Innovation in Offshore Renewable Energy: International Collaboration and INORE

Cameron McNatt [1], Matthew Hall [2], Josh Davidson [3], Adrian de Andres [4], Soraya Hamawi [5]

[1] Institute of Energy Systems, University of Edinburgh, Edinburgh (UK)
[2] Department of Mechanical Engineering, University of Maine, Orono, Maine (USA)
[3],Centre for Ocean Energy Research, Maynooth University (Ireland)
[4] Environmental Hydraulics Institute - IH Cantabria, University de Cantabria, Santander (Spain)
[5] Wave Energy Centre (WavEC) Offshore Renewables, Lisbon (Portugal)

Abstract

Innovative research and development, supported by creative, enthusiastic and collaborative researchers, is vital to advancement of the offshore renewable energy (ORE) sector. The innovation system concept stresses that the flow of technology and information between people, enterprises and institutions is key to innovation. R&D, engineering and project development in the ORE sector are extremely multidisciplinary and rely on a wide breadth of skill sets and knowledge. No individual actor has the expertise to manage it all alone. Similarly, no individual country has the financial, market or knowledge resources to completely support the ORE industry. Collaboration, knowledge sharing and open innovation, particularly on an international level, are critical to the development, diffusion and implementation of a successful ORE sector.

In the ORE business community, traditional reluctance toward information sharing due to intellectual property concerns is giving way as the benefits of cooperation become increasingly apparent. Some of the areas where collaboration can be particularly beneficial, not just to the industry as a whole but also to the individual actors engaged in the process, are: mutual benefits from best-practices sharing, lowering cost barriers for small and medium enterprises, and catalysing innovation through collaboration. Furthermore, in the academic research community, the limitations of only sharing information through written articles alone are being acknowledged. The nascent state of the ORE sector opens a range of opportunities for beneficial collaborations; a number of already-successful programs are described in this paper.

The International Network on Offshore Renewable Energy (INORE) serves as a hub for international and multidisciplinary collaboration between researchers at early stages of their careers. INORE facilitates collaboration through a variety of activities, events, and programs as well as via its online presence. By instilling a positive attitude towards and experience with collaboration in the next generation of ORE professionals, INORE is advancing innovative research and is building a foundation for successful innovation in the ORE sector for years to come.

1. Introduction

As offshore renewable energy (ORE) is an emerging field, there are significant technological, environmental, social, and political challenges to address, many of which are unique to the industry. Out of these technologies (wave, tidal, offshore wind, ocean thermal, and salinity gradient energy conversion), only offshore wind has

reached the point of wide commercial viability and only for pile-mounted wind turbines; floating offshore wind turbines are still at research and development (R&D) stages. For the most part, ORE is in a pre-commercial stage, and should be viewed as a long term investment. Ultimately, success in the industry will mean that the power generated from ORE sources is competitive with conventional energy sources. To reach this point, there is a strong need to accelerate the development of ORE technology and reduce risks associated with it.

One way to do this is through collaboration. Herein, collaboration is meant in a broad sense to refer to practices in which actors (individuals or organizations) share information freely and openly. In some cases, there may be quid pro quo exchange, but in others, it is making information available without any guarantee of direct compensation. This behavior is often referred to in official contexts as "knowledge transfer," and is commonly known as cooperation. The term open-source is equally applicable. Open source is well-known from its application to software, which is where it gets its name - in open source software, the source code is released openly and for free. However, the term open source, or the word open, is now also applied to hardware projects, educational institutions, science, and business models. Henry Chesbourgh (Chesbourgh 2003) uses the very apropos term: "open innovation," where innovation is more than simply invention, it is turning an idea into a successful process, product or service in the marketplace. Collaboration is open source, knowledge sharing, cooperation, and open innovation.

Open, collaborative approaches contrast with the traditional closed business model of innovation, which emphasizes secrecy, intellectual property (IP) protection, and control of information. In the traditional model, a manufacturer does most or all of its innovation in-house and behind closed doors; users do not innovate but just purchase products from the manufacturer. In an open innovation model, the manufacturer for various strategic reasons will release information and will also be very active in looking for information outside of its own walls, including from users who may also engage in the innovation process (Chesbourgh 2003).

For businesses, the idea of sharing information for free may be unconventional and controversial. However, in academia, information sharing is standard practice. The ORE industry has grown and continues to grow out of academic research. The commercial and academic sectors are closely tied, and in some cases, it may be hard to distinguish between the two. Academic researchers use commercial products; businesses contract academic research; and academic research is spun-off into new companies. In this paper, collaboration is discussed as it applies to the whole industry including both academia and commercial enterprises.

The International Network on Offshore Renewable Energy (INORE) serves as a hub for international and multidisciplinary collaboration between researchers at early stages of their careers. INORE is an association of early-stage researchers (e.g. postgraduate students, post-docs) consisting of over 1000 members from more than 70 countries with a variety of backgrounds from engineering to biological sciences to public policy. INORE facilitates collaboration through a variety of activities, events, and programs as well as via its online presence.

Collaboration is vital to success in the nascent ORE industry. INORE helps to facilitate collaboration and perhaps most importantly, it is establishing a tightly-knit collaborative network that will grow stronger as its members progress in their careers.

2. Theories and Perspectives on Collaboration

Collaboration and the Innovation System

The growth of a complex technology into an economically viable industry is made possible with the support of a system of actors, institutions, knowledge, resources, economic competence, and infrastructure. This is commonly referred to as an innovation system, which Carlsson and Stankiewicz (1991) define as "a network of agents interacting in the economic/industrial area under a particular institutional infrastructure … and involved in the generation, diffusion, and utilization of technology." Hekkert et al. (2007) point out that an innovation system is "both an individual and a collective act." Although individual actions by inventors and entrepreneurs are essential, innovation could not happen without a network and support structure. In colloquial terms: "it takes a village."

The challenges to forming a new industry are even higher for renewable energy technologies as they face many barriers associated with the established carbon-based energy market. To meet these extraordinary challenges, a successful innovation system is even more important than

in other areas (Jacobsson and Bergek 2004). Hekkert and Negro (2009) show through several real world examples of renewable energy technologies that good innovation systems lead to 'virtuous cycles' or positive feedback growth, while poor innovation systems lead to 'vicious cycles', negative feedback decline and stagnation.

Knowledge sharing is a critical function in a successful innovation system (Hekkert and Negro 2009). Collaboration improves and refines products and processes and inspires new ones. By working together the development of successful and reliable technologies happens faster. Because ORE is expensive, complex, and new, the vast technological advances, cost reductions and risk mitigation cannot be handled by any single actor alone. The industry needs to work together to develop reliable, well-understood, efficient and effective devices.

International Collaboration

Currently for ORE, direct competition with established carbon-based energy sources is not possible. Entrepreneurs need to find niche markets, many of which are created by national government policies. These local policies create national innovation systems, where some national innovation systems are better than others, which in turn draws innovation to that country.

Although national innovation systems often strive to keep the economic benefits of the industry within their own borders, studies have shown that ORE companies actively seek out international business opportunities. Løvdal and Neumann (2011) examined internationalization as a business strategy in the ORE industry by taking a comprehensive survey of 50 companies in the wave and tidal sectors in 2007. They found that 84% of companies agreed with the following statement: "It is important for our company to internationalize rapidly." Further, 84% agreed that: "Internationalization is the only way to achieve our growth objectives." And 58% agreed to the statement: "We would move our main office to a foreign country if needed."

They found that the most important enticements of countries with favourable national innovation systems are, in order of importance: 1) access to government funding, 2) supportive political environments and 3) access to private capital. Lovdal and Neumann discuss how supportive political systems create better access to private capital because they reduce investment risks and because local investors are likely better informed in nations with supportive governments.

The traditional model of incremental internationalization says that companies develop their business in their home nation first and then gradually expand to international markets as they grow. Of the companies that responded to Lovdal and Neumann's survey, over 90% classified themselves as start-ups. Companies in the ORE industry do not fit the traditional mould. Instead they may be considered International New Ventures, which are defined by Oviatt and McDougall (1994) as "a business organization that, from inception, seeks to derive significant competitive advantage from the use of resources and sale of outputs in multiple countries." Forming international networks and connections is therefore vital to ORE firms looking to expand internationally, and this is important at very early stages of the development.

Open Science

Academia is a specialized but important case for collaboration in the ORE industry. In academia, sharing ideas is the norm. Its products are free information, which typically come in the form of papers and presentations - written or spoken words. There was a time when, and the philosophy still holds that, the purpose of a paper was to describe research in such a way that it could be reproduced by others. However, in recent times, research relies more and more on custom codes, complex software input files or expensive and time-consuming experiments. This often prohibits others from replicating or more importantly building upon that work.

In addition to sharing ideas, academic researchers should consider freely publishing their data or code in an open source manner. This is embodied in a movement called open science, which emphasizes that data is evidence of the claims made in papers. The more available the data is, the better the science (Molloy 2011). The published software or data is a source of citations, which are valuable commodities in the academic world. As the journal paper or report may be the ultimate product of academic research, if the code or data is not made publicly available, it risks being lost after the project is completed. Freely releasing the code or data and making it easier for others to use can also dramatically increase the impact of the research.

3. Collaboration Outlook in the ORE Industry

The ORE industry is beginning to realize the benefits of collaboration, but there are still opportunities for improvement. Wieczorek et al. (2013) discuss the

innovation system of the offshore wind industry, and show that its success was the result of and still depends on massive interconnecting network of actors, infrastructure, and behaviours. Collaboration has been vital. Although, they also found that free knowledge sharing was limited by commercial competitiveness.

In the wave energy industry, Hamawi and Negro (2011) critique the innovation system in Portugal and found several weak and detrimental knowledge sharing interactions - between researchers, between manufactures, between technology users, and between governmental organizations. Hamawi and Silva (2013) examine risks in the wave energy sector as whole and suggest that a knowledge sharing network would be a way to better understand and mitigate risks.

To accelerate the development of the wave and tidal industry in the UK, Jeffrey et al. (2013) identify needs for knowledge sharing on project and device development experience, on cross-platform technologies, and from other industries. However, like in the offshore wind industry, they acknowledge that commercial competition is a challenge to this.

Topper and Ingram (2011) did an extensive survey of numerical models used and needed for evaluating wave and tidal technologies. They warn against an "in-house culture" of modelling in which, because of limited availability, researchers apply the models they have at hand even if they may not be the most appropriate and have not been verified and validated for their application. Their ultimate recommendation is for modellers to focus on a few open source software tools that are broadly-used and quality-assured for wave and tidal energy.

These findings show that a successful industry will not be created by one single actor who devises a breakthrough device; it will be created by the combined efforts and technologies of many. Although allowances should be made to protect commercial enterprise, it is important to acknowledge that knowledge sharing is necessary and that if the ORE industry as a whole does *not* succeed, these technologies will lose some if not all of their potential commercial value. In order to build ORE into a successful commercial industry, a successful innovation system needs to be developed, a key part of which is knowledge transfer.

Specific collaboration outcomes in the ORE industry can be grouped into three categories: reducing start-up barriers, reducing cost and risk, and maximizing innovation. The nature of ORE presents unique needs in each of these categories.

Reducing Start-up Barriers

At the beginning stages, a start-up ORE device developer faces a number of hurdles in growing from the concept stage to moving along the design development process. Even the task of assessing feasibility is usually resource-intensive due to the complexity of the salient hydrodynamics phenomena and the harsh offshore environment which is unfamiliar to many. Collaborative and open-source initiatives can ease these start-up challenges by providing expertise or access to entry-level modelling tools.

Consider a device developer seeking expert assistance from a research institution. At research institutions with strong collaborative practices, the developer is more likely to be directed to the right expert. This phenomenon can be further strengthened by ORE research networks and directories – INORE's researcher list being a good example of the latter.

To illustrate the benefit of open-source tools, software from MIT and NREL are widely used to assess the performance of wind or hydrokinetic turbines (e.g. Drela and Youngren 2014, Jonkman 2006). While the availability of tools such as these is not always obvious to newcomers to the field, open-source directories such as INORE's planned website OpenORE (www.openore.org) are improving the visibility of the various options available. Given the difficulties faced by newcomers to the ORE field, collaborative and open-source initiatives are an important source of assistance.

Reducing Costs and Risks

As an ORE device developer moves through the development stages, it faces more specialized design challenges and decision points, and increasing costs and risks. There are enough commonalities between subsets of devices that many instances of isolated (and unshared) problem-solving constitute wasted effort. It is unsurprising that companies would be reluctant to freely share the fruits of their effort with potential competitors. However, avenues exist through which the benefits of sharing experience can be reaped, reducing costs and risks.

For ongoing challenges that are faced by more than one company, the Joint Industry Project (JIP) model is a

proven solution. In this approach, companies interested in resolving a common problem pool resources into a consortium that leads the problem-solving process, sharing the results with all members. Maritime Research Institute of the Netherlands (MARIN), for example, has coordinated numerous programs in this model (eg. Buchner et al. 2011). When they find a problem that is slowing down the whole industry, they seek industry partners to collaborate on research and share costs (S. Gueydon, personal communication, 11 September, 2014).

For past challenges that a company has resolved but which others have yet to surpass, experience-sharing provide a means of inducing companies to share this information. At its most basic, this approach sees two or more parties come together and exchange their experience and lessons learned. In the larger approach, an external organization oversees an experience-sharing program which compiles information from member parties to produce a best-practices document that (ideally) is publicly available for all entities to benefit from. The incentive for parties to participate in this process is typically that they receive access to the content without publication delay. Some examples of this approach demonstrate its value, although there are other cases where this sort of approach is sorely missing. In the floating wind turbine community, the OC3/OC4 code comparison efforts (Jonkman et al. 2010) have been highly informative to the field at large. These types of exercises help establish best-practices that are widely sought by the industry. Another example of these types of collaboration is in the development of standards, which codify recommendations and best practices, reducing risks throughout the design and deploy process.

Multiple parties working together reduces the cost and risk to each by sharing resources and increasing the information used in a decision-making process. The availability of outside information from parties developing different device types may be especially important to encourage developers to adapt their design to be best. As has been noted by Weber (2012), stubborn adherence to a suboptimal design configuration is a common hindrance in the ORE industry.

Maximizing Innovation

ORE is a nascent industry, with developers pushing the state of the art along various fronts, and consequently specialists emerge in various fields, in various locations, and who are not necessarily connected. A device development project will require expertise from a wide range of subject areas. Bringing together the distributed and diverse expertise is therefore a good avenue for maximizing the potential of a device under development.

The industry is full of examples of developers keeping their doors closed and doing their R&D with significant weaknesses in key knowledge areas. A number of recent developments lend some hope to the prospect of benefiting from combining expertise. As Bill Joy, co-founder of Sun Microsystems, has said: “No matter who you are, most of the smartest people work for someone else.” (Lakhani and Panetta, 2007)

The most assured way of combining expertise is to literally bring experts together. This is done with great success in many ad-hoc situations, such as internships or consulting arrangements. It can also be done through formal collaboration support programs. For example, Zurkinden and Beatty (whose research was funded by an INORE ICIS) shows the success of combining the experimental expertise of one party with the theoretical expertise another (Zurkinden et al. 2014). The collaboration between MARIN and UMaine to develop a performance-matched wind turbine (de Ridder et al 2014, Fowler et al. 2013) is another excellent showcase of collaboration over distance.

Collaborative or open-source software development is another means of bringing expertise together. By, for example, developing an open-source mooring line model, the mooring expertise of one party can be utilized by other parties who may have expertise in other aspects of a floating system. Without requiring open-source access, code-coupling collaborations between parties can improve the tools available to each, such as in the case of a wind turbine code being coupled to a commercial hydrodynamics simulator. The open-source simulator development WECsim seeks to gain the benefits of combining expertise, and share these benefits with others, from the beginning (Ruehl et al. 2014). The floating wind turbine simulator FAST, which is open source, recently took things a step further by developing a framework for the specific purpose of facilitating exchangeable modularized models from other contributors (Jonkman 2013).

The prevalence of papers resulting from these efforts indicates the benefit of these collaborative paradigms. As time goes on, the common development challenges and common goals of growing an industry may well trump the more traditional competitive concerns, and collaboration

will play an ever-increasing role in the developing ORE industry.

4. International Network of Offshore Renewable Energy

The International Network on Offshore Renewable Energy (INORE) is a network of postgraduate students and early stage researchers in academia, industry or government, working on topics related to ORE. INORE brings together researchers from around the world to meet, collaborate, and share knowledge, with the vision to realise the potential of young researchers and ORE.

INORE was founded in 2007, evolving from the Norwegian project: "PhD Pool on Offshore Renewable Energy" which aimed to assemble ORE researchers with different areas of expertise to create solutions to interdisciplinary challenges. It soon became apparent that to achieve this goal a community larger than was available nationally would be required and that international cooperation was then severely lacking. So motivated, INORE was born.

From these beginnings INORE has grown to a network of 1,200 members from over 70 countries, covering all aspects of the ORE sector ranging from social policy to technical engineering. The steady and continuous growth is shown in Figure 1.

Although some of the original INOREans may no longer fit the mould of an early stage researcher, as they are now established in their careers. Most emeritus INOREans still remain in the network, sharing their knowledge and experience, advertising jobs and postgraduate positions, and keeping in contact with the friends they made along the way. One of the greatest strengths of INORE is that as the INOREans of today work up through the ranks of industry and academia, they maintain long established relationships with many other researchers from all areas of ORE.

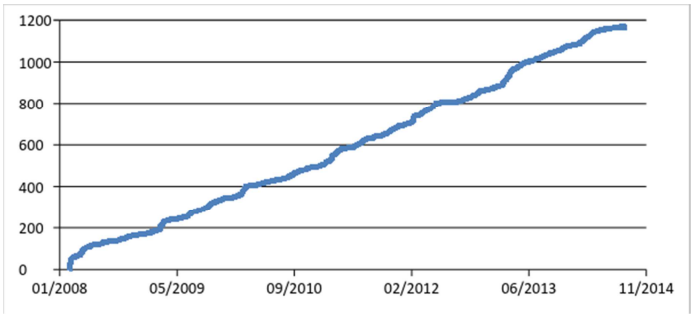

Figure 1: The growth in INORE membership numbers over time

INORE enhances the development of early stage researchers within ORE by creating opportunities for its members to meet and collaborate. INORE hosts international symposia, conference workshops and networking events that bring members together to share what they know in a fun, welcoming and casual environment where peers become friends. To maintain these connections amongst the geographically dispersed network, INORE has its main website (www.inore.org), where news, jobs, contacts and documents can be exchanged, and is also developing a new website, OpenORE (www.openore.org) for sharing data. INORE also provides grants to be put towards collaborative projects between members working in different countries.

The INORE Symposium

The international symposium truly is the heart of INORE. It is where colleagues are made and friendships are formed, where conversations are started and collaborations begin. It is a chance to get outside of the box and exchange ideas with peers. It is an opportunity to discuss research work in a relaxed and informal setting, to share successes, failures and lessons learned and to gain feedback and advice from other researchers at a similar stage of their career.

The symposium is week-long retreat, typically in a remote location, free from external distractions. Attendees live, work and play together, sharing in a week of keynote speakers, workshops, poster sessions, focused presentations, collaborative tasks, site tours and much more! The busy work schedule is balanced out with recreational, sporting and social activities allowing attendees to have fun and get to know one another.

Figure 2: INOREans at the Spain Symposium in May 2014

The symposium is free for attendees, so that the limited travel budgets of early stage researchers does not restrict them from attending. This is only possible with the generous support of sponsors. The 2014 INORE sponsors are listed in the acknowledgments section. Table 1 is a history of the symposia locations and attendance.

Year	**Location**	Number of attendees
2007	Trondheim, **Norway**	20
2008	Comrie, **Scotland**	39
2009	Maarkedal, **Belgium**	56
2010	Dartmouth, **England**	59
2011	Alcoutim, **Portugal**	58
2012	Thisted , **Denmark**	45
2012	Boston, **USA**	26
2013	Pembrokeshire, **Wales**	50
2014	La Vega, **Spain**	66
2014	Halifax, **Canada**	T.B.A.

Table 1: Summary of symposia attendance

The INORE Website

The INORE website (www.inore.org) first came online in March 2008. The purpose of the website is to foster research collaboration between INOREans and others in the ORE sector, to keep members abreast of upcoming events and news, and to attract new members and sponsors.

The INORE website has the following features: members profiles, news, events, jobs, grants, sponsors links and a bit of information about us. It will soon be upgraded as the result of a successful crowdfunding campaign that raised over $6000 from INOREans and supporters. The new website will include many more features such as improved member browseablity and a research section. In the last couple years, the INORE presence in social media has been increased to include LinkedIn, Facebook and Twitter and in an attempt to reach all the ORE community.

In 2013 there were 22,000 visits to inore.org, with nearly 40 countries averaging at least one visit per week and on average over 60 countries registering at least one visit a month. The website is visited by a few hundred different users each week, as shown in Figure 3.

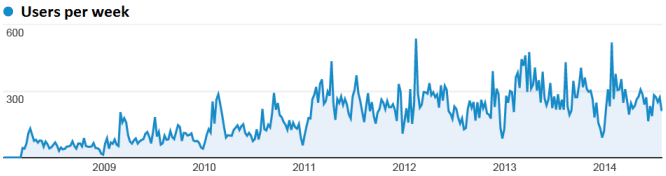

Figure 3: Number of unique visitors to the INORE website per week

OpenORE

OpenORE (www.openore.org) is a new website being developed by INORE that will allow users to share the

fruits of their labor. Users can upload code, models, projects, data, and media relating to ORE. In the spirit of open source, everything uploaded will be free to use, modify, and improve upon.

OpenORE will host three basic categories of data: 1) Static items – like experimental or environmental data sets or CAD models, 2) Code – full open-source software projects of just code snippets. Code will be linked/hosted through GitHub.com to allow for modification and subversion control, 3) Links – links to other databases and software projects. OpenORE will connect and advertise for the breadth of open-source software projects and open-access databases that already exist or are being developed.

No restrictions shall be applied to the types of data uploaded. However, it is INORE's expectation that the site will contain a significant amount of data related to computational models. Similarly, no limits shall be imposed on who can use and benefit from OpenORE, but initially, early-career researchers as embodied by INORE shall be the targeted niche.

ICIS grants

The International Collaborative Incentive Scholarship (ICIS) grants are awarded annually to groups, of two or more INOREans based in different countries, who have identified collaboration opportunities and wish to meet together in one location to carry out investigative research with the intention of generating further research publications. In 2014, the ICIS scholarships have been renamed OES-ICIS grants thanks to the generous support of Ocean Energy Systems (OES) towards this initiative. The new OES-ICIS scholarships aim to encourage intercontinental collaboration by increasing the amount of money awarded in order to cover the costs of intercontinental mobility.

The ICIS grants are a tangible output of the collaborative culture fostered by INORE. Past recipients of the award include; Thyng and Roc (2011), Stefanovich and Chozas (2010), Pecher et al (2011) and more recently, Collazo et al (2013) and de Andres et al (2014).

Workshops and Networking Events

Workshops and networking events are usually held alongside any conference with relevance to the ORE field. By hosting these events INORE strives to create a fun, friendly atmosphere for young researchers to meet one another and promote friendly networking.

As an example, in the past year INORE has held workshops at the European Wave and Tidal Energy Conference 2013 (EWTEC'13) in Aalborg, Denmark; the Offshore Marine and Arctic Engineering 2014 conference (OMAE'14) in San Francisco, USA; and at the Asian Wave and Tidal Energy Conference (AWTEC'14) in Tokyo, Japan; and networking events at Marine Renewable Canada 2013 in Ottawa, GMEWC 2014 in Seattle, USA, and the Renewable Energies Offshore 2014 conference (RENEW'14) in Lisbon, Portugal.

Figure 4: INOREans and panelists during the INORE @ OMAE 2014 workshop in Berkeley, California

At EWTEC'13 more than 100 early stage researchers attended the workshop, which consisted of an expert panel session, group discussions and ended with food and drinks at a local restaurant. The questions discussed by the panel included: What is the future of offshore renewables, where will wave and tidal energy be in the next 5-10 years, and what are the main challenges that must be overcome in order for large scale power production to become possible? The workshop at OMAE'14 followed a similar format and focused on the topic of how the ORE sector can learn from the offshore oil and gas industry. The theme of the AWTEC'14 workshop centred on the advantages of networking for PhD students, post-doctoral researchers and young industry workers. Questions were explored with invited speakers, and in group discussions. The evening was completed with fun, food and drinks. The networking events, are typically held on the last night of the

conference and are a chance for members to get together in a social environment, usually dinner and drinks at a nearby restaurant or pub, to establish and strengthen bonds between each other.

How the Industry Benefits from INORE

INORE aims to foster collaboration between early stage researchers at research institutions, companies and in the government. The industry is very much a part of INORE. Many companies and organisations share INORE's aims and donate, much-appreciated, funding to become an INORE sponsor (INORE's sponsors are listed in the acknowledgements). In this section, the benefits of being part of INORE from an industry perspective are outlined.

1. The annual INORE Symposium is an opportunity for companies to be exposed to the current level of academic research, bringing them up to date on the latest research developments in ORE by the top research centres and universities. Also, the achievements and progress of the attending company can be highlighted and its capabilities advertised to the research community and future industry leaders.
2. It is an opportunity for the companies to form associations with a large and international community. Some of the problems that a company is facing may already be studied by R&D centres and universities. All the INORE events (symposiums and workshops) are key venues for creating collaborations to solve the sector's challenges together.
3. The INORE events are great places to meet the next generation of researchers and the future industry talent pool. Attending these events allows face-to-face meeting with potential recruitment candidates.
4. The collaborative tasks undertaken at the symposium are a forum where the industry can propose some of the problems they are having, so that they can be addressed by a group of international researchers with different backgrounds. It is a good way to garner different perspectives on how to approach the problems.
5. Hiring INOREans means hiring very well connected people within an international and multidisciplinary network.

INORE serves as a forum for the international ORE community, both academia and industry, where collaboration and knowledge sharing are promoted with interesting and exciting events, through face to face meetings, and online.

What Makes INORE Unique

INORE is unique from other ORE groups, networks, conferences and events in that it is run by early stage researchers for early stage researchers. The INORE events are designed first and foremost to be friendly and fun. These informal yet professional events allow the attendees to openly discuss and share their research amongst their peer group rather than be hidden by the large shadows often cast by world-leading experts in attendance at other events. As attendees are in the early stages of their research and at similar career levels, there is no pressure and all are very keen to share information and very open to collaborate.

To think outside of the box, you have to get outside of the box; the INORE Symposia are traditionally held in relatively remote/reclusive venues in close quarters like hostels. The attendees live together for the week, and stronger bonds are formed than in typical conferences.

INORE facilitates networking opportunities across the entire ORE sector for researchers across disciplines and around the world. The connections made through INORE will be a valuable asset for these researchers as they progress as professionals. ORE is a very international and interdisciplinary field and as such no one party can typically have the required expertise across the whole spectrum of issues. However, through INORE it is possible to have established connections, and to collaborate across borders with other experts who have the diverse knowledge.

INORE's ethos promotes very strong bond between its members. Because it is fun yet professional, and run by early-stage researcher for early-stage researchers, INOREans are extremely dedicated and passionate about their organisation. This paper is a good example of what make INORE unique. It was written by five members of INORE, from five different countries on four continents (some not working in their home country), with different backgrounds, who volunteered their time and effort in order to tell the world about INORE.

5. Conclusion

Collaboration, in science and industry, and across borders is vital to the success of the ORE sector. However, the current state of collaboration could use some improvement. Fortunately, there are many ways in which collaboration can be helpful to actors in the industry, by: reducing start up barriers, reducing costs and risks, and maximizing innovation. INORE serves as a hub for international and multidisciplinary collaboration between researchers at early stages of their careers. INORE facilitates collaboration through a variety of activities, events, and programs as well as via its online presence. By instilling a positive attitude towards and experience with collaboration in the next generation of ORE professionals, INORE is advancing innovative research and is building a foundation for successful innovation in the ORE sector for years to come.

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