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Evaluation of LIST-ERIN

Report by the external peer review committee

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Executive summary

This report presents the results of the peer review of the Department of Environmental Research and Innovation (ERIN) of the Luxembourg Institute of Science and Technology (LIST). The review covers the period 2014-2017 (with a focus on the period after 2015 when LIST was formed in a merger) and considers scientific performance, relevance for society including client and partner interaction and the governance and organisation as requirement to sustain the ability and suitability for promoting both scientific performance and interaction with clients.

The review was performed by an independent external assessment committee, consisting of five internationally renowned researchers in the field of the research of the Department: Dr Marc Benoît (chair, France), Dr Johanna Berlin (Sweden), Prof. Minna Hakkarainen (Sweden), Prof. Gerik Scheuermann (Germany), Prof. Justin Sheffield (UK). Geert van der Veen and Katharina Warta (Technopolis Group) acted as support for the peer review committee.

The overall scientific performance of ERIN is considered good enough to be internationally visible. ERIN is to a limited degree internationally active, with the possibility to become a strong player on the international stage.

ERIN's research productivity is adequate, being about one publication per FTE position on average across the department, but should not decrease further. Over the period that bibliometric data could be analysed (2015) ERIN published on average in high impact journals with respect to its field and received about the same citations as expected for these journals. 16.7% of ERIN publications are considered to be in the highly cited group (while world average is 8-10%). Competitive research funding is an indicator for research quality, especially FP/H2020 funding from the EC. Although FP income more than doubled over the evaluation period, participation is still limited.

International research partnerships are diverse and well developed across the different units/groups. The overall mission and goals of LIST-ERIN are clearly stated and executed. The department lives up to its mission and goals as an RTO in practice. The research agenda shows the ambition to really help Luxembourg to sustain its natural resources, and allow for a sustainable economy. There are obvious benefits to Luxembourg and national companies, via industrial collaborative activities and agreements/inputs to national ministries, and several activities in the area of environmental policy support. It is possible to strengthen coherence of the research agenda, which may allow LIST-ERIN to go beyond the international visibility in some domains and reach an internationally leading position in some areas. There is however a tension between striving for international excellence (which requires focus and critical mass) and serving for all environmental questions for Luxembourg on a national level. To deal with this tension requires a well-designed strategy.

In general, the department has been successful in recruiting very good and competent people. The working conditions are attractive and competitive. There is an efficient infrastructure with very good instrumentation and personnel with expert knowledge who know how to use the instruments. Development, management and mentoring seem to work relatively well and there is possibility to get training on different aspects and/or take courses on complementary skills. PhD training seems to be taken care of in a proper way. The interaction between the various units at ERIN and the collaboration between the ERIN units and other departments could be improved.

The gender balance among senior research staff and management of LIST-ERIN is poor. There is clear need to analyse the reasons for this imbalance and to define a gender policy and take active measures to improve the situation through a more strategical position at department level.

Overall, the management at department and unit level works well. However, their efficiency is hindered by the intransparent budgeting and missing financial clarity.

The peer review committee has recommendations at two levels. At the level of LIST-ERIN the committee suggests to develop an overall departmental strategy to strengthen coherence and critical mass in certain

areas to go beyond the existing international visibility in some domains and reach an internationally leading position in one or two areas while maintaining the broad service role for Luxembourg.

To help develop the strategy, the committee recommends to install an advisory board at the level of LIST-ERIN. To increase the level of innovation it is recommended to continue to increase the quantity of applied research and to continue and increase the partnership work with industry and society. To be more attractive in recruiting talented staff that is rare on the market, it is suggested to offer (more) permanent positions in very competitive research areas.

At the level of LIST-ERIN, but also extending to the whole of LIST, it is recommended to define and implement an active strategy to improve the gender balance at all levels among the researchers and management. Furthermore, it is recommended to increase the interaction between units and departments by e.g. horizontal platforms, joint projects, informal networks or get-togethers and more seminars at the different LIST locations. This could also decrease the psychological distance between the various working locations within LIST.

At the level of LIST, the peer review committee suggests to design and implement a strategy to distribute the block grant in a more transparent way. The review committee also suggests to make the departments real business units, as well as taking care that the units also operate under clear financial conditions. This can be looked into further at the peer review of LIST at institute level.

Table of Contents

1	Introduction.....	1
1.1	Background.....	1
1.2	Composition of the Committee, independence, data provided and procedures followed.....	1
1.2.1	Composition of the Committee	1
1.2.2	Independence.....	2
1.2.3	Data provided to the Committee	2
1.2.4	Procedures followed by the Committee.....	2
2	The positioning of LIST-ERIN research	4
2.1	LIST-ERIN strategy and targets	4
2.2	LIST-ERIN clients and stakeholders.....	4
3	Assessment of LIST-ERIN	6
3.1	Research quality and contribution	6
3.1.1	Environmental sensing and Modelling (ENVISION)	7
3.1.2	Environmental and Industrial Biotechnologies (BIOTECH).....	8
3.1.3	Environmental Informatics (ENVINFO).....	8
3.1.4	Environmental Sustainability Assessment and Circularity (SUSTAIN)	9
3.1.5	Environmental Research and Technology Platform.....	9
3.2	Value for Luxembourg	10
3.3	Innovation quality and impacts	10
3.4	Management and governance	11
3.4.1	HRM	11
3.4.2	General working conditions and infrastructure	11
3.4.3	Governance and post-merger development	11
3.4.4	Management and organisation	11
4	Conclusions.....	13
5	Recommendations	14
	Appendix A Members of the Assessment Committee	15
	Appendix B Site visit programme.....	17

1 Introduction

1.1 Background

This report presents the results of the peer review of the Department of Environmental Research and Innovation (ERIN) of the Luxembourg Institute of Science and Technology (LIST).

LIST contributes to society by becoming a fully operational research and technology organization (RTO) anchored in Luxembourg, with a strong influence in Europe, positively impacting the country's socio-economic development through its oriented research and technological development activities. LIST undertakes research, development and innovation activities in order to promote the transfer of knowledge and technology and secure scientific and technological cooperation at national and international level. LIST's activities are positioned primarily at levels 3-7 of the technology readiness levels (TRL): experimental proof of concept, technology validation in laboratory, technology validation in relevant environment, demonstration in relevant environment and demonstration in operational environment.

The ambition of ERIN is to implement a smart green vision in an RTO context. The mission of the ERIN department is to deliver impact-driven research aimed at: (i) developing technologies, processes, IT-based tools, and solutions, and (ii) providing science-based policy support to:

- monitor, analyse, manage, and sustainably use natural resources (water, renewable energy, bioresources)
- reduce the environmental footprint of human consumption and production activities and enhance resilience against natural and non-natural risks

The peer review is part of an evaluation of the three research institutes under the responsibility of the Luxembourg Ministry of Higher Education and Research (MESR). The evaluations cover the period 2014-2017 (with for LIST a focus on the period after the merger to form LIST, so 2015-2017) and take into account scientific performance, relevance for society including client and partner interaction and the governance and organisation as requirement to sustain the ability and suitability for promoting both scientific performance and interaction with clients. The evaluation has been assigned to Technopolis Group (www.technopolis-group.com).

The results of this peer review feed into the evaluation of LIST as an institute and into the evaluation of the three institutes at national level. For this reason, the chairman of the LIST-ERIN peer review also participates in the peer review of LIST at institutional level. The results are intended for MESR to (re)define their relation to the institute; for the institutes to help them to improve their performance further and for other (mainly public) stakeholders to use as they find suitable.

The peer review set-up has been designed by Technopolis Group, based on the Terms of Reference from MESR. It aligns with good practices used in many evaluations.

1.2 Composition of the Committee, independence, data provided and procedures followed

1.2.1 Composition of the Committee

The audit was performed by an independent external assessment committee, consisting of five internationally renowned researchers in the field of the research of the Department:

- Chairman: Dr. Marc Benoît; senior scientist, environmental agronomy; INRA, France.
- Dr. Johanna Berlin, Manager Corporate Strategic Initiatives at RISE Research Institute of Sweden.
- Minna Hakkarainen, Full Professor in Polymer Technology at KTH Royal Institute of Technology, Sweden.
- Gerik Scheuermann, Full Professor of Computer Science and expert on Visual Analytics, Data Analysis, and Big Data at Leipzig University, Germany.
- Justin Sheffield, Full Professor of Hydrology and Remote Sensing at the University of Southampton, UK.

Short CV's from all assessment committee members are attached in Appendix A.

Geert van der Veen and Katharina Warta (Technopolis Group) acted as support for the peer review committee.

1.2.2 *Independence*

Any existing personal or professional relationships between committee members and programmes under review were reported and discussed in the committee meeting to safeguard an independent assessment of the quality of LIST-ERIN and its research programmes in an unbiased and independent way. The Committee concluded that there were no close relations or dependencies and that there was no risk in terms of bias or undue influence.

1.2.3 *Data provided to the Committee*

In preparation of the review the peers received the following information:

- A self-assessment report of LIST at institute level
- A self-assessment report of LIST-ERIN at department level
- A background report for the peer review of LIST prepared by Technopolis Group, including an analysis of the participation of LIST in FNR and EC research projects and a bibliometric analysis of the publications of LIST (by ECOOM).

The assessment in combination with the discussions of the peer review committee with the research leaders, researchers and stakeholders allowed an objective evaluation of LIST-ERIN.

1.2.4 *Procedures followed by the Committee*

The final assessments are based on the documentation provided by the Institute and the site visit to LIST-ERIN in Luxembourg on 13-14 September 2018 (programme in Appendix B).

At the beginning of the site visit, the Committee was briefed by Robert Kerger of MESR and Geert van der Veen and Katharina Warta of Technopolis Group about the objectives of the evaluation in general and of the evaluation by the committee in particular. During this meeting, several questions were clarified. The Committee also agreed upon procedural matters and aspects of the assessment.

At the end of the site visit and interviews the Committee discussed the conclusions and recommendations. Draft conclusions were presented to the participants in the discussions including the management of ERIN and LIST and representatives of the Ministry of Research.

A first version of this report was drafted by the peers in the week after the site visit to Luxembourg. The report was finalised through email exchanges. The final version was presented to the Institute mid-October 2018. The reaction of LIST-ERIN was discussed by email by the Committee and led to adjustments of some factual points. The final report was then submitted to MESR.

Although direct comparison of LIST-ERIN with other institutes in Europe is difficult, since the mission and environment of various institutes can be very different, the quality of the research and innovations of LIST-ERIN was compared by the peer reviewers in a qualitative way with international state of the art. Publication and citation records were examined, major achievements were considered and the capacity to attract highly qualified students and collaborators was discussed. For obtaining a view of the relevance for science, elements such as recognition as a knowledge centre, participation in expert groups, editorial boards and professional societies were used.

The relevance of LIST-ERIN in relation to environmental research was judged at the international and local level. Services and expertise rendered to private and public clients and partners and the impact on the general public served to assess the relevance for society.

The aspects of governance and organisation of LIST-ERIN were mainly based on the discussion about the strategy with LIST-ERIN staff members. The findings are presented in this report. The findings related to the departmental organisation show adequate robustness, since they have been discussed with the most relevant stakeholders. The findings related to the positioning of the department within LIST and the positioning of LIST in the research and education landscape in Luxembourg and in international perspective give the reflection of the peers on the vision of LIST-ERIN but require further input from

other stakeholders inside and outside LIST. Therefore, these findings are preliminary and will feed into the evaluation of LIST at institute level.

2 The positioning of LIST-ERIN research

2.1 LIST-ERIN strategy and targets

As stated in the introduction, LIST-ERIN has selected the mission to deliver impact-driven research aimed at: (i) developing technologies, processes, IT-based tools, and solutions, and (ii) providing science-based policy support to monitor, analyse, manage, and sustainably use natural resources (water, renewable energy, bioresources), in order to reduce the environmental footprint of human consumption and production activities and enhance resilience against natural and non-natural risks.

This is clearly in line with the expectation of society (i.e. government, non-government organizations and citizens) of an RTO department focusing on environmental research and innovation. Furthermore, it became clear in the discussions with (a limited number of) stakeholders from industry that it also fulfils their expectations.

Overall, the mission is clearly stated and executed. Focus in research is on water resources management, environmental biotechnologies, computational life cycle assessment and visual analytics of environmental data.

Besides this focus, the department, as the only RTO in the sector in Luxembourg, serves the role of looking into other environmental and agricultural questions on request by Ministries, e.g. air pollution, crop protection. Therefore, the department has (and accepts) the double challenge of striving for international level competence while also serving as the only Luxembourgish research institution on environmental questions. The latter requires obviously a broad agenda without the means to reach international level in all areas.

The department lives up to the mission and goals in practice. There are areas as mentioned above which can be roughly attributed to its four units. However, the appearance of these areas looks like a bottom up development without a clear overall thematic strategy. This can be understood if one takes the history of the ERIN and LIST, especially the merger, into account, but the committee suggests to develop a more explicit strategy to strengthen coherence. This might carry the consequence that resources are too limited to reach international top quality in several areas, so there may be the need for a clearer focus. One possibility might be to focus stronger on interdisciplinarity and to take the ENVINFO unit as role model. This may allow integration of the strengths of all parts into a coherent and very competitive department.

The mid-term plans foresee a continuation of the current path, with more acquisition of European and national funding, and moving the centre of gravity up the TRL-ladder. This is a valid plan, which sounds realistic when looking at the current state.

The department is well connected to other research institutes, companies and public institutions in Luxembourg and the greater region around Luxembourg.

2.2 LIST-ERIN clients and stakeholders

The long experience in interdisciplinary research is a good basis for co-production of innovative thinking by LIST-ERIN with strategic clients and stakeholders. There is (a useful) tension between two categories of end users: public authorities focusing on public common services (water quality, air quality, ...) and private clients focusing on innovation.

The relationships with the Luxembourg public authorities are focused on the area of water and agriculture, and are strong, have a long legacy, with a high level of confidence between LIST-ERIN and the authorities. Working on quantitative and qualitative aspects of the water cycle for decades, and more recently on air pollution (small to very small particles due to diesel emissions), LIST-ERIN provides a high quality level of results.

The client companies of LIST-ERIN located in Luxembourg are partly old clients from Tudor and Lippmann, and partly new clients from after the start of LIST. The clients that were present at the peer review were very positive about their partnerships with LIST-ERIN and open for new cooperation in the future.

Opportunities for further growth might come from a more open strategy to new clients located in the European countries around Luxembourg: Germany, France, Belgium, Netherlands.

3 Assessment of LIST-ERIN

3.1 Research quality and contribution

LIST-ERIN provides a broad range of research activities spread across the four research units and the common Environmental Research and Technology Platform.

The overall scientific performance of ERIN is considered good enough to be internationally visible. ERIN is to a limited degree internationally active, with the possibility to become a strong player on the international stage.

The research agenda shows the ambition to really help Luxembourg to keep its natural resources, and allow for a sustainable economy. The research agenda is clearly unique in Luxembourg, while there are similar institutions with similar roles and strategies in most other European or developed countries around the globe.

Some of the individual units are stronger in their research activities than others, but this is a function of the disciplines represented, with some units and groups further down the transition to the new centre of gravity at TRL 3-7, and therefore focused more on applied research and innovation, rather than fundamental research and its associated outputs.

In the eyes of the peers, 3 out of the 4 ERIN units have international visibility. 84% of ERIN publications has international co-authors. This suggests that there is potential to become strongly internationally competitive, given investment in personnel and resources in some research disciplines. To strengthen the ERIN role in international competition, the review committee suggests to create a more streamlined overall department strategy with the goal to reach an internationally leading role in one or two areas. One potential avenue is to draw from the multi-disciplinary expertise across the ERIN department, to develop internationally recognised or potentially world leading interdisciplinary research capability. This may also require strengthening/expanding collaborations with social-economic research groups, for example, and/or developing in-house expertise in specific disciplines such as decision making.

ERIN's research productivity is adequate. In the years 2015-2017 the publication intensity was approximately 1.3 per researcher FTE, above the target of 1.0 from the LIST Performance agreement. The number of publications per researcher is however reducing over time. This is caused by the larger attention for application and higher TRL research. However, this has also resulted in not achieving the target for the number of publications in ISI/Scopus in 2017 (0.78 per researcher FTE, target was 0.90), while this target was easily achieved in 2015 and 2016. The number of publications with an impact factor of >2 also dropped sharply (37%) in 2017 (but still seems above target, since it represents approximately 50% of the total LIST target; however a specified ERIN target is not known to the peers).

Since LIST was only formed out of Lippmann and Tudor in 2015, and since a citation needs to be based on a three-year citation period, the citation analysis made for this evaluation is only covering the first years of ERIN. Over this period ERIN published on average in high impact journals with respect to its field and received about the same citations as expected for these journals. 16.7% of ERIN publications are considered to be in the highly cited group (while world average is 8-10%)¹.

Beyond peer-reviewed publications, ERIN appears to have good collaborative activities, via visitors, conference hosting/organization, and committee/editorial board membership, which facilitates collaborations, visibility and standing.

To increase research standing and visibility further, ERIN should not decrease the number of publications per researcher further and focus on increasing quality further.

Competitive research funding is an indicator for research quality, especially FP/H2020 funding from the EC. Over the period 2015-2017 ERIN received MC1.858 FP/H2020 funding, which is, although it more than doubled over the evaluation period, still a limited participation.

¹ Citation analysis performed for this evaluation: Bibliometric screening of Luxembourg Institute of Science and Technology, ECOOM, Leuven, 2018

The FNR competitive funding remained stable over the period (at approx. M€4 per year). The competition for this funding is however far more limited than for the EC funding.

A general increase in research funding from the EC and FNR, should provide more opportunities to publish research outputs. Focusing on the existing interdisciplinary strengths of the department is another aspect that could improve the quality and visibility of the research.

By its nature, the research work is focused on societal problems with regard to the environment, and this appears to be increasing in practical terms since the merger. There are obvious benefits to Luxembourg and national companies, via industrial collaborative activities and agreements/inputs to national ministries, and several activities in the area of environmental policy support, with presumably trickle down benefits to society. There is of course some tension between research and innovation on technologies that may improve industrial productivity but with trade-offs on environmental impacts.

From the discussions with staff, ERIN/LIST also appears to be a source of highly trained scientists (PhDs and postdocs) to national companies and public institutions.

International research partnerships are diverse and well developed across the different units/groups. The continued investment in the water/climate national monitoring networks is advantageous to facilitate research and attract international research collaborations, as shown by the virtual joint research group on “Catchments as organised systems”.

3.1.1 *Environmental sensing and Modelling (ENVISION)*

The ENVISION unit is comprised of three groups (Catchment and Ecohydrology; Remote Sensing and Natural Resources Modelling; Agro-Environmental Systems), which have quite different scope and legacy, including their TRL level focus and therefore their impact on companies and policies.

The unit has 21 research staff and 16 PhDs (mainly in the Doctoral Training Unit in hydrological sciences).

The catchment group has excellent fieldwork/monitoring infrastructure and capabilities that are comparable or exceed capabilities in other international groups, and enable a range of activities including process understanding, scaling of processes and applications. This capability appears to have enabled international collaboration in catchment processes and understanding, which is internationally recognised. There appear to be good collaborations with the Luxembourg water agency and agricultural administration with good responsiveness to partner needs. This group has potential to be world leading with some aspects of its work (e.g. use of diatoms as hydrological tracers, isotope hydrology) and there may be potential to enhance this with investment. The large number of PhDs (14) in the Doctoral Training Unit really can boost the scientific position of the group. The primary focus on the Luxembourg perspective is good to see.

The remote sensing group is global in its scope, and is internationally visible in some areas, such as flood monitoring. They have innovated well in this area so far with good collaborations and impact via ESA. The agro-environmental systems group, which was only recently established, is still in its development phase and currently has an approach focused on national problems at a higher TRL level, but with potential to have broader impact internationally. In this respect, there appeared to be emerging synergies across groups in terms of bringing together disciplinary approaches (hydrological modelling, remote sensing, environmental analysis) applied to national agro-environmental problems. This unit has the potential to be internationally leading in some areas, such as flood monitoring, but this requires further innovation and conversion to high-impact research outputs. The scope to partner with commercial partners is clear, but this could be explored further: There is collaboration with insurance/reinsurance companies interested in natural hazard risk management, but the income from these sources is low and there should be opportunities to expand research collaboration.

Although collaboration among groups is well established for example through the hydrology doctoral program which covers agricultural and remote sensing aspects of water-environment problems, the synergies across groups could be explored further to see how each group can enhance the work of the other, with potential for expanding international standing.

The unit published 32 publications/year (comparable to most other units in ERIN) and filed 2 patents. Bibliometric analysis at unit level was not performed.

ENVISION was involved in 14 FNR projects, 2 EC projects, 5 ESA projects and 15 collaborative projects. Figures on the income distribution per unit have not been made available to the peer reviewers.

3.1.2 *Environmental and Industrial Biotechnologies (BIOTECH)*

The BIOTECH unit focuses on three main challenges with a focus on the middle range of TRL:

- Bio-based production of high-value chemicals and enzymes from plant cells and microbes.
- Valorisation of end-of-use plant biomass and other waste streams from agri-food supply chains as a source for bioenergy, biopolymers and chemical building blocks for innovative and commercially interesting applications.
- Development of new technologies for environmental monitoring and pollution remediation using biotechnologies.

The unit has 26 research staff and 8 PhDs.

The impact on clients (i.e. PM International (LU), Biogas Vereeniging a.s.b.l. (LU)) is strong and recognised by them. The recent option to innovate on microbial functioning of bio-gas plants may create new business opportunities (both as analytical service provider and R&D) in related fields, eg in agriculture (measuring the impact of (bio)fertilisers in the soil microbiome: services to ASTA) and other areas related environmental biotechnology involving microbial ecology topics and may help in finding new clients for the BIOTECH unit.

The networking through universities is at a satisfying level (with e.g. Université Catholique de Louvain (BE), Université de Lorraine - ENSAIA - Nancy (FR), University of Luxembourg - LCSB (LU)).

BIOTECH is a powerful unit with a central role for ERIN and LIST as a whole because of its strong knowledge and competencies on biology and biotechnology.

The unit published 60 publications/year (double of the other units in ERIN) and filed 14 patents (out of 18 for whole ERIN). BIOTECH was involved in 23 FNR projects, 4 EC projects and 6 collaborative projects.

Having a number of smaller topics with Luxembourg clients is a sensible strategy, but will not be enough to make BIOTECH internationally leading. Expanding research into larger scale pilot plants is sensible in relation to client demands, but this requires large investments and there are already quite some other pilot plants available in Europe (e.g. in Ghent (BE), Delft (NL) and Pomacle (near Reims, FR)). A good niche for BIOTECH (also from a scientific perspective) could be in watery waste streams, fermentation and selected downstream processing.

3.1.3 *Environmental Informatics (ENVINFO)*

The ENVINFO unit defines its mission as “to design, implement, and evaluate innovative IT methods and tools that contribute to a more sustainable future.” The unit focuses on four research and development lines: visualization, augmented & virtual reality, artificial intelligence and geo-computation. The main strategy is to do interdisciplinary work with other units of the department and beyond, where ENVINFO performs the data analysis and visualization part in numerous projects. All projects focus on environmental applications, so from a scientific point of view, there is a clear focus. The research reaches from TRL level 3 to 7, with a clear focus on 3-6: basic research and applied basic research play a minor role in the activities of the unit. The real strength of the unit is the use of technology for experimental proofs of concept and technology validation in the laboratory i.e. software prototype or VR/AR equipment, and demonstration in relevant environments. The publication rate is 1,3 publication/year/member of this unit (28,5 publications/y in total, comparable to most other ERIN units). At present ENVINFO is involved in 5 European projects. They are also involved in 11 national (FNR) projects, 3 ESA projects and 8 collaborative projects. Furthermore, there are direct contracts with companies for software adaptation and implementation of prototypes developed at the unit.

The unit employs 18 researchers and 4 PhDs.

ENVINFO published 26 publications/year (comparable to most other units in ERIN) and filed no patents (this is related to the subject they mainly work in).

Focus of activities is obviously on obtaining funding, creating collaboration and “helping” the other units with their research problems. Writing articles had lower priority. Considering the lack of personnel and difficulty in recruiting this is understandable. However, this could be a harmful strategy in the longer run, because research publications are often an evaluation point for funding applications.

3.1.4 *Environmental Sustainability Assessment and Circularity (SUSTAIN)*

The mission of the SUSTAIN unit is “To foster the transition towards a more circular economy and a more sustainable society by providing industry and policy makers with transdisciplinary, science-based quantification of the impact and risks of production and consumption patterns”. Their research questions are related to both societal as well as industrial challenges. To be able to reach their mission an inclusive way of working is needed as their mission is to change behaviour of people, industry and society. To be able to fulfil this, the involved actors need to be part of both the question and the solution.

SUSTAIN is working in four group activity domains: Life Cycle Sustainability Assessment (LCSA), Environmental Health (EH), Environmental Policies (EPS) and Sustainable Energy Systems (SES). This is a good setup for working with the mission of the unit: LCSA has the responsibility for the quantification of today’s and future sustainability impact; EH concentrates on the health aspects within sustainability; SES on the energy aspects which includes societal as well as industrial challenges. While EPS works at realising transitions through policymaking. An even better set up of the unit will be achieved when the planned future competence in environmental economics will be in place. This will increase the unit’s ability to also stimulate a change in consumption patterns.

SUSTAIN has 21 research staff and 3 PhDs.

SUSTAIN’s project portfolio includes activities at TRL level 3 to 7 with a focus on the upper part of this.

SUSTAIN published 28,5 publications/year (comparable to most other units in ERIN) and filed 2 patents. SUSTAIN has 8 collaborative projects.

A suggestion is to work more with the financial sector in order to support them in meeting the demands of their stakeholders to be more active in contributing to a more sustainable society.

Finally SUSTAIN seems to have a great impact on policies through assessing the consequences of new policies and though their regulatory expertise (e.g. SUSTAIN has the responsibility for the REACH and CLP national helpdesk).

3.1.5 *Environmental Research and Technology Platform*

The laboratories, facilities and instrumentation of ERIN are organised as an independent Research and Technology Platform. The facilities include state-of-the-art analytical instrumentation, facilities for biological work from genomics, proteomics and metabolomics to bioinformatics, cell and plant facilities, toxicology and bioenergy as well as of field infrastructure – such as an observatory for climate and environment for monitoring e.g. hydroclimatology, air quality, biodiversity and remote sensing. Quite substantial investments were made during 2015-2017 on new instrumentation and facilities. The facilities are from very good to excellent quality.

There seems to be a good process for acquiring new instrumentation, which includes both purchasing commercial products but also some own development work for e.g. field sampling.

The management of the laboratories and infrastructure is very well organised with clear routines through which training and access to instruments and laboratories is obtained. Safety is prioritised, and clear safety routines are in place. The instrumentation is available for all employees and projects through established routines. Balance is however needed between laboratory safety and bureaucracy in order not to make access to laboratories and instrument-time too time consuming.

The Environmental Research and Technology Platform is crucial for all ERIN research units. It is a prerequisite for the continuation of the large amount of work performed and the good results ERIN is

demonstrating. In addition, the Environmental Research and Technology Platform makes state-of-the-art monitoring, analytical, computational and modelling resources accessible to industry and public stakeholders. Access to this significant infrastructure should also be a very valuable selling point for attracting new business and customers.

3.2 Value for Luxembourg

Collaborative research and contract research are indicators for the societal relevance of the research. For ERIN the total public collaborative funding increased to M€2.1, mainly because an increase in public utility missions and an increase in ESA funding (to k€367 in 2017).

Contract research is still predominantly for the public sector in Luxembourg (approx. M€ 1 /year).

LIST-ERIN is the main and single actor of environmental research in Luxembourg. Holding this position constitutes a great responsibility to serve the Luxembourg government and the Luxembourg society with knowledge in this area. This requires good quality of expertise over a broad area which the institute has proven to possess. However, there is a tension between the broad knowledge needs from society and the need for focus and critical mass to achieve international excellence in research. ERIN has proven to be able to combine both roles in the field of water, where the daily measurements for the Luxembourg government and other public partners have been used as input for valuable research.

The amount of collaborative income from industry at ERIN is worth k€367 in 2017 which is very limited for a department the size of ERIN although it increased from k€89 in 2015. Contract research & services income is also very limited (284 k€ in 2017).

There are some impacts of this however. For example, PM-International has chosen to have its own laboratory including equipment within the LIST-ERIN laboratory because of the added value they see in LIST-ERIN.

The cooperation between LIST-ERIN and the University of Luxembourg is good, although not very intensive because the University is not performing research in most areas ERIN is active in. However, researchers from LIST-ERIN act as teachers at the University of Luxembourg in these areas, which is a valuable contribution.

Besides the value for customers and partners, Luxembourg LIST-ERIN provides value to Luxembourg as well by attracting highly educated people from all over the world. PhD students employed at LIST-ERIN are affiliated to a number of different universities with supervision both from the institute and the universities.

3.3 Innovation quality and impacts

As has been described above, all units at LIST-ERIN contribute to industrial and societal innovation. The tension between the broad knowledge needed for supporting society and the smaller focus needed to achieve excellence has also been discussed.

Overall, LIST-ERIN has a high contribution of knowledge to policymaking, especially at the unit of SUSTAIN. The other units also provide input to policymaking for example with measurements of emissions and environmental impacts in the unit ENVISION.

The position of LIST-ERIN as the only institute in the small country of Luxembourg poses unique challenges but also offers opportunities. A comparison with other institutes in Europe is difficult, since the mission and environment can be very different. Notwithstanding the difficulties to compare, many other institutes show more focus and a higher level of research in cooperation with industry and society, and tend to have a higher innovation performance.

This would suggest for LIST-ERIN to increase the quantity of applied research and to increase the partnership work with industry and society and other RTO's. Because of the limited size of the market in Luxembourg, a more international view of LIST-ERIN is suggested.

The LIST-ERIN network is well developed at national level and quite well aligned with the main research topics. The international network seems to be built through successive opportunities (contract driven). This strategy was, in the eyes of the peer review committee, very useful after the merger and allowed the new units to build their own competences. In order to make the next step, and for LIST-ERIN to become

an international player with a high quality international network, LIST-ERIN must focus on some main topics and clients/societal users (main clients/companies in Europe and some main public authorities in the “Grande Région”).

3.4 Management and governance

3.4.1 HRM

In general, the department has been successful in recruiting very good and competent people. For some research units, scarcity of staff with the right competences and high international competition make it more difficult to recruit new people. Development, management and mentoring seem to work relatively well and there is possibility to get training on different aspects and/or take courses on complementary skills.

PhD training seems to be taken care of in a proper way. A PhD student network has been established. PhD students at LIST-ERIN identify the benefits of having at least two supervisors (one from ERIN and one from University) and of exposure to different environments (university, institute and industries). They however consider the limited options to teach a disadvantage for their academic career. The soft skills courses at the University of Luxembourg (also accessible for those PhDs graduating at other universities) are well appreciated.

The interaction between the various groups at ERIN and the collaboration between the ERIN units and other departments could be improved. The Environmental informatics groups can be seen as an example, utilizing its competence to connect, collaborate and help the other units.

The gender balance of the LIST-ERIN is poor. Although at PhD level and in the technical expertise line the balance is fair (45% female), all research managers (department head, research unit heads, group leaders and Lead R&T associates: all in all 28 persons) are male. Only the Environmental Research and Technology Platform has a female leader. There is a clear need to analyse the reasons for this imbalance and to define a gender policy and take active measures to improve the situation.

3.4.2 General working conditions and infrastructure

The working conditions are attractive and competitive.

The high level of financing from the block grant (which in the opinion of many staff the peers spoke contributes to relatively low work pressure) is well appreciated. There is a good infrastructure with very good instrumentation and personnel with expert knowledge who know how to use the instruments. The facilities are very well managed. Although instruments are available to all research projects, the time and bureaucracy to get access to instrument time could, according to quite a number of researchers be reduced to be more effective, although this should not lead to reduced quality, traceability and security.

The organisational and the physical environment seems to fulfil its purpose. However, it was pointed out that there was not enough office space.

LIST is situated at three sites within Luxembourg. It was pointed out that the cultural distance between the sites seemed to be further away than the distance in meters. This could be overcome with an increase in cooperation projects within LIST.

3.4.3 Governance and post-merger development

The merger had negative effects over the past years, but these seem to have been mostly overcome. The current units appear to be an efficient solution to deal with the past of the two previous RTOs. The next step is to build more strategic governance at department level.

3.4.4 Management and organisation

The department is organised in four research units (each 20-30 researchers with 3-16 PhDs), Each unit has 2-4 research groups. The research groups within each unit cooperate quite closely and see themselves as integral part of the units. This works fine.

The department and unit level management works well. The units seem to make good use of their autonomy and define useful strategies. As mentioned before, the department might look into a somewhat more coherent overall strategy.

There seems to be no dissatisfaction about the level of financing of the units.

Most external income of ERIN is from public collaborative contracts and from FNR contracts. Although external income from ESA and EC increased sharply and in 2017 k€367 collaborative income from industry was achieved, ERIN does not achieve the target of 40% external (non-block grant) income: The institutional funding (block grant) stands for about 60-65% of the overall funding of the department.

From the SAR, the interviews, and additional provided material, it became unclear to the review committee how this substantial amount of money is actually used. It is clear that this funding allows to cover potential losses from subsidies lower than the actual costs, employing permanent staff that is not sufficiently productive, use of buildings, laboratory equipment, and administration costs.

According to the interviews, the use of the block grant is not understood by the unit and group leaders either. Consequently, the units have no control over the budget, and cannot decide about hiring additional workforce based on the grants and other income they receive. They have to ask the department, and the department has to ask the institute highest management. This complex process is really hampering growth and seems to have a negative impact on the motivation of the unit managers. This should be looked at in more detail at the institute level evaluation.

This departmental review committee suggests to make the departments real business units, and allow even the units to operate under clear financial conditions. This will create a higher motivation to acquire additional funding and a more thoughtful and strategic use of the institutional funding.

Furthermore, the review committee was surprised to find that subsidised and collaborative projects cover only part of the overall costs. This means that any success in acquiring additional funding creates an additional demand on the block grant which substantially limits the possibility to grow. Therefore, the review committee of this department suggests to have a careful look at the cost structure at LIST level.

4 Conclusions

LIST-ERIN provides a broad range of research activities spread across four research units and a common Environmental Research and Technology Platform.

The overall scientific performance of ERIN is considered good enough to be internationally visible. ERIN is to a limited degree internationally active, with the possibility to become a strong player on the international stage. The research agenda is clearly unique in Luxembourg, while there are similar institutions with similar roles and strategies in most other European or developed countries around the globe.

ERIN's research productivity is adequate, being about one publication per FTE position on average across the department, but should not decrease further.

Over the period that bibliometric data could be analysed (2015) ERIN published on average in high impact journals with respect to its field and received about the same citations as expected for these journals. 16.7% of ERIN publications are considered to be in the highly cited group (while world average is 8-10%).

Competitive research funding is an indicator for research quality, especially FP/H2020 funding from the EC. Although FP income more than doubled over the evaluation period, participation is still limited.

International research partnerships are diverse and well developed across the different units/groups as documented through the high rate of publications with international co-authors, the success in European projects, the presence of ERIN staff in international committees.

The overall mission and goals of LIST-ERIN are clearly stated and executed. The department lives up to its mission and goals as an RTO in practice. The thematic and spatial scope of the department fits well, and is adequate to future environmental challenges. The research agenda is clearly unique in Luxembourg while there are similar institutions with similar roles and strategies in most other European or developed countries around the globe. There are obvious benefits to Luxembourg and national companies, via industrial collaborative activities and agreements/inputs to national ministries, and several activities in the area of environmental policy support.

The research agenda shows the ambition to really help Luxembourg to sustain its natural resources, and allow for a sustainable economy. It is possible to strengthen coherence of the research agenda, which may allow LIST-ERIN to reach an internationally leading position in some areas. There is however a tension between striving for international excellence (which requires focus and critical mass) and serving for all environmental questions for Luxembourg on a national level. To deal with this tension requires a well-designed strategy.

In general, the department has been successful in recruiting very good and competent people. The working conditions are attractive and competitive. There is a good infrastructure with very good instrumentation and personnel with expert knowledge who know how to use the instruments. Development, management and mentoring seem to work relatively well and there is possibility to get training on different aspects and/or take courses on complementary skills. PhD training seems to be taken care of in a proper way. The interaction between the various groups at ERIN and the collaboration between the ERIN units and other departments could be improved.

The gender balance among senior research staff and management of LIST-ERIN is poor. There is clear need to analyse the reasons for this imbalance and to define a gender policy and take active measures to improve the situation through a more strategic position at department level.

Overall, the management at department and unit level works well. However, their efficiency is hindered by the intransparent budgeting and missing financial clarity. The way the block grant is distributed should be looked at in more detail at the institute level evaluation.

5 Recommendations

The peer review committee has recommendations at two levels.

At the level of LIST-ERIN the committee suggests to develop an overall departmental strategy to strengthen coherence and critical mass in certain areas to reach an internationally leading position in one or two areas while maintaining the broad service role for Luxembourg.

There is potential for some units/groups to become world leading in their research discipline. One potential avenue is to draw from the multi-disciplinary expertise across the ERIN department, to develop internationally recognised or potentially world leading interdisciplinary research capability. To increase the external revenues needed to achieve this, we suggest to choose, at the department level, a few main partners at European level and to develop long term strong linkages with them.

To help develop the strategy, the committee recommends to install an advisory board at the level of LIST-ERIN, composed of internationally renowned scientists and relevant national and international stakeholders dedicated to the identification of societal needs (and public authorities supporting them), and market needs (and clients wanting them).

To increase the level of innovation it is recommended to continue to increase the quantity of applied research and to continue and increase the partnership work with industry and society. Continuing and strengthening the solution oriented approach leading to customer oriented tailor made solutions is suggested.

To be more attractive in recruiting talented staff that is rare on the market, it is suggested to offer (more) permanent positions in very competitive research areas. The present targeted distribution between permanent and temporary staff seems rather artificial.

At the level of LIST-ERIN, but also extending to the whole of LIST, it is recommended to define and implement an active strategy to improve the gender balance at all levels among the researchers and management. Lots of work has been done internationally on identifying possible actions: actively approaching potential (female) applicants from outside LIST, making sure the evaluation of applicants is gender neutral, actively identify and support promising existing female staff by for example leadership or management training, etc. Also an internal LIST female network could have high value. As the number of female research staff is low and on research management level basically non-existent, the female network could have important influence on supporting and connecting the female researchers to improve their work comfort and confidence.

Furthermore it is recommended to increase the interaction between units and departments by e.g. horizontal platforms, joint projects, informal networks or get-togethers and more seminars at the different LIST locations (e.g. PhD students presenting their research, presentations of new projects, public lectures etc.). This could also decrease the psychological distance between the various working locations within LIST.

At the level of LIST, the peer review committee suggests to design and implement a strategy to distribute the block grant in a more transparent way. The review committee also suggests to make the departments real business units, as well as taking care that also the units operate under clear financial conditions. This can be looked in further at the peer review of LIST at institute level.

Appendix A Members of the Assessment Committee



Agr. Ing. and Dr from Institut National Agronomique Paris-Grignon (France), Dr **Marc Benoit** is senior scientist in INRA (French institute of agricultural researches) in SAD department (Science for Action and Development). In this multidisciplinary department, he is in charge of co-management of the agronomists (42 researchers). After a Ph.D. on land management by farmers, his research activities are focusing on landscape agronomy and water quality protection at watershed level. He has focused his research activity on land use dynamics, and more specifically on spatial organisation of land changes in mixed and agricultural landscape. He is co-manager of an interdisciplinary research group (“E_LTSEr Moselle”) on the Moselle watershed (18 research teams) and working on the AGREV DT project (Agriculture For Water Protection on Vittel-Contrexeville watershed). He chaired the 3rd division of European Society for Agronomy “cropping system from farm to global scale” until august 2014 and is president of French Association for Agronomy. He is member of Scientific Council of Seine-Normandie watershed Committee and president of the Scientific Council of Rhine-Meuse watershed Committee. He authored or co-authored 69 peer-reviewed scientific publications and 91 communications in international conferences.



Dr **Gerik Scheuermann** is full professor for Image and Signal Processing at Leipzig University since 2004. He got a master's degree (Diplom) in Mathematics in 1995, and a doctoral degree in Computer Science in 1999, both from TU Kaiserslautern. He spent one year as doctoral student at ASU, AZ, USA, and one year as postdoc at UC Davis, CA, USA. His research interests concern visualization, visual analytics, computational topology, and Cliffordalgebra, with applications in fluid dynamics, structural mechanics, neuroscience, environmental sciences, bioinformatics, and digital humanities. He has published more than 250 reviewed articles on these subjects. Dr Scheuermann has been paper co-chair of all major visualization conferences (EuroVis 2008, IEEE SciVis 2011 & 2012, IEEE PacificVis 2015), organised several Dagstuhl seminars (Scientific Visualization 2014, Foundations of Data Visualization 2018) and conferences (TopoInVis 2007, AGACSE 2008, EuroVis 2013). He served as associate editor for all major visualization journals (IEEE TVCG 2008-2012, CGF since 2015, IEEE CG&A 2014-2018, The Visual Computer since 2010). He has served three years dean of study affairs, six years as vice-dean, and five years dean at the Faculty of Mathematics and Computer Science of Leipzig University.



Minna Hakkarainen is full professor in Polymer Technology at KTH Royal Institute of Technology in Sweden (2011-). She got MSc in Polymer Chemistry from University of Helsinki in 1992 and PhD in Polymer Technology from KTH in 1996. Her research interest is sustainable polymers including biobased, degradable and/or recyclable polymers. She published ~140 papers in international journals and has h-index 41. She is the Head of the Division of Polymer Technology (2012-). She has been Vice Head of Department of Fibre and Polymer Technology (2011-18), coordinator of master programme in Macromolecular Materials (2009-16) and Nordic joint master programme in Polymer Technology (2013-16), member of PhD programme committee (2011-2017), appointment committee (2008-15), vice-chair of recruitment committee for School of Chemical Sciences (2015-17) and member of KTH promotion committee (2015-18). She is one of 8 academic members presenting Swedish universities in Formas' Scientific Council (2016-18). She is/has been associate editor/editorial board member of several international journals. <https://www.kth.se/fpt/polymer-technology>



Dr Johanna Berlin holds the position as manager of corporate strategic initiatives at RISE Research Institute of Sweden since 2017. Former positions were head of Energy and Environmental Systems Analysis, Leader of the Systems Analysis Platform as well as Life Cycle Assessment (LCA) Research and Business Developer at SP Technical Research Institute of Sweden. She has also accomplished 13 years of research within environmental systems analysis of food at SIK –The Swedish Institute for Food and Biotechnology. Dr Berlin got a PhD in environmental systems analysis at Chalmers in Göteborg, Sweden in 2005, in 2002 a licentiate of engineering in environmental systems analysis, Chalmers and in 1996 Master of Science in Automation Engineering with specialization in Environmental Measurement Technique, Chalmers. Master thesis fulfilled at Imperial College of Science, Technology and Medicine,

London. Her professional skills fall into the category of environmental systems analysis i.e. life cycle assessment, environmental industrial production management and optimisation as well as sustainable industrial production. In depth knowledge of environmental improvement assessment of industrial production with specialisation of the actor perspective within LCA.



Justin Sheffield is Professor of Hydrology and Remote Sensing at the University of Southampton, UK. He spent 16 years at Princeton University in the US before returning to the UK in 2016, carrying out fundamental and applied research on large-scale hydrology and its interactions with climate variability and change. He has published extensively on hydrological extremes, climate change, and hydrological processes from catchment to global scale, and on the application of research to natural hazards impacts reduction, and water and food security particularly in developing regions, including monitoring and prediction systems. He has received a number of awards including the Prince Sultan Bin Abdulaziz International Prize for Water in 2014 for research work on drought monitoring

and prediction, and the Plinius Medal of the European Geosciences Union in 2013 for outstanding multi-disciplinary research and applications in hydrological hazards. Most recently he was named as the 2019 Robert E. Horton Lecturer in Hydrology by the American Meteorological Society for advancing hydrologically coherent analyses of drought across time and space scales, and for pioneering the development of integrated drought monitoring tools for food-insecure countries.

Appendix B Site visit programme

12 September 2018

Time	Programme	By
late afternoon	Arrival of peers in Luxembourg	
19:00 - 22:00	Get together of the panel (over dinner), inform peers about peer review goals and approach	peers, client, Technopolis (TP)

13 September 2018

Time	Programme	By
9:00- 11:15	Short introduction to the institute, the department (and critical self-assessment of the department); discussion	Fernand Reinig, Lucien Hoffmann, Pau Ferrer Alegre, Enrico Benetto, Jenny Renaut, Benoît Otjacques, Christina Ehlert
11.15 - 12.30	Tour around the department	Jenny Renaut, Lucien Hoffmann(+ presentors at each stop)
12:30 - 13:30	(Simple) Lunch	Lucien Hoffmann, Pau Ferrer Alegre, Enrico Benetto, Jenny Renaut, Benoît Otjacques
13:30 - 15.00	Presentation and discussion on ENVISION "Environmental Sensing and Modeling" : based on max 30 min short presentations	Lucien Hoffmann Laurent Pfister, Maria Rita Palattella, Nuria Martinez, Patrick Matgen, Carlos Lopez-Martinez
15.00 - 15.15	Tea/coffee	
15.15 - 16.45	Presentation and discussion on "Environmental and Industrial Technologies" : based on max 30 min short presentations	Pau Ferrer Alegre, Jean-Francois Hausman, Henry-Michel Cauchie, Leslie Ogorzaly, Magda Calusinska
16.45 - 17.00	Short break	
17:00 - 18:30	Presentation and discussion on ENVINFO "Environmental Informatics" : based on max 30 min short presentations	Benoît Otjacques, Mohammad Ghoniem, Ulrich Leopold, Rod Mc Call, Patrik Hitzelberger
18.30 - 19.00	Draft conclusion on the first day	Peers Only
20:00	Dinner	In Presence Of Department Management

14 September 2018

Time	Programme	By
08:30 - 10:00	Presentation and discussion on research SUSTAIN "Environmental Sustainability Assesment and Circularity" based on max 30 min short presentations	Enrico Benetto, Arno Gutleb, Arno Biwer, Ruth Moeller, Bendetto Rugani
10.00 - 10.15	Tea/Coffee	
10:15 – 11:00	Informal group meeting (with e.g. PhD students or trainees)	Valentin Ambroise (BIOTECH), Paul Baustert (SUSTAIN), Sukriti Bhattacharya (ENVINFO), Jasper Foets (BIOTECH), Oona Freudenthal (SUSTAIN), Mariem Jobrane (BIOTECH), And Ramona Pelich (ENVISION)
11:00 - 11.45	Time scheduled for meeting clients/partners of the department	Frank Petry (Goodyear), Carlo Spina (Contern SA), Christian Schroeder (Syndicat Des Eaux Du Barrage d'Esch-Sur-Sûre), Nico Pundel (Department Of Energy And Environment Of The City Of Luxembourg), Joachim Kiefer (Delphi Automotive Systems), Norbert Frey (Dupont De Nemours), Cécile Albini (Biorock), Markus Hermann (PM-

Time	Programme	By
		International)
11.45 - 12.15	Time reserved for clarification questions	Lucien Hoffmann, Pau Ferrer Alegre, Enrico Benetto, Jenny Renaut, Benoît Otjacques, Christina Ehlert
12:15 - 13:15	(simple) Lunch	
13:15 - 14:45	Time to draft preliminary conclusions	
14:45 - 15:00	Tea/coffee	
15.00 - 16.00	Presentation of preliminary conclusions and discussion on possible recommendations	Fernand Reinig, Lucien Hoffmann, Pau Ferrer Alegre, Enrico Benetto, Jenny Renaut, Benoît Otjacques, Christina Ehlert, Robert Kerger (MESR), Gaston Schmitt (MESR)
16.00	End of programme, transfer to train station/airport	

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