WASHINGTON CENTER FOR ELECTRIC ENERGY SYSTEMS

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Abstract

Over the coming years, electricity supply systems around the world will have to adapt to integrate large amounts of renewable generation and a probable increase in the amount of energy consumed in electrical form. This will present daunting challenges and substantial opportunities for electricity suppliers, technology suppliers, regulators and other system participants.

Washington and the Pacific Northwest have a unique combination of electric sector assets – clean hydro and wind power, strong conservation and efficiency practices, progressive utilities, technology and research talent. However, these assets are often deployed as separate components, leaving potential system-level synergies unrealized.

Leading researchers at the University of Washington and Washington State University have founded the Washington Center for Electric Energy Systems to help unify efforts in our State and region toward meeting the challenges and opportunities of the coming electric transformation.

This paper describes the objectives of this center and outlines an initial research agenda, which we will refine via active discussions across the energy and technology communities. We invite you to review it, provide feedback and work with the Center toward a clean, sustainable and economic electric energy system.

Introduction

From Sweden to South Africa and from China to California, governments are encouraging the development of renewable sources of electrical energy. At the same time, many of these governments are taking measures to reduce the use of fossil fuels for transportation and heating and are thus likely to increase the proportion of energy that is consumed in electrical form. Accommodating these changes in the generation and consumption of electricity will require a fundamental rethinking in the design and operation of the power grid. A consensus is emerging that many of these challenges could and should be met primarily through the development of a "smart grid" rather than simply increased deployment of physical assets.

While the State of Washington and the Pacific Northwest could simply follow that trend, we believe that it should *lead* in that direction, not only to better serve the consumers of electricity, but also to capitalize on its competitive advantages in the field to further its economic development.

As a starting point, it is worth examining the competitive advantages that the State of Washington has in this area.

Electric Utilities

The electric utilities of the Pacific Northwest have a long tradition of expertise and innovation. In recent years they have successfully integrated a very large amount of renewable energy sources in their system. However, as the exploitation of these renewable resources continues, the regional power system is likely to become one of the first in the world to have to explore how operating practices might need to be changed to deal with the challenges that this integration poses.

Another characteristic of the regional utilities is their cooperative planning process leading to the development of the Northwest Conservation and Electric Power Plans[1], which have achieved impressive conservation and efficiency gains despite power prices that are among the lowest in the nation. These plans demonstrate the region's acknowledgement that building more traditional infrastructure will not solve energy issues, but that the answer lies in more efficient use of the existing resources.

Technology Companies

The State is home to numerous smart grid companies, both large and small. Companies with global presence include Alstom Grid (Redmond), Itron (Liberty Lake) and Schweitzer Engineering Labs (Pullman). Each of these companies is a global leader in its space, solving a broad range of power system issues on behalf of regional, national and international clients. Alstom Grid's Redmond facility develops software solutions for advanced transmission and distribution management on behalf of customers in over 70 countries,[2] giving them a truly global perspective of power systems. Itron[3], through its smart meters, communication services and consulting expertise, supports utilities all over the world to manage advanced metering of electricity, water and gas. Schweitzer[4] has grown quickly into a world-leading company in the design and manufacture of digital relays and related equipment for substation and distribution

[1] www.nwcouncil.org/energy/powerplan/6/default.htm
[2] www.alstom.com/grid/FEF
[3] www.itron.com
[4] www.selinc.com

automation. Collectively, these companies represent a broad range of important technologies within the smart grid stack.

Washington State is also host to a lively startup culture, which involves a number of companies that will also help to shape the future of the grid. Among others, these companies include Demand Energy (Spokane), PowerIT Solutions (Seattle), Optimum Energy (Seattle), Distributed Energy Management (Bremerton), Grid Mobility (Redmond), enerG2 (Seattle), FlyBack Energy (Spokane), PCS UtiliData (Spokane), Clarian Power (Seattle), Demand Energy (Liberty Lake), IncSys (Bellevue).

Locally based global IT companies such as Microsoft and Google are also exploring how they can serve the electric energy sector either on their own or through partner companies.

National Labs

The Pacific Northwest National Laboratory[5] (PNNL) has a very active research program in smart grids and other technologies that can improve the performance of the power system and is heavily involved in the nation's largest smart grid demonstration project. Its structure and activities are a perfect complement to the academic research performed at UW and WSU.

Universities

Both the University of Washington and Washington State University have strong programs in energy and power systems and have recently made substantial investments in this area with support from the State, companies and private individuals. In particular they have hired additional faculty members to expand their research and educational activities and enhance their links to industry.

[5] www.pnnl.gov

Washington Center for Electric Energy Systems

As the previous section demonstrates, Washington State and the Pacific Northwest have the mass and mix of expertise, talent and industrial might to address the challenges faced by electric energy systems and to develop solutions that the rest of the world will adopt. UW and WSU view catalyzing this process as part of their mission and have created the Washington Center for Electric Energy Systems[6] for this purpose. This Center will be co-directed by Prof. Daniel Kirschen of UW and Prof. Anjan Bose of WSU.

The objectives of this center are as follows:

- Help all stakeholders sharpen the vision of what the energy grid of the future will look like and how it could be deployed. This will be achieved by providing a forum for discussions between all interested parties. Experts from the universities will also be able to provide a neutral perspective on the benefits of various changes.
- Carry out research on the technologies needed to make the smart grid happen and explore how these technologies can be deployed for maximum benefit.
- Involve in this initiative other faculty members who have relevant expertise but are not working on energy issues
- Support the commercial deployment of the smart grid by working with companies to find the most effective ways to transfer the results of this research
- Work with regulators and government to explore how non-technical barriers to this deployment can be removed
- Foster the development of an ecosystem of energy-related startup companies
- Provide the specialized educations that engineers will need to develop and deploy the smart grid
- Build regional consortia to pursue large, federally funded research and demonstration grants[7].

[6] http://www.wacees.org
[7] For example the Smart Grid E-RIC mentioned by DOE Secretary Chu in his Congressional testimony of 3/2/11.

Research Agenda

While many aspects of the smart grid have already reached the development, field-testing or even commercial availability stage, it is clear that much research remains to be done if the broader concepts are to come to fruition and be deployed successfully on a large scale and a commercially viable basis. In particular, we believe that a considerable amount of work remains to be done to determine how the new control, computing and communication technologies installed by the consumers, the network companies and other stakeholders will interact. Optimizing these *systems* aspects will ensure that the smart grid delivers the expected improvements in economy, reliability and sustainability.

We will carry out research on system issues in collaboration with our partners from the utility and manufacturing industries as well as government to ensure that our results are societally and commercially relevant. This research will draw not only on the expertise of Profs. Bose and Kirschen but also on contributions from colleagues in the following areas:

- Communications
- Cyber security
- Software systems
- Optimization
- Data-driven systems
- Sensors and sensor integration

The Center will focus its research on the following system issues:

System architecture

How should the communication, computing and control infrastructure be mapped on the existing and the new transmission and distribution infrastructure? Where and how should new sensors and measurement technologies be deployed to improve system operation? How can we ensure the security of this vast cyber-physical system? How can we protect the privacy of the consumers when the operation of the system needs more information about their usage patterns? What useful knowledge can be extracted from the vast amounts of data that smart meters and distributed sensors will provide?

System planning

How will the engineering interact with the business models of the various companies involved? How can the smart grid be rolled out in a competitive electricity market environment? What are the impacts of the national and regional energy policy? How to optimize investments in an increasingly uncertain environment? How can the massive amounts of data that will be generated by the smart grid be harnessed to help planners and program implementers?

System operation

How can we improve the forecasting, scheduling, and dispatching of conventional and renewable energy sources to maximize sustainability, minimize cost and enhance reliability? How much storage and active demand should be deployed to facilitate the balancing of systems with a large penetration of stochastic renewable energy sources?
How should the various actors interact in the operation of the smart grid in a competitive electricity market? What can be achieved through the active operation of distribution networks?

System protection and control

How can smart grid technologies help in the control of renewable generation and in the control of the demand side? How can System Protection Schemes and wide-area control help maintain or improve reliability in increasingly stressed and uncertain power systems?

Computational issues

What new optimization and simulation algorithms need to be developed to handle the increased size, complexity and uncertainty of the system?

The following section provides more detailed examples of research questions that we are exploring or are planning to investigate in the near future. Each of these represents a current challenge in the operation, planning or design of the electric energy system and an opportunity to develop and market creative solutions.

Examples of Research Topics

Flexibility and Storage

Description of the challenge and opportunity

Recent years have witnessed the integration of large amounts of stochastic renewable energy sources, such as wind and solar photovoltaic. This is likely to continue and will probably be accompanied by the deployment of a significant amount of demand response. While these developments are desirable, they are also likely to increase the uncertainty on the load/generation balance. The standard answer to this problem is to say that the system needs more “flexibility” to handle this uncertainty. However, installing and deploying flexibility costs money. On the other hand, if the system is not sufficiently flexible, operators may have to resort to load shedding or the curtailment of renewable generation to maintain the stability of the system.

Research questions

1. How do we quantify flexibility on various timescales?

2. How much flexibility do we actually need under existing reliability standards (which may have been developed without fully accounting for variability issues and flexibility resources)? Are these standards open to review, for example if research identifies improved methods to increase flexibility?

3. How much *physical* flexibility (i.e. from generation, storage, and demand response) is needed and how much can be accomplished using *virtual* flexibility (i.e. improved operating procedures and market design)?

4. What can the various flexibility resources deliver taking into account exogenous constraints (such as irrigation, fish conservation, etc.)?

5. What are the fixed and exercise costs of the various flexibility resources cost?

6. What is the value of different flexibility resources?

7. What is the optimal portfolio of flexibility resources?

8. What revenue stream or other reward mechanism for flexibility resources needs to be put in place to ensure the provision of this optimal portfolio?

9. Do we need a market or market-like mechanism for flexibility? Should the flexibility provision be handled in a centralized or decentralized manner? What incentive should be given to the “consumers of flexibility” to encourage them to reduce the stress that they put on the system?

Potential partners

- Utilities responsible for balancing

- Owners/operators of renewable energy sources
- Providers and potential providers of flexibility resources
- Developers of software for system operation
- Utility planners, such as the Northwest Power and Conservation Council
- Energy services companies.

Demand response

Description of the challenge and opportunity

It is widely agreed that making the demand more responsive to the time-dependent supply of electricity would help reduce the cost of energy and would facilitate the integration of stochastic renewable energy sources. While the deployment of smart meters and electric vehicles are undoubtedly giant steps in that direction, a number of systems issues must be addressed to optimize the exploitation of this resource.

Research questions

1. Demand response can be used to help meet the imbalances caused by the stochastic nature of some forms of renewable generation. To maximize the effectiveness of this form of control, it has to be done in a dynamic way, i.e. not simply on the day ahead. If this is to be done on a large scale, new forecasting, scheduling, and dispatching mechanisms will need to be developed. The design of these mechanisms has to balance the needs of system operators with the willingness of consumers to adjust their demand. In particular, how can we ensure the stability of the load/generation balance?

2. The mechanisms described in the previous question would be used to make energy trading more flexible. The demand side is also able to provide various services that could be used to maintain the security and stability of the system and involve changes in the sign or rate of consumption of energy rather than changes in the amount and time of consumption of energy. The overall question is “How can we harness these services?” In particular:

    a. What is the definition of each service that best matches the needs of the system operator with the capabilities of the consumers?

    b. Can we forecast with a sufficient degree of confidence the capacity available for each service at a given instant?

    c. A given load might be able to provide two or more services but usually only one at a time. How do we avoid double counting and ensure that each demand provides the service that has the highest value?

    d. Can we design a communication and control system that will deliver these services in a reliable and cost-effective manner?

e. Since the savings on energy costs are minimal for the consumers that provide these services, what other incentives can be designed to encourage consumers to provide these services?

3. We also need to take the consumer's perspective (particularly the residential consumer's perspective) on this issue because demand-side participation in the control of the power system will happen only if consumers find value in signing up. The challenge is therefore to design a package of technologies, services and incentives that meets the needs of the consumers as well as the system operators.

    a. We need a better understanding of how consumers use electricity and how their demand could be shifted and adjusted using communication and control technologies.

    b. We need to explore whether selling services rather than power could make energy consumption transparent to the consumers and hence facilitate demand-side participation.

Potential partners

- System operators
- Aggregators
- Manufacturers of metering equipment, communication equipment, and appliances
- Designers of building control systems
- Developers of software for system operation

Managing Operational Uncertainty

Description of the challenge and opportunity

In conventional power systems, uncertainty takes the form of sudden outages of generators, lines, transformers and other network components. The uncertainty on the load is relatively small and can usually be handled with current technology and practice. With the integration of large amounts of renewable energy sources and the use of demand-side solutions, the uncertainties on the injections will increase significantly. The better we take these uncertainties into account, the cheaper it will be to operate the system and the more reliable it will be.

Research questions

1. We need a thorough audit of the uncertainties, taking into account the correlations between the sources of uncertainty

2. Deterministic security criteria (e.g. N-1 criterion) do not ensure a consistent level of risk. In some cases the resulting level is too high, in other cases it might be too low. We need to adopt a probabilistic approach to take into account the potential consequences of the new sources of

uncertainty. To develop a base line, we should perform retrospective risk calculations based on actual system operation. Besides providing this baseline, these calculations would also allow us to determine whether:

   a. There were periods during which the risk was unacceptably high and the system should have been operated differently

   b. There were periods where a significant amount of money could have been saved by accepting a somewhat higher level of risk

3. Having established this baseline, we could then perform prospective risk calculations by adding different amounts of stochastic generation to the previous cases and repeating the probabilistic risk calculations. This would allow us to study the effect of various approaches/standards for maintaining system security and the potential savings that might be achieved.

4. Probabilistic calculations are notoriously time consuming. However, reasonably priced cluster computers are now available. On a more fundamental level, it would thus be very useful to investigate how we could perform Monte Carlo simulations in parallel on such computers

5. Current scheduling practices take uncertainty into account by providing a fixed reserve margin to cater for contingencies. Taking all the uncertainties explicitly into account in the scheduling would make possible a better control of the level of risk and of operating cost. This would involve not only the development of robust probabilistic scheduling algorithms but also the implementation of new scheduling processes with regular re-scheduling to take advantage of new, more accurate forecasts.

6. Because of the increase in uncertainty, traditional preventive control (e.g. fixed reserve margins, N-1 criterion) will become more expensive and less reliable. We are likely to move towards a more flexible form of control that includes post-contingency corrective actions from both the supply and the demand side. However, operators will want to make sure that they have available enough resources to deal with contingencies using corrective actions for a wide range of uncertainties. This will require the development of probabilistic security constrained optimal power flow programs.

Potential partners

- System operators
- Developers of software for system operation
- Policy makers

Understanding the demand

Description of the challenge and opportunity

Power system planners and operators have a reasonably good understanding of the behavior of the load at an aggregate level and when energy is sold on the basis of a fixed tariff. We know considerably less about the loads and how they behave when they are disaggregated level or when consumers are given signals or incentives to which they can respond. Enhancing our fundamental understanding of how loads behave will facilitate planning and will make possible the development of more effective operating practices at both the distribution and the transmission levels.

Research questions

1. The deployment of smart meters will produce vast amounts of data, which could yield very useful information if, and only if, it is properly structured and linked to other relevant sources of information, such as the appliances owned or used by the consumer, the price signals that this consumer might have received and the local weather conditions.

2. The information extracted from these databases could be used to develop probabilistic demand models at the system level, at the level of point of connection between the transmission and the distribution networks and at the level of an individual feeder. These models could then be used to infer the likely behavior of the load under both normal conditions and in response to signals sent by the operator to deal with problems in a particular area of the distribution or transmission network.

3. In particular, models of this type could be used to develop more robust distribution state estimators.

Potential partners

- Transmission and distribution utilities

- Developers of software for network planning and operation

Packet-Switching Transmission and Distribution Networks

Description of the challenge and opportunity

Integrating more renewable energy sources in the power system will require more transmission capacity because the most economical resources are often located far from the load centers. However, building new transmission lines is getting increasingly difficult for ecological and esthetic reasons. At the same time, upgrading the distribution network to handle a large increase in the load stemming from an electrification of transport and heating would be extremely costly. On the other hand, existing transmission lines and distribution cables are typically used at their full capacity for only a fraction of the time. It would therefore be possible to transport considerably more electrical energy through the existing transmission and distribution infrastructure if these networks were operated in *packet switching* rather than circuit mode. In packet switching mode, electric energy would be transported when intermittent sources of generation are producing and when transmission and distribution capacity are available. Storage would be used to buffer excess energy and to supply the load when insufficient generation or transmission capacity is available. Implementing this packet switching mode would thus require the installation of a substantial amount of physical energy storage or virtual storage (e.g. demand-side management in general and charging of electric vehicles in particular).

Research questions

1. Since storage is currently too expensive for packet switching operation to be economically viable, the following questions need to be addressed:
   - What level of carbon price would result in a shift to renewable energy sources that would require a switch to packet switching transmission?
   - What is the value of storage depending on its power and energy rating, its grid location and the time (TOD, TOW, season)?
   - Conversely, if the transmission or distribution capacity is simply not available, by how much does packet switching transmission and distribution increase the cost of electric energy to the consumers?
2. Since one of the main goals of packet switching is to provide the ability to cope with the uncertainty associated with stochastic renewable energy sources, stochastic techniques must be developed to optimize the control, sizing and siting of the storage facilities.
3. Since storage facilities will probably be introduced gradually, the system will initially have to be operated in a mixed or partial packet switching mode.

Potential partners

- Transmission and distribution utilities
- Manufacturers of storage equipment
- Developers of power system analysis and operation software

IT Infrastructure for the Power Grid

Description of the challenge and opportunity

The availability of high bandwidth networked communications and high performance computing provides the IT infrastructure needed to support operation and control applications that can take full advantage of the new sensor technologies (phasor measurements, smart meters) and fast controllers (FACTS devices). While the *components* of the present communication and computation system have been upgraded regularly, its *architecture* was designed four decades ago. There is thus an opportunity to design and deploy a completely new architecture that can support a set of much more powerful applications that can provide a higher level of reliability and efficiency to the grid. The challenge is to develop an architecture that is flexible and scalable enough to support all the applications that will be conceived over the next few decades.

Research questions

1. New sensor technologies can produce quantities of measurement that are several order of magnitude larger than what is used today. In addition, PMUs produce measurements at data rates

that are two orders of magnitude larger than SCADA measurements. It is generally accepted that all of this data should not be gathered centrally at the control center as is done today. The first research question is thus the specification of the communication network needed for the future power grid. The most challenging applications are for wide area controls (see below) because the communication system has to be able to move real time data from the sensors to the control computer to the field controllers in milliseconds.

2. The volume of data being produced by all the new sensors – from PMUs to smart meters – is many orders of magnitude larger than what utilities are currently dealing with and will be impossible to centralize in one place. Thus the database will need to be geographically distributed. The management of such a distributed database for a large and varied set of applications is a large and new challenge. Off-the-shelf data management products will not be able to handle the new requirements of the power grid and research is needed to develop such a distributed database for the power grid.
3. With a distributed set of computation resources and a distributed database, the power grid applications can also be distributed. In fact, the present practice of locating one application on one computer processor will no longer be the most efficient way to perform such applications. Thus distributed processing, parallel processing, agent-based processing and other techniques need to be considered when rethinking the present and future applications.

Potential partners

- ISOs and large electric utilities that own and operate their own power network
- Manufacturers of control centers
- Manufacturers of distribution automation systems, substation control equipment and protection

Analysis and Design Tools for the Smart Grid

Description of the challenge and opportunity

The smart grid provides the opportunity to deploy many new applications that will make the power grid more efficient and reliable. However, because the smart grid will be quite different in structure than the existing grid – more sensors, more communications, more computers/processors, more controllers – the new applications will require different design and implementation methodologies. This, in turn, will require new analysis and design tools. At present, the development of applications for control, operation, and grid planning requires software tools that can carry out complex simulations and calculations. Even more sophisticated tools will be needed to do the same for the smart grid.

Research questions

1. Since protection and control today is mainly local, the design tools do not have to consider any communications. The new tools to design wide area control and protection will require taking into account the impact of the communication system. When moving signals over large distances over a communication network, the communication latency can have significant influence on the control performance. In the case of protection, this latency may mean the difference between stability and instability following a fault in the network. The challenge is that the simulation of the power grid and the communication system, as available today, are dissimilar and integrating these will require significant research.

2. Many of the new sensor and control technologies – like PMUs or FACTS devices – will require testing with the control strategies. That is, the design of new controls or protection will require testing with software and hardware at the same time. Integrating software and hardware in one testing platform is a difficult challenge and will require research.
3. The proliferation of smart meters will provide large amounts of data about electricity uses. Developing tools to analyze this data and turn it into meaningful information is a big challenge. For example, tools are needed to change the load pattern to get more optimal (efficient) operation of the grid. Incorporating this information into the design tools for operation and control strategies is an even bigger challenge. For example, if the loading pattern is well understood the distribution management system (DMS) can be programmed to operate the new distribution controls to optimize both real and reactive power.

Potential partners

- Manufacturers of control centers
- Manufacturers of distribution automation systems, substation control equipment and protection
- Developers of communication systems for electric utilities
- Developers of database systems for electric utilities
- Large electric utilities and ISOs.

Wide-Area Control and Protection Applications

Description of the challenge and opportunity

Almost all protection and control are local, that is, the inputs, the processor, and the outputs are all in the same geographic location. With the availability of high bandwidth communications, this doesn't have to be a constraint any longer, as the input and output signals for a protection or control scheme can be delivered over long distances. In fact, many special protection schemes (SPS) and a few wide area controllers have already been implemented to mitigate particular operational problems. However, such controls are expensive to develop, design and implement as each is a unique implementation.

The availability of an infrastructure consisting of high bandwidth communication and large-scale computation is expected to make this development, design and implementation much more routine and hence, cost-effective.

Research questions

1. One of the reasons why the development and design for wide area protection and control is expensive is that there are no established methodologies for these tasks. If such controls are to be developed and designed routinely, a more standard process for doing so must be conceptualized. If this can be done, the maintenance of such controls can also be streamlined. At present, the maintenance of a SPS requires periodic studies to determine the new settings required to take into account the changes that have happened over time in the power system. A more routine procedure to do so will decrease the amount of engineering time needed for such studies.
2. The main reason to implement such wide area protection and control is to increase the transmission limits over certain transmission corridors or flowgates. Today, such controls have been applied to only the most important transmission corridors. However, a more streamlined

process for implementing wide area protection and control can make it cost-effective to implement such controls on more lines and at lower voltage levels. The challenge is to determine where the cost of this type of control is justified by the increased capacity of a particular flowgate.

3. The other possible use of wide area control is the coordinated optimization of the voltage profile over large areas to reduce the losses in the transmission and distribution networks. Voltage adjustments can also be used to control the loads to minimize the loading of the system. While there are good optimization techniques to calculate the optimal voltages, how to implement this form of voltage control in real time is not understood very well.

Potential partners

- Manufacturers of protection systems and control systems
- Developers of communication systems for electric utilities
- Developers of software systems for electric utilities
- Large electric utilities and ISOs.

Education

The enormous changes that the electricity supply industry is about to undergo will require a larger work force equipped with a new set of skills. WSU and UW will work in partnership to provide the degree and the continuing professional development courses that new and experienced engineers need to work efficiently in this new environment.

A first example of joint education initiatives is the DOE-sponsored grant for smart grid workforce education led by WSU in collaboration with UW, Incremental Systems, PNNL, Alstom Grid, BPA, Avista Utilities, Puget Sound Energy, Tacoma Power, Snohomish PUD, Northwest Public Power Association and Schweitzer Engineering Labs.

Commercialization

We believe that the research agenda outlined in the previous sections will lead to the development of commercially valuable technologies. The University of Washington Center for Commercialization and the Washington State University Research Foundation have considerable experience handling intellectual property and licensing issues. These organizations work with researchers to identify inventions that should be protected and then handle the patent prosecution. They also help structure the intellectual property terms for sponsored research agreements with companies. Companies typically have the “first shot” at licensing any innovations that come out of research that they sponsor. Technology transfer can also be achieved through creation of university spin-out companies. Here the technology transfer organizations can provide business-planning support, advising from experienced entrepreneurs, and access to startup funding. Spin-outs can be a good option when members of the research team are available to move from the lab into the new venture.

The way forward

The challenge of adapting the electric energy system to the new energy landscape represents an opportunity for the State of Washington to establish itself as the leading provider of smart grid solutions. This paper has presented the objectives of the Washington Center for Electric Energy Systems and outlined some of the research that UW and WSU intend to carry out in this area. It is, however, only a first draft. Our hope is that it will be the beginning of a dialogue between the State universities, utilities, manufacturers, startups and other stakeholders about how to proceed.

We would therefore welcome:

- Comments about the research topics that we have presented
- Suggestions about other research questions that should be added to the research agenda
- Offers of support for the investigation of particular issues. These offers can take the form of full research partnerships, provision of data, industrial expertise, or review of research results
- Offers to participate in large regional or national research or demonstration projects.