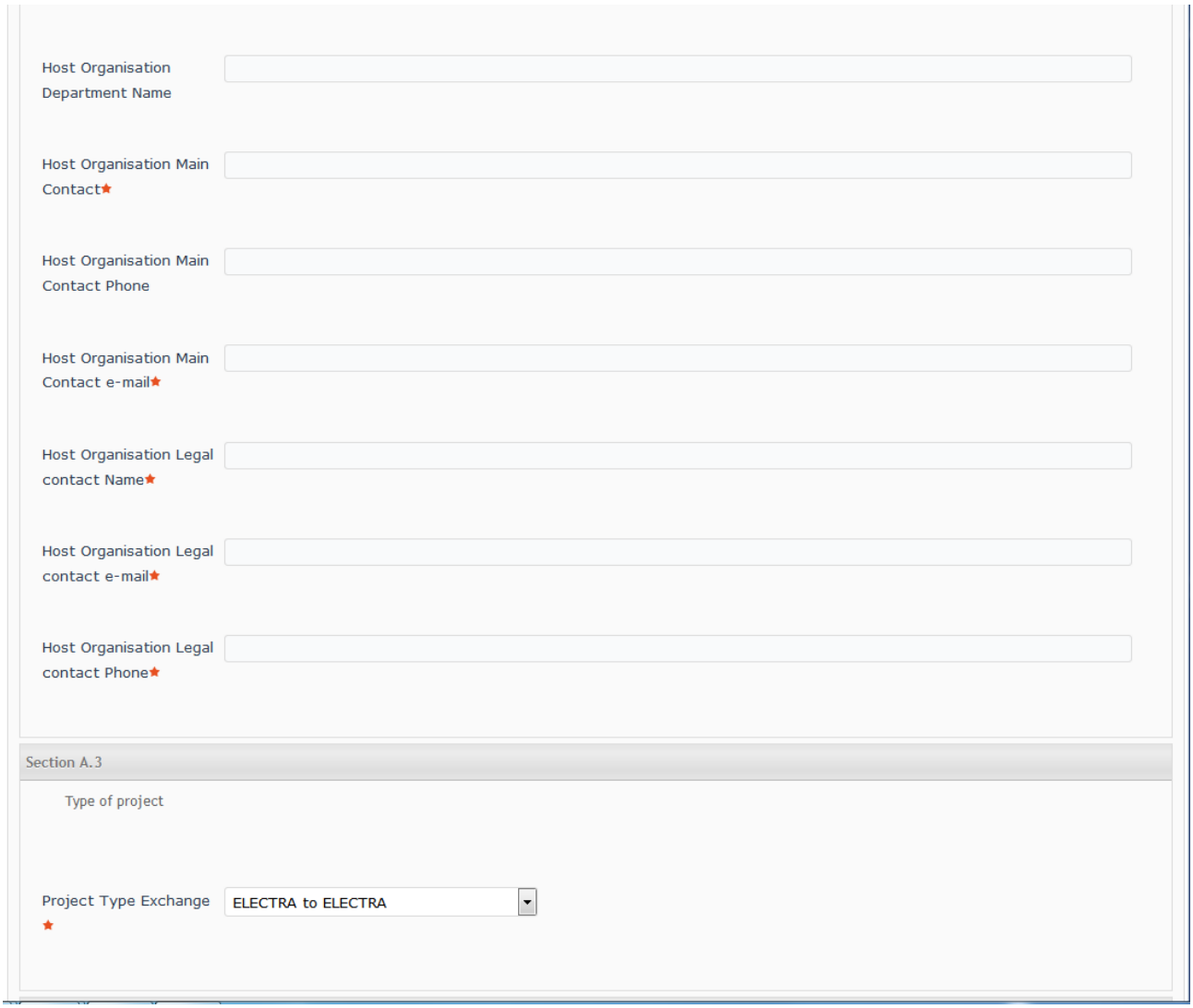

Figure 33 Parts 2 cont. and 3 of application form

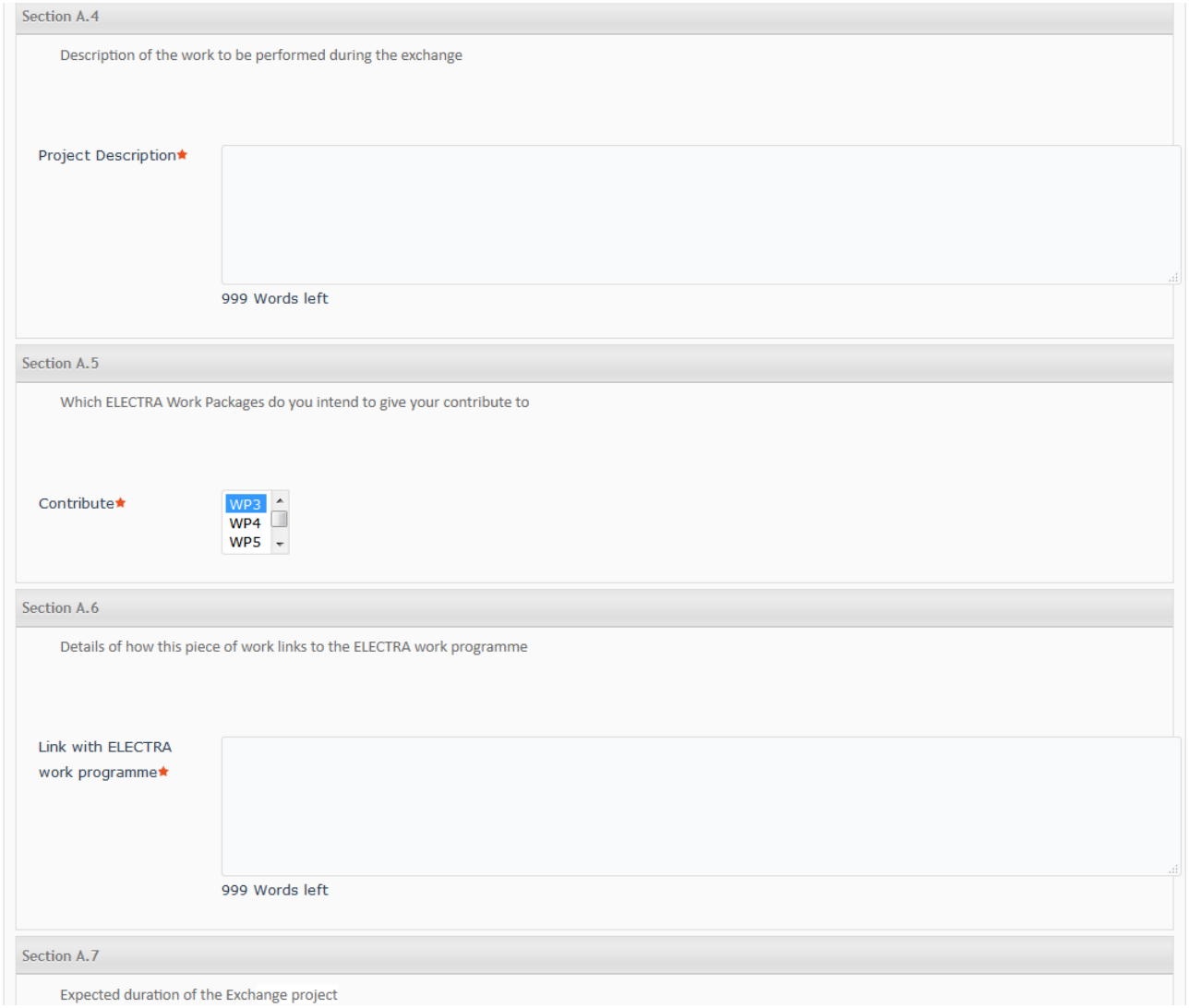

Figure 34 Parts 4 to 6 of application form

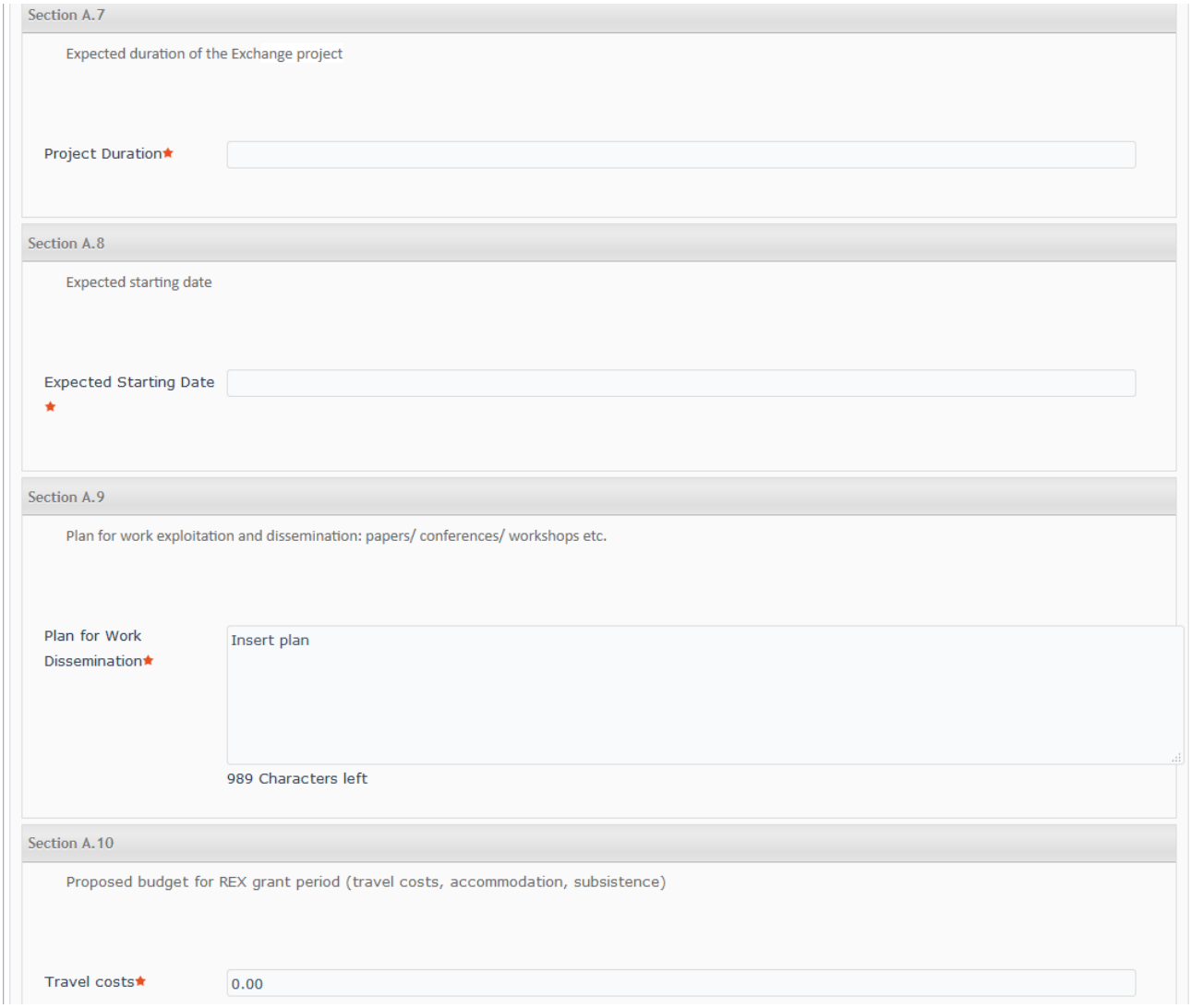

Figure 35 Parts 7 to 10 of application form

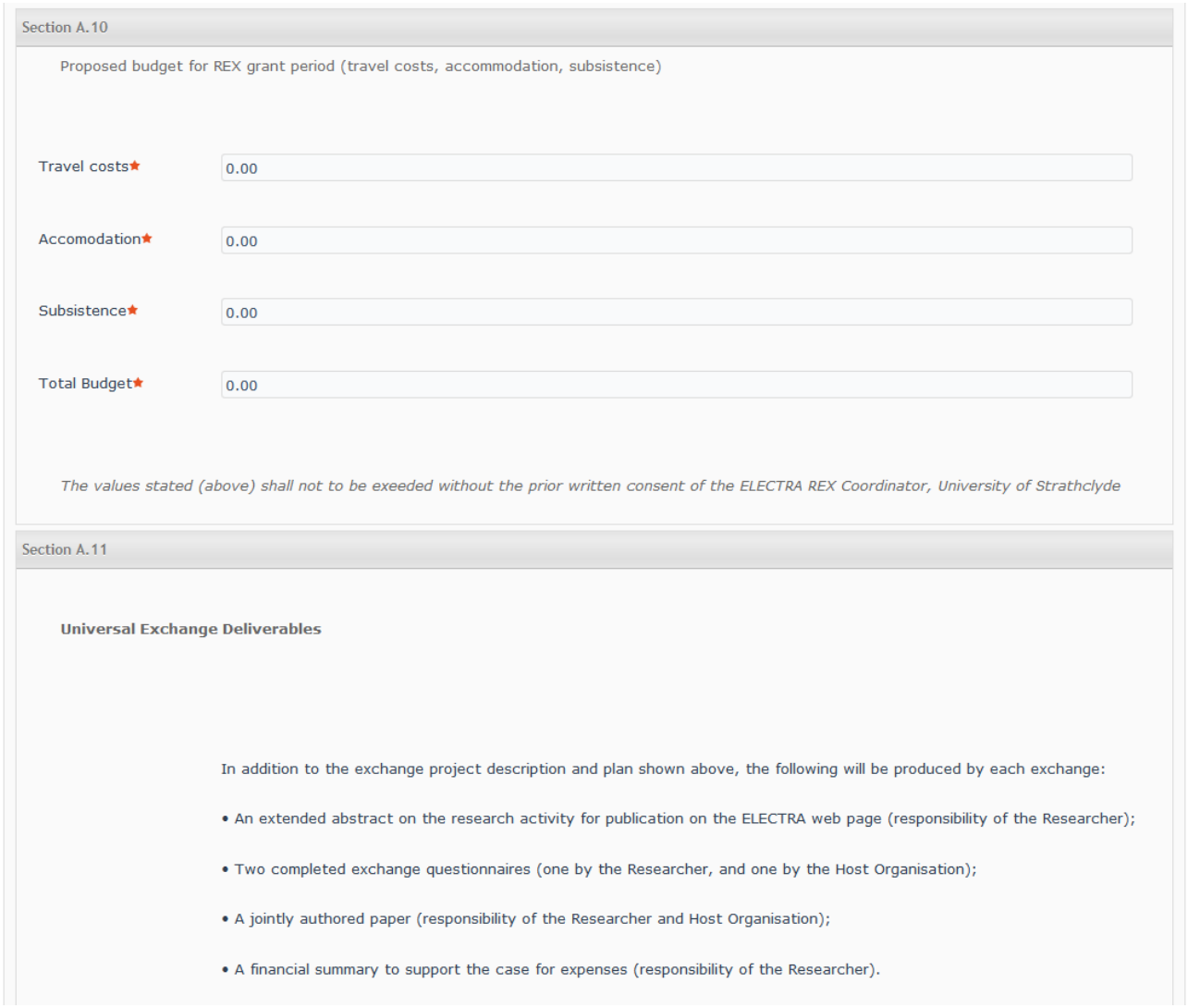

Figure 36 Parts 10 and 11 of application form

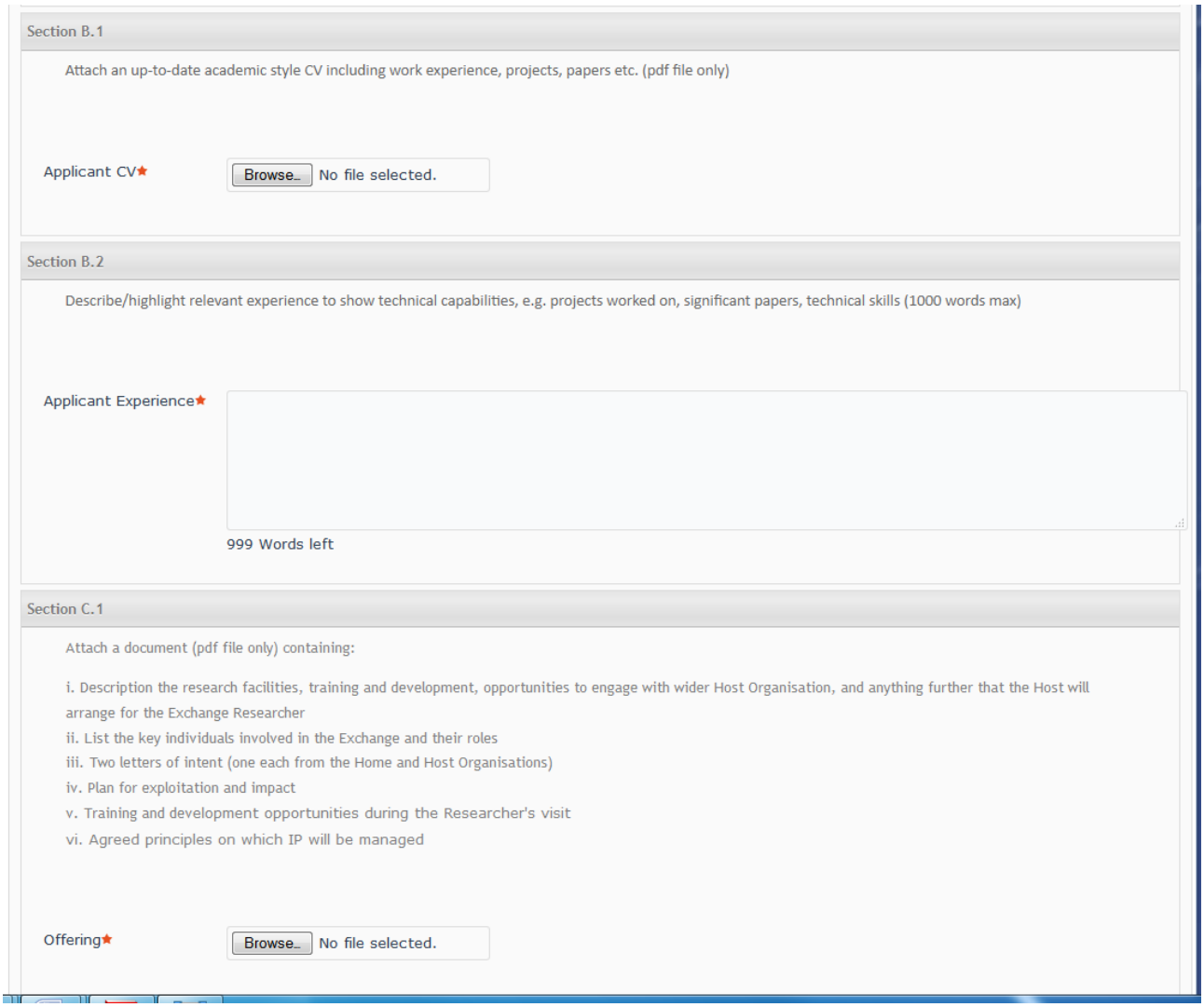

Figure 37 Final parts of application form

Annex 4: Selected example abstracts resulting from exchanges

First REX Call

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

GRID IMPACT AND SIZING OF PV STORAGE SYSTEMS - A COMPARATIVE ANALYSIS FOR AUSTRALIA AND GERMANY

J. von Appen*

*Fraunhofer IWES, Königstor 59, 34119 Kassel, (Germany)

The traditional business case for rooftop PV systems has evolved over the last years in Australia and in Germany. Since the feed-in tariff has dropped below the electricity price for households, PV self-consumption drives the installation of rooftop PV systems and a business opportunity for small scaled storage systems emerges. Such systems are also discussed as a solution for facilitating PV grid integration by increasing active and reactive power control flexibilities. However, the impact of different pricing schemes and grid integration approaches on the sizing and operation of such systems and on distribution grids has not been evaluated

Within this Electra REX project these challenges are addressed and several aspects of the grid integration of PV storage systems are analyzed:

- Development and adaption of an integrated sizing and control for PV storage systems under different economic and regulatory circumstances to assess their impact on distribution systems
- Voltage control possibilities using PV storage systems exploiting voltage dependent active and reactive power control possibilities (including stability aspects)
- Control of thermal storage systems to increase demand flexibilities for distribution systems with high amounts of PV generation

Results of a comparative case study to assess the interactions between sizing and control of PV storage systems and grid integration are published in [1].

ACKNOWLEDGMENT

This research has been supported by the European Commission, under the FP7 project ELECTRA (grant no: 609687). The work has also been supported by the German for Economic Affairs and Energy through the projects "INE-VES" and "HiPePV2" (FKZ: 0325561A, 0325785) and by ARENA, the Australian Renewable Energy Agency, through the VPS2 Project. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the funding parties.

Fig. 1: Jan von Appen at the CSIRO site in Newcastle, Australia.

REFERENCES

[1] J. von Appen, J. H. Braslavsky, J. K. Ward, and M. Braun, "Sizing and grid impact of PV battery systems - a comparative case study for Australia and Germany," in 2015 International Symposium on Smart Electric Distribution Systems and Technologies (EDST), Sep. 2015

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

DEMAND SIDE PARTICIPATION FOR FREQUENCY CONTAINMENT IN THE WEB OF CELLS ARCHITECTURE

M. H. Syed*, G. M. Burt* and J. K. Kok**

*Institute for Energy and Environment, University of Strathclyde, Glasgow, (*Scotland*)

**TNO, The Hague, (*The Netherlands*)

The ELECTRA IRP Researcher Exchange Programme has given the opportunity to bring together the expertise of TNO in multi-agent systems, PowerMatcher [1] and secure communications, and that of Strathclyde University researchers in Real-Time Power Hardware-In-the-Loop (RT-PHIL) based testing, power system operation and control, wide area monitoring and adaptive protection techniques [2].

The exchange builds upon the ongoing project, "Testing and Validation of Time Critical Ancillary Service Provision by Demand Side Management" between University of Strathclyde and TNO. In this work, demand side management (DSM) is implemented within the ELECTRA web of cells architecture (EWOC). A large number of demand side management schemes have been proposed in literature for provision of frequency control ancillary services to the network. However, it is assumed that all the flexible devices within the network are managed and controlled under one DSM scheme. In this work, two independent demand side management schemes control the portfolio of flexible devices within EWOC. A methodology and scenarios for analysis of the performance of more than one DSM scheme within the same network have been realized using a real-time power hardware-in-the-loop co-simulation platform, and the paper presents this as a basis for investigations into the validation of such DSM schemes.

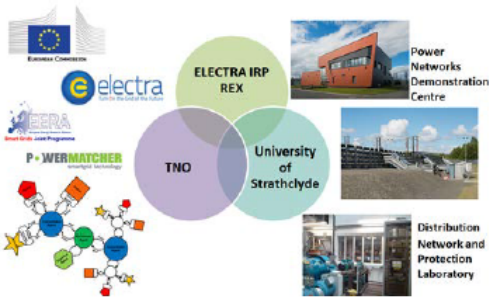

Fig. 1. The collaboration.

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687, as part of the ELECTRA REX researcher exchange programme. The work has also been supported TNO under ERP Program "Energy Storage and Conversion"

REFERENCES

[1] Kok, K., Roossien, B., MacDougall, P., van Pruissen, O., Venekamp, G., Kamphuis, R., Laarakkers, J. and Warmer, C., "Dynamic pricing by scalable energy management systems — Field experiences and simulation results using PowerMatcher", *Power and Energy Society General Meeting, 2012 IEEE*, pp.1,8, 22-26 July 2012.

[2] Roscoe, AJ, Mackay, A, Burt, GM & McDonald, JR 2010, "Architecture of a network-in-the-Loop environment for characterizing AC power system behaviour", *IEEE Transactions on Industrial Electronics*, vol 57, no. 4, pp. 1245-1253.

Second REX Call

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

LINEAR DECISION RULES FOR POWER SYSTEM BALANCING CONSIDERING DISTRIBUTED ENERGY RESOURCES

A. Junjie Hu*, B. Bert Claessen2**, C. Kai Heussen3*, and
D. Reinhilde D' Hulst**

*Technical University of Denmark, Frederiksborgvej 399,
Building 776 (*Denmark*)

**VITO, Boeretang 200, 2400 Mol (*Belgium*)

The increasing penetration of renewable energy resources and alongside reduction of centralized generation requires flexibility to be provided from other control reserves. As demand side resources are widely regarded as key to this flexibility, we observe that, in contrast to conventional controllable generation, a) demand side resources cannot continuously be activated (limited energy flexibility), and b) these resources require much shorter planning and reservation periods, as they follow other use patterns. With respect to conventional and energy constrained flexibilities, two types of control signals are investigated in this study to active the corresponding flexibilities, namely the fast and slow signals. These two types signal generally represents the system imbalance signals and reflect the features/requirements of the power system.

In order to address the different realization of the control signals, a linear decision rule based robust control method [1] is used in this study to optimally dispatch the policies to the flexibility resource providers. Compared to [1], the main contribution of this study is the integration of two types of control signals and the linear decision rules. By using these two types of control signals, it is expected that the fast signal can be mainly used for activating energy constrained resources, while the conventional flexibility resources are mainly activated by the slow signal.

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme. The work has also been supported by *"Sponsor 2"*.

REFERENCES

[1] Warrington, J., Goulart, P., Mariethoz, Sebastien., Moran, M., Policy-based reserves for power systems, IEEE Transactions on Power Systems, Volume 2, 2013, pp. 4427-4437.

Junjie Hu is a PostDoc with the Center for Electric Power and Energy, Technical University of Denmark, Denmark. His research interests include schedule and control of electric vehicles, market-based control application in power systems.

Location of the exchange

VITO NV
Boeretang 200
2400 MOL
Belgium
Tel. + 32 14 33 55 11

Route description
Route description with Googlemaps

RPR 0244.195.916 Turnhout

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

FUTURE ELECTRICITY MARKET STRUCTURE TO ENSURE LARGE VOLUME OF RES

A. Obushevs*, I. Oleinikova*, M. H. Syed**, A. Zaher** and G. M. Burt**

* Smart Grid Research Centre, Institute of Physical Energetics, Riga, (*Latvia*)

** Institute for Energy and Environment, University of Strathclyde, Glasgow, (*United Kingdom*)

In the 2030+ power system, it is expected that generation will shift from mostly few large central generators to many smaller distributed generators. The local fluctuations will increase the activation of reserves. Flexible operation of the networks requires radically new control schemes, which enable grid operators to ensure dynamic balance and stability in a future power system with a high share of decentralized generation. Variable renewable energy sources can affect the design of ancillary services markets in the following ways: the variability and uncertainty of wind and solar energy increases requirements for various ancillary services, affecting the scheduling and pricing of those services. Their impacts vary depending on system conditions, which make the ancillary services, demands difficult to be generalized across timescales and systems [1]. Allowing variable renewable energy and demand to participate in the ancillary service markets can offer more supply to the market, but could offer challenges based on the unique characteristics of variable resources. Therefore enhanced the market design is needed to facilitate EU-wide member state centric approach to renewable deployment.

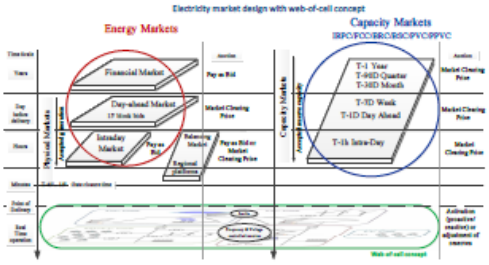

Figure 1. Electricity market design with WoC concept

During the ELECTRA Research Exchange call at the University of Strathclyde, a new market design was defined based on new way of power system operation development, namely Web-of-cell concept, with set of rules for future Electricity market structure, taking account network codes, legislation and directives to ensure RES integration targets.

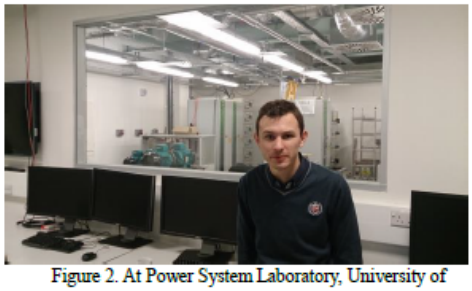

Figure 2. At Power System Laboratory, University of Strathclyde, United Kingdom

ACKNOWLEDGMENT

This research has been supported by the European Commission, under the FP7 project ELECTRA (grant no: 609687). Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the European Commission.

REFERENCES

[1] A. Obushevs, I. Oleinikova. Market Design for Electricity Ensuring Operational Flexibility // 5th International Conference on Power Engineering, Energy and Electrical Drives (PowerEng'2015) Riga, Latvia, 11-13 May 2015

Third REX Call

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

HARDWARE IN THE LOOP TESTING OF ELECTRA WEB OF CELLS ARCHITECTURE WITH DISTRIBUTED CONTROL UNDER A FREQUENCY EVENT.

E. Guillo-Sansano*, G. M. Burt*, M. Steurer** and K. Schoder**

*Institute for Energy and Environment, University of Strathclyde, Glasgow, (*Scotland*)
**Center for Advanced Power Systems, Florida State University, Tallahassee, FL, USA

The Power Systems Group at Florida State University's (FSU's) Center for Advanced Power Systems (CAPS) facility hosts extensive electric power systems simulation capabilities utilized and supported by an experienced and highly skilled research team. This facility was optimal for testing distributed control algorithms such as the developed control within the ELECTRA IRP project and Strathclyde. ELECTRA IRP Researcher Exchange Programme has given the opportunity to bring together the expertise of CAPS and Strathclyde on electric power systems modeling and simulation, control systems and the emerging hardware-in-the-loop (HIL) concept for testing advance power and control systems.

The Smart-Grid Cyber-Physical Systems Testbed [1] was the ideal testbed for the prototyping and testing of a distributed control that was under development [2]. In this project, a Controller Hardware in the Loop (CHIL) simulation for a real-time distributed control algorithm concept developed within the ELECTRA IRP project is performed. The collaboration favored for a fast integration of the distributed control algorithm within the existing testbed along with a further development of simulated power system. As a result, this work presented some early data of the HIL simulation behavior of the distributed controller under a frequency event.

The development of the CHIL testing in this project will provide a starting point for an implementation of a distributed frequency control scenario in the WoC architecture on a Power Hardware in the Loop (P-HIL) simulation were real devices could be directly controlled instead of simulated in real-time.

Acknowledgment

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687, as part of the ELECTRA REX researcher exchange programme.

References

[1] M. Stanovich, I. Leonard, K. Sanjeev, M. Steurer, T. Roth, S. Jackson, and B. McMillin, "Development of a Smart-Grid Cyber-Physical Systems Testbed," in Proc. of the IEEE PES Innovative Smart Grid Technologies (ISGT), Feb. 2013.

[2] Guillo-Sansano, E, Syed, MH, Roscoe, AJ, Burt, G, Stanovich, M & Schoder, K 2016, 'Controller HIL testing of real-time distributed frequency control for future power systems'. in IEEE Innovative Smart Grid Technologies 2016 Europe Proceedings. IEEE, Ljubljana, Slovenia.

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

WOC LABORATORY EXPERIMENTS USING BDI AGENTS AND CARTAGO ENVIRONMENT

Diego Issicaba*, *Member*, *IEEE*, Alexander M. Prostejovsky**, *Member*, *IEEE* and Henrik W. Bindner**, *Member*, *IEEE*

* INESC P&D Brasil, Rua José Caballero, Santos, São Paulo (Brazil).

**Center for Electric Power and Energy, Technical University of Denmark, Riso (Denmark)

ELECTRA introduced a grid control architecture, the so-called "Web-of-Cells (WoC)", with the paradigm to solve local problems locally, where the grid is split in cells which are connected through tielines and can span at multiple voltage levels. The concept itself copes with the agent modeling paradigm, so that the development of agent-based approaches to WoC proof-of-concept and validation is a field of research to be exploited.

In this collaborative work, Belief-Desire-Intention (BDI) agents have been modeled to operate on Syslab (see Fig. 1), which is a smart grid laboratory designed as a testbed to advanced control and distributed solutions to power systems. BDI agents have been implemented in JASON, while an agents and artifacts application [1] has been developed using CArtAgO, as shown in Fig. 2.

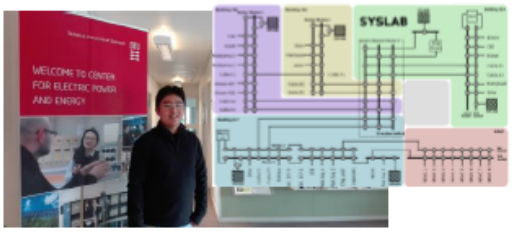

Fig. 1. Exchange researcher D. Issicaba at Syslab.

The research activities included: (a) familiarization with research facilities and infrastructure; (b) familiarization with Syslab coding, protocols, and applications; (c) definition of an agent control scheme using the WoC philosophy; (d) specification of experiments to test the scheme; (e) devising of preliminary experiments in Syslab;

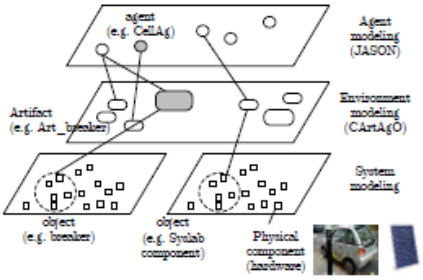

Fig.2. Implementation layers.

Experiments where a group of cells negotiate to control tieline power flow have been successful, even by emulating equipment failures. Future work will exploit the developed framework to validate other properties of the WoC paradigm.

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme. The work has also been supported by CNPq/Brazil.

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[1] D. Issicaba, "Block-Oriented Agent-based Architecture", PhD thesis, Faculty of Engineering of Porto University, Portugal, May 2013.

Fourth REX Call

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

DETERMINATION AND VALIDATION OF A PROTECTION SCHEME WITH DISTRIBUTED INTELLIGENT ELECTRONIC DEVICES FOR THE WEB-OF-CELLS

M. Valov

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In the light of flexibility and unpredictability of a new grid concept, so called Web-of-Cells, adaptive protection systems become an important issue. In this context, the work performed during the ELECTRA Researcher Exchange Programme outlined an approach for determining and validating an adaptive protection system where a protection scheme using distributed intelligent electronic devices (IED) was proposed. The determination and validation of the protection scheme was performed in the simulation software DIgSILENT PowerFactory for an illustrative example of a medium voltage cell with distributed energy resources based on the CIGRÉ European medium voltage benchmark network. A scheme of protection units widely used today in the medium voltage level of distribution systems was taken as a basis and advanced with the implementation of an adaptive functionality. The adaptivity of the protection system was based on an assumed centralized supervisory control termed as "Cell Central Controller" (CCC) and pre-defined setting groups between which can be switched according to the cell operating state. The CCC as well as its communication with the IEDs was represented by a programmed script in the used software. Its functionality enclosed the estimation of the cell's short-circuit level and the automatically adaptation of the IED settings in order to match with this level. The setting groups of IEDs' overcurrent units were pre-calculated and coordinated based on a short-circuit analysis for different short-circuit levels. For the recording of these setting groups an additional function unit was created in the used IED relay model that enabled the adaptive functionality.

The validation of the proposed protection scheme combined an analysis of the necessity for adaptive protection and an examination of selective fault isolation by the IEDs with adapted protection settings according to different cell operation conditions. The results showed that the CCC represented by a programmed script enabled a proper automatic adaption of IED settings according to the short-circuit level within the cell. The proposed protection scheme with its adaptive capability indicated an appropriate response and selectivity in case of disturbed grid conditions coping with different cell operating states.

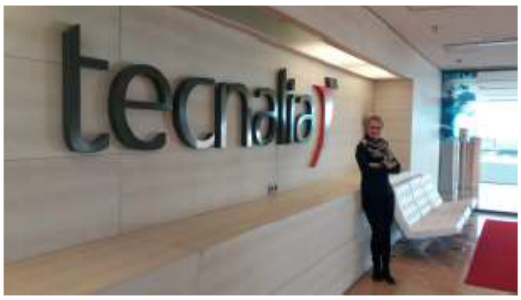

Figure 1: The exchange activity was performed at TECNALIA (Bilbao, Spain) through the engagement of J. Merino and J. E. Rodriguez Seco

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme.

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

MODELLING AND ANALYSIS OF THE EXTERNAL BEHAVIOUR OF A CELL IMPLEMENTING THE ELECTRA PROPOSED CONTROL

E. Rikos*, M. Cabiati**, and C. Tornelli**

*CRES, 19th km Marathonos Ave., 19009, Pikermi, (*Greece*)

**RSE, Address, via Rubattino, 54 - 20134 Milano, (*Italy*)

The two main objectives of the activity were the implementation of a power systems model suitable for the ELECTRA use cases validation and investigation of specific aspects such as the behaviour of cells under the control concepts developed in ELECTRA.

For the first objective a simplified approach, in which DER are represented by equivalent current sources, was used. The target power system model used in the analysis was the CIGRE MV grid, based on Task Force C6.04.02, also adopted by the ELECTRA consortium as a reference system. In order to achieve optimal performance in terms of computational and time requirements the model was developed using purely Matlab/Simulink. Through the exchange the model was improved and validated by making some crucial assumptions, such as absence of inertia in all small-scale generators. In addition, based on the requirements posed by the research questions of the project consortium regarding the validation of stand-alone and combined use cases, the model was processed in order to represent a number of three cells at MV and one at HV level. As a result, the main achievement of the activity with regard to the implementation is a model suitable for simulating any stand-alone or combination of use cases while, the model can also be used for developing use case functions. Last but not least, the model can be used by the host organisation in order to assess the implementation of specific tests on their experimental microgrid.

Concerning the second objective the activity focused on the implementation of specific use cases, either in a simplified form (i.e. BRC) or by implementing the detailed aspects of it such as the adaptive FCC. Specifically, the latter function was implemented and tested in the short as well as long run by implementing 24-hour profiles for loads and RES production. Overall, the test results showed that the adaptive FCC control performs as planned by detecting the instantaneous imbalance state of cells correctly, reducing the total usage of FCC reserves and without compromising the overall system stability.

Exchange location-RSE premises

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme.

Fifth REX Call

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

VALIDATION OF ADVANCED INTEROPERABILITY FUNCTIONS FOR BATTERY ENERGY STORAGE SYSTEMS

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*AIT Austrian Institute of Technology, Giefinggasse 2 - 1210 Wien *(Austria)*

** Fukushima Renewable Energy Institute, AIST (FREA), Machiikedai, 2-2-9, Koriyama, Fukushima,963-0298

In a future cell-based power system, decentralized Battery Energy Storage Systems (BESS) will play a key role in controlling voltage and frequency of the grid.

To ensure secure and reliable system performance, it is crucial to validate the individual functions as well as their interdependency in a dedicated laboratory environment, encompassing multiple domains, and various interfaces.

Consequently, specific test procedures and acceptance criteria are required. A first set of test procedures is available in the 'SIRFN Draft Test Protocol for Advanced Battery Energy Storage System Interoperability Functions' [1], based on the function definitions within the IEC/TR-62850-90-7 technical report [2] and national grid codes.

The aim of the research exchange is to validate the advanced interoperability functions, as well as the testing procedures on a 50 kW/50 kWh BESS. Tests are done in the specific function domain as well as the time domain (e.g. intentional delays, ramp rates etc.) and for multiple functions operating at the same time.

Following list gives a brief overview about the test portfolio:

- Power capability of the BESS by use of the request active and reactive power function (INV4, VV13)
- Frequency support
  - Frequency-Watt (FW21, FW22)
  - RampRates, Time Delays etc.
- Voltage support
  - Voltage-Var (VV11, VV12)
  - Voltage-Watt (VW51,VW52)
  - Watt/PowerFactor (WP41/WP42)
- Combined functions
  - VV11 and VW52
  - FW22 and WP41
  - FW22 and VV11

Figure 1: Fukushima Renewable Energy Institute

The work shows that BESSs are able to perform advanced interoperability functions very fast and precisely. The same applies for a combination of functions. Tough the DuT showed also several inaccuracies, which underlines the importance of acceptance criteria. It is also seen that certain parameter definitions (e.g. timing parameters) and how the manufacturer shall implement them is not always clear defined or multiple definitions exist in different documents.

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

P-HIL TESTS FOR ELECTRIC VEHICLES SMART CHARGING STRATEGIES INCLUDING INERTIAL RESPONSE AT THE NORWEGIAN NATIONAL SMART GRID LABORATORY

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The activities at the Norwegian National Smart Grid Laboratory aimed at investigating the need for requirements on time and granularity responses of aggregated electric vehicles (EVs) when providing frequency regulation. To do this, the potential major impacts of fast frequency regulation provided by EVs connected to an islanded microgrid were studied. Two different controllers based on droop logics were implemented, namely a primary frequency controller and a synthetic inertia controller. The crucial roles played by the EV response time as well as the response granularity have been investigated within the Power-Hardware in the Loop (P-HiL) experimental setup in Fig. 1.

Results show frequency oscillations due to the controllers' discrete nature related to the 1-Amp granularity required by IEC 61851 and IEC/ISO 15118 technical standards [1], [2]. Frequency oscillations are experimentally prevented by gradually reducing the amplitude of the required EV charging rate granularity, leading to the conclusions that a continuous regulation may be necessary for microgrid applications. As for the implemented droop-based synthetic inertia controller, the performance is limited due its derivative nature. In fact continuous oscillations between the limit charging rates took place in the tested low-inertia microgrid, leading to massive instability issues. The crucial role played by the EV response time was investigated by gradually enhancing the responsiveness up to a value that enabled the implemented controller performing as desired. However, it is clear that not only the EV response time but also the tuning of the controllers' parameters (e.g., proportional gain and/or dead band) is of utmost importance when designing such control schemes for a given power systems.

To conclude, one has to note that also in larger power systems such phenomena may take place when a considerable number of EVs are aggregated responding simultaneously to the same discrete charging/discharging signal. Thus, the authors recognize that also on large scale applications, a smooth overall response is needed to prevent system problems, achievable by making the regulation continuous, or by introducing additional requirements on the whole aggregated EV fleet response.

Fig. 1. (a) Opal-RT simulator; (b) power amplifier; (c) 3-phase converter; (d) physical connections.

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme.

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[1] IEC 61851-1:2010, "Electric vehicle conductive charging system." 2010.
[2] IEC/ISO 15118-1:2013, "Road vehicles—V2G communication interface." 2013.

Sixth REX Call

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

COUPLING OF GRID AND PV-EMULATORS TO A COMMUNICATION MIDDLEWARE FOR VALIDATION OF ADVANCED SMART GRID CONTROL APPROACHES

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Lab testing of advanced voltage and balancing control solutions for future cell-based power systems requires a combined use of real power hardware (like PV and grid emulators, DC sources, EV supply equipment and the device under test itself, etc.), pure simulations (like power system simulation, communication network simulation, energy management, home automation, prediction tools, optimization, etc.), data acquisition tools, and maybe a real-time system.

To overcome this complex combination of different tools, equipment and devices of different domains AIT developed a middleware called Lablink. The AIT Lablink builds upon MQTT and provides a convenient data-agnostic communication interface to couple lab hardware and simulation tools. An additional Python API can be used for scripted and automated testing.

During this researcher exchange at Electric Energy Systems Laboratory (EESL, see Fig. 1) of the National Technical University of Athens (NTUA) two Lablink drivers have been developed: one for a Regatron TopCon Quadro DC source and one for a Spitzenberger & Spies PAS four quadrant amplifier (SPS). The Regatron source can be used as PV emulator while the SPS acts as a grid emulator. Those are two typical devices of a smart grid laboratory.

Figure 1: The Electric Energy Systems Laboratory at NTUA

The two drivers show the typical variety of such implementations. Regatron provides a .NET-API with high level functions. But there exists only an API documentation and no document with instructions of how to use the API and which methods have to be called in which order. On top of that not all necessary functions are documented and officially supported. Hence, a lot of debugging and trial and error was necessary whereas the implementation effort was comparable small.

In comparison, the SPS is controlled via SCPI commands over GPIB. The interface is well documented, but provides only low level functions. So most of the effort was implementing high level functions.

This work like implementing further Lablink clients as well as the collaboration with NTUA will be continued within the project *European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out (ERIGrid).*

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme.

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

STABILITY MONITORING OF ACTIVE DISTRIBUTION GRIDS – SMART GRID

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The scope of the project is twofold. First to systematically evaluate the applicability of different identification techniques [1], for the dynamic analysis of active distribution networks (ADNs). Secondly, to propose a multi-signal methodology able to handle both ringdown and ambient data, allowing the accurate identification of oscillatory modal parameters close to real-time.

Fig. 1. PHIL simulations during the exchange.

During the exchange period, power hardware in the loop (PHIL) simulations were conducted using the RTDS unit and the existing lab equipment. More specifically, the RTDS was used to emulate a transmission [2] and a medium voltage distribution network [3], while the hardware of the laboratory used to emulate a typical low-voltage (LV) ADN. Several disturbances, such as load disconnection and voltage drops, as well as the ambient operation of the examined system were investigated.

The dynamic responses, obtained from the above-mentioned experiments will be used to evaluate the applicability of the examined identification methods for the dynamic analysis of ADNs.

ACKNOWLEDGMENT

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme.

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[1] IEEE Task Force on Identification of Electromechanical Modes, Identification of Electromechanical Modes in Power Systems, IEEE Power & Energy Society, 2012, PES-TR15.

[2] P. Kundur, Power System Stability and Control. New York: McGraw-Hill, 1994.

[3] Cigre Report, Working Group C6.04. Benchmark Systems for Network Integration of Renewable and Distributed Energy Resources, April 2014.

Seventh REX Call

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

REGULATORY RULES FOR THE MARKET DESIGN SOLUTIONS WITHIN THE WEB-OF-CELLS CONCEPT

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** Energy Technologies Department, ENEA, Portici, (*Italy*)

Research Centre of Portici of ENEA is engaged in research activities oriented towards analysis of European Union (EU) energy sector related regulatory framework. The Centre was optimal for analysing European level regulatory rules on electricity market design.

Within the existing power system architecture and present power system balancing paradigm, the EU establishes the regulatory rules for the system balancing market. However, the decentralized managed future where the power system will be decomposed into grid areas, called Cells, which will be capable for self-providing (locally) balancing services, shall require reconsidering market design for system balancing services.

Research aimed at clarifying which and how electricity market development and design related regulatory rules enforced by the EU could be tailored to the market design for the Web-of-Cells architecture.

Research results demonstrated that with the purpose to develop a well-functioning market for frequency and voltage control under the Web-of-Cells architecture, the following regulatory rules should be established:

- Regulatory rules for the provision of generation / load forecast information for the Cell's Merit Order Decision function by obliging the Aggregator to take this responsibility in the Cell.
- Regulatory rules for the process of procurement of flexibilities via the auction-based exchange based on short-term flexible, non-discriminating, transparent and competitive market principals.
- Regulatory rules for the market information distribution to improve the transparency of the market for frequency and voltage control.

The results of the research are included into the Deliverable 3.2 "Market design supporting the Web-of-Cells control architecture", Deliverable 3.3 "Market design supporting the Web-of-Cells control architecture" and are published in [1].

Acknowledgment

The research leading to these results has received funding from the European Union Seventh Framework Programme ([FP7/2007-2013] under grant agreement n°609687 (ELECTRA project), as part of the ELECTRA REX Researcher Exchange Programme.

References

[1] Bobinaite, V., Oleinikova, I., Di Somma, M., Graditi, G. Market Transparency for the Architecture of Frequency and Voltage Control under the Web-of-Cells Power Grid Structure. 18th IEEE International Conference on Environment and Electrical Engineering. Palermo (Italy), 15-17 June 2018.

Annex 5: Flyers for REX Call 2 & 6

Contact informations

ELECTRA IRP website link
www.ElectraIRP.eu

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European Commission

EERA Smart Grids Joint Programme

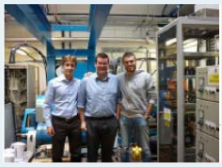
electra Turn On the Grid of the Future

European Liaison on Electricity Committed Towards long-term Research Activity Integrated

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

Pre-announcing the second Call for Applications



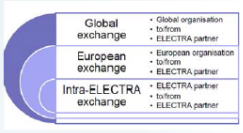
ELECTRA IRP

The ELECTRA Integrated Research Programme on Smart Grids brings together the partners of the EERA Joint Programme on Smart Grids (JP SG) to reinforce and accelerate Europe's medium to long term research cooperation in this area and to drive a closer integration of the research programmes of the participating organisations and of the related national programmes.

ELECTRA offers assistance to support transnational and international researcher exchanges to or from ELECTRA partners that will complement and enhance the collaborative research undertaken within the research programme and associated EERA Joint Programme. This enhancement will be seen in the work of the visiting researcher engaging with the host team and accelerating key smart grid concepts and solutions aligned with the objectives of the ELECTRA IRP.

ELECTRA REX PROGRAMME

ELECTRA's Researcher Exchange (REX) Programme offers the opportunity for ELECTRA partners and European or International collaborators to work closely together through an exchange of staff. The scheme is open to participants from research organisations and industry, including SMEs. A range of options are available:



Three types of ELECTRA REX exchanges

Host organisations are encouraged to offer elements of training, and so this represents an excellent development opportunity, especially for early career researchers.

ELECTRA REX supports:

- increased coordination across smart grid research programmes, complementing the work of EERA JP;
- personal development of early career researchers;
- enhanced impact from the laboratory demonstration within the ELECTRA IRP.

INTERESTED IN APPLYING?

REX Call 2 will be issued at the end of June 2015.
Click the Mobility Tab at www.electrairp.eu for more.

ELECTRA REX WORKSHOP

The programme offers the opportunity to the visiting researcher to embed themselves within the environment of the host institution throughout the duration of their exchange, conduct collaborative research in support of the JP and IRP objectives, and write up their results in joint publications.

REX Call 1 was published late 2014 and 6 proposals have been successfully approved.

REX call 1 researcher Alexander Prostejovsky (DTU) at PNDC, University of Strathclyde

The first ELECTRA REX Workshop on Smart Grid Researcher Exchanges will take place in Vienna at the EDST2015 symposium, 8-11 September. The main objectives of this dedicated workshop are to allow the participants in the first exchanges to:

- disseminate the results of their exchanges, their methods and experience;
- share their experience of exchange working in leading global smart grid organisations.

SAVE THE DATE—8-11 September 2015!!!!
For more information, www.electrairp.eu .

ELECTRA PARTNERS

RSE · AIT · vito · ENEA · TNO innovation for life · tecnalia · LABORELEC · ΚΑΠΕ CRES · Fraunhofer IWES · INESCPORTO · cea · SINTEF · DERlab · OFFIS · Strathclyde Glasgow · MAM · DTU Technical University of Denmark · VTT

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EERA electra

European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

Find out more at the ERIGRID/ ELECTRA stand H11

ELECTRA REX

A Researcher Exchange Programme for Smart Grids

Sixth & Final Call for Applications for industry and research organisations including Global & European partners

ELECTRA IRP

The ELECTRA Integrated Research Programme on Smart Grids brings together the partners of the EERA Joint Programme on Smart Grids (JP SG) to reinforce and accelerate Europe's medium to long term research cooperation in this area and to drive a closer integration of the research programmes of the participating organisations and of the related national programmes.

ELECTRA offers assistance to support transnational and international researcher exchanges to or from ELECTRA partners that will complement and enhance the collaborative research undertaken within the research programme and associated EERA Joint Programme. This enhancement will be seen in the work of the visiting researcher engaging with the host team and accelerating key smart grid concepts and solutions aligned with the objectives of the ELECTRA IRP.

ELECTRA REX PROGRAMME

ELECTRA's Researcher Exchange (REX) Programme offers the opportunity for **International and European collaborators** to work closely with **EERA & ELECTRA partners** through an exchange of staff. The scheme is open to participants from research organisations and industry, including SMEs. A range of options are available:

Three types of ELECTRA REX exchanges

Host organisations are encouraged to offer elements of training, and so this represents an excellent development opportunity, especially for early career researchers.

ELECTRA REX offers funding for the additional costs of conducting the exchange including travel, acccomodation, subsistence, and participation in an international ELECTRA REX workshop. Successful recipients can expect to gain significant benefit from the period of focussed collaboration with respected smart grid experts, while engaging with the advancement of the Web of Cells concept for real time smart grid control, and achieving an internationally co-authored paper.

For more info: **www.electrairp.eu**

INTERESTED IN APPLYING?

REX Call 6 opens June 2017, and provides an opportunity for applicants from research organisations and industry to bid for a global exchange, a European exchange or an intra-ELECTRA exchange.
This is the last scheduled call for applications so do make use of this valuable opportunity.
For more information and priority topics click the "Mobility" Tab at **www.electrairp.eu**

ELECTRA REX WORKSHOPS

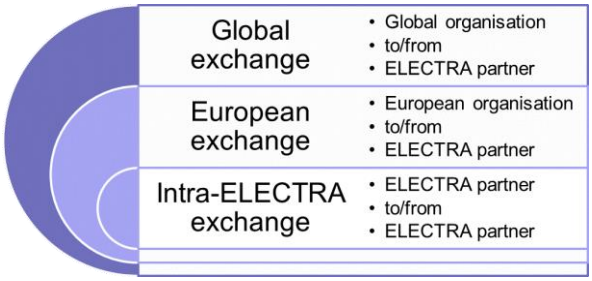
The results of previous exchanges are available at **electrairp.eu**, where you will also find more ELECTRA news.
Furthermore a number of successful recipients of ELECTRA REX exchanges plan to present their results at ISGT Europe'17. More details are available at **electrairp.eu**

Annex 6: Announcement of REX Call 2

Second REX Call

Call opens: 22th June 2015
Deadline: 22th August 2015
For exchanges starting by October 2015

The Exchange Programme Management Committee of the ELECTRA Integrated Research Programme is pleased to announce the second call for applications for Researcher Exchanges. A number of exchanges is available in this call for applicants in ELECTRA partners, European organisations, and organisations around the world as shown below:



The ELECTRA Researcher Exchange (REX) Programme provides funding for travel and subsistence costs to the successful researcher applicants to support an exchange to another country which supports the aims and objectives of the overall ELECTRA Integrated Research Programme (IRP). These aims and objectives encompass two aspects: ELECTRA's research goals and its ambition for establishing working relationships with leading international research organisations.

This Call is open to applicants from research organisations alone. Applications are particularly welcome at this time in relation to one of the following:

- Coding of distributed control solutions for real time voltage and frequency management
- DER management in support of low voltage network operation
- Detailed (functional) specifications of new smart grid control frameworks, such as microgrids or distributed cells
- Resilience of smart grid controls under disturbance conditions

It is important to note that the proposed exchange must be agreed with the Host Organisation in advance of submission. By working together, the proposed Host Organisation and Home Organisation should demonstrate that they are supporting the threefold objectives of the ELECTRA REX Programme:

a) The proposed work is relevant to the goals of creating and demonstrating advanced voltage and frequency control as described by the ELECTRA IRP.
b) The Exchange Researcher will be capable of completing a quality body of work from the exchange and will gain useful personal development from it.
c) The value of the exchange is such that the host organization and key individuals are willing and able to commit to producing valuable outcomes.

ELECTRA IRP

The ELECTRA Integrated Research Programme on Smart Grids brings together the partners of the EERA Joint Programme on Smart Grids (JP SG) to reinforce and accelerate Europe's medium to long term research cooperation in this area and to drive a closer integration of the research programmes of the participating organisations and of the related national programmes.

ELECTRA offers assistance to support transnational and international researcher exchanges to or from ELECTRA partners that will complement and enhance the collaborative research undertaken within the research programme and associated EERA Joint Programme. This enhancement will be seen in the work of the visiting researcher engaging with the host team and accelerating key smart grid concepts and solutions aligned with the objectives of the ELECTRA IRP.

ELECTRA REX PROGRAMME

ELECTRA's Researcher Exchange (REX) Programme offers the opportunity for **ELECTRA partners and European or International collaborators to work** closely together through an exchange of staff. The scheme is open to participants from research organisations and industry, including SMEs. A range of options are available:

Three types of ELECTRA REX exchanges

Host organisations are encouraged to offer elements of training, and so this represents an excellent development opportunity, especially for early career researchers.

ELECTRA REX supports:

- **increased coordination across smart grid research programmes, complementing the work of EERA JP;**
- **personal development of early career researchers;**
- **enhanced impact from the laboratory demonstration within the ELECTRA IRP.**

For more info: www.electrairp.eu

INTERESTED IN APPLYING?

REX Call 2 is currently open, and has a closing of 22nd August 2015. The exchanges will start in October.

REX Call 3 will open in early October, and is dedicated to Global Exchanges between overseas organisations & ELECTRA partners.

For more info click the "Mobility" Tab at **www.electrairp.eu.**

ELECTRA REX WORKSHOP

The six researchers who were successful in REX Call 1 will be presenting their results in the ***"First ELECTRA REX Workshop on Smart Grid Exchanges"*** on 9th September as part of the EDST2015 symposium, Vienna. Come along to hear first hand the researchers:

- disseminate the results of their exchanges
- share their experience of exchange working in leading smart grid organisations.

Annex 7: Application assessment for ELECTRA REX

Quantitative Criterion	Quality of Ambition	Credibility of impact
A. The proposed work is aligned with the goals of creating and demonstrating advanced voltage and frequency as described by the ELECTRA IRP. I.e. is the proposal technically feasible and value adding for the ELECTRA IRP	(…/15)	(…/15)
B. Based on the applicant's résumé they are capable of completing a quality body of work from the exchange and will gain useful personal development from it	(…/10)	(…/10)
C. Does the host organization provide a value adding experience to the proposed research, i.e. will the research be better because of the facilities/experience at the Host Organization	(…/10)	(…/10)
TOTALS (out of 35)		
Overall score (out of 70)		

Qualitative criterion	
Is the application from an ELECTRA partner?	Yes (5 points)/ No (0 points)
Is the application from a European organisation involved in the EERA JP Smart Grids but not in ELECTRA?	Yes (5 points)/ No (0 points)
Is the application from a European or an international organisation that ELECTRA is developing a partnership with?	Yes (5 points)/ No (0 points)
Is this the first REX submission from the researcher's institution?	Yes (3 points)/ No (0 points)
Is this the first REX submission from the researcher's country?	Yes (3 points)/ No (0 points)
Is the researcher an 'early career researcher'?	Yes (6 points)/ No (0 points)
Is the researcher female?	Yes (3 points)/ No (0 points)
Overall score	(…/30)
Final comments	

Annex 8: Announcement of REX Call 3

Third Call for Applications dedicated to exchanges between ELECTRA Partners and extra-EU Organizations

Call opens: 5th October 2015
Deadline: 5th December 2015
For exchanges starting from February/March 2016

The Exchange Programme Management Committee of the ELECTRA Integrated Research Programme is pleased to announce the third call for applications for Researcher Exchanges.

The ELECTRA Researcher Exchange (REX) Programme provides funding for travel and subsistence costs to the successful researcher applicants to support an exchange to another country which supports the aims and objectives of the overall ELECTRA Integrated Research Programme (IRP).
These aims and objectives encompass two aspects: ELECTRA's research goals and its ambition for establishing working relationships with leading international research organisations.

Applications are particularly welcome at this time in relation to one of the following priority topics:

- Assessment and control of system inertia
- Ancillary services for voltage and frequency regulation
- Power systems supervision & monitoring by considering smart meter data
- ICT & control system Interoperability: power & information flows with grid operators
- Integration of intelligent components such as IEDs and PMUs for wide area control
- Experimental investigation of DER control methodologies
- Definition of reference test networks

It is important to note that the proposed exchange must be agreed with the Host Organisation in advance of submission. By working together, the proposed Host Organisation and Home Organisation should demonstrate that they are supporting the threefold objectives of the ELECTRA REX Programme:

a) The proposed work is relevant to the goals of creating and demonstrating advanced voltage and frequency control as described by the ELECTRA IRP.
b) The Exchange Researcher will be capable of completing a quality body of work from the exchange and will gain useful personal development from it.
c) The value of the exchange is such that the host organization and key individuals are willing and able to commit to producing valuable outcomes.

Annex 9 EERA success story flyer

The ELECTRA IRP's Researcher Exchange (REX) Programme is a mobility scheme for smart grids researcher. It is developed under the ELECTRA Integrated Research Programme (IRP) on Smart Grids, an EU funded project which brings together the partners of the EERA Joint Programme on Smart Grids (JP SG) to reinforce and accelerate Europe's medium to long- term research cooperation in this area and to support integration of research programmes. **ELECTRA REX** offers international and European operators and researchers the opportunity to work closely with EERA & ELECTRA partners through an exchange of staff or research students. The scheme is open to participants from research organisations and industry, including SMEs.

Launched in November 2014 with a first call, and now in its fifth edition, **the ELECTRA-REX Programme has promoted 25 exchanges so far:** fourteen within Europe, involving ELECTRA Partners, JP Smart Grid members and other European organisations ("European exchanges") or solely ELECTRA or JP Smart Grids partners ("Intra-ELECTRA exchanges"); the remaining nine involving organisations from non-EU countries ("Global exchanges").

"The ELECTRA REX mobility programme has attracted significant interest, as well as providing excellent opportunities for in-depth research collaboration between industry and research organisations. From an EERA point of view, it has also supported the Joint Programme in European coordination and international engagement."
Luciano Martini, JP Smart Grids Coordinator

Main achievements of ELECTRA REX are not only the results in terms of exchanges, but also the innovativeness of the overall scheme, based on a well-defined procedure for the whole process: call, selection, execution of the exchange, exploitation and dissemination of results, the latter being one of the most innovative features.
The results of the exchange programmes are exploited and disseminated through collaborative peer-