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1. Introduction

In 2012 the RAE (Research Assessment Exercise) was performed resulting in rich material about KTH’s research. One of the recommendations from the RAE was that Sustainable Development (SD) should be more strongly integrated into KTH’s research base and education programs.

This document sets out the main findings of a team of three advisors brought in by KTH to make more specific recommendations on how to develop and strengthen KTH’s research and doctoral-level teaching in sustainable development. The aim of this review was to produce valuable material for internal and external communication about KTH’s strengths in the area of Sustainable Development and to obtain recommendations for KTH’s future strategic work in this area. The team of advisors was asked to answer the following questions:

- In an international comparison, what are the strong areas of KTH’s sustainability research?
- Given the aim that KTH should be one of Europe’s leading technical universities broadly and also within the area of environmental and sustainability research, what areas should be strengthened?
- How can KTH-Sustainability’s project plan for the period 2013-2015 be further improved?
- What advice would the panel like to give to KTH management, and also to specific schools in order to strengthen KTH’s sustainability research? This advice could relate to strategy, organization, new positions, infrastructure etc.

2. Description of the process

The basis for the evaluation was the material produced within the RAE 2012. In addition, all units being assessed were invited to write a one-page update. The update included major changes that have occurred since the RAE-process in 2012 with relevance for sustainability research. This could include major organizational changes, new important recruitments (e.g. new professors), new major research projects, centers or other initiatives. The update also gave the units of assessment the opportunity to give their vision on future plans and aspirations for research in the area of sustainable development. The updates were written in the format of the appended template (Appendix 1).

Three reviewers/advisors (Appendix 2) assessed the RAE material from 2012 along with the updates and also conducted a round of interviews with 25 selected RAE units in groups of one to four from 15th to 17th April 2013. Each group had the possibility to meet with the three evaluators for 40 minutes, with the meeting divided into two parts: the first 25 minutes were with the coordinators and “key scientists”, after which a group of PhD students met with the reviewers for 15 minutes.

Subsequent sections of this report set out the observations and recommendations of the advisors.

3. Defining the concept of sustainable development

Sustainable development differs from more familiar research areas or the topics of KTH’s platforms in a number of key respects: it necessarily takes a long-term perspective; it is inherently a broad, trans-disciplinary agenda covering the aspects People, Planet and Profit. Therefore the lead times in developing research expertise in SD are long: sufficient time must be invested to understand different disciplinary perspectives to the point where transdisciplinary working can be productive. A
measure of success in transdisciplinary research is the ability to address questions which cannot be formulated within a single discipline.

The general definition of SD according to the Brundtland commission (1987) is perceived by researchers as being rather abstract and difficult to relate to their own work. To impose an interpretation which researchers cannot translate into their daily business is not the way forward; rather, an active and inclusive process is needed. For this reason, some of the recommendations focus on processes to enable researchers to interpret the concept of Sustainable Development and apply it to their research so as to contribute to developing the SD research agenda at KTH.

A further important aspect of SD is that it deals not only with understanding systems, processes and technologies but also with improving them. By understanding the interlinkages in systems, one is better able to identify which improvement measures could contribute most to SD and which do not merit so much attention. This analysis is important in selecting the research topics that should get priority.

4. Current situation
KTH has the potential of being a leader in the challenge of sustainable development but is presently performing below its potential. This is a missed opportunity. Research in SD is becoming increasingly important to tackle the major problems facing our society in the 21st century. This research is multidisciplinary and challenge-led. The budgets for SD research inside and outside Sweden are growing. Research budgets for disciplinary research will, of course, continue to be available, but a growing proportion of the money will go to challenge-led, multidisciplinary research. If KTH is not more pro-active in engaging with SD research, the institution risks losing out to others who aspire to take the lead in this type of research.

4.1 Strengths
KTH could potentially be at the forefront of SD research due to a number of strengths. First of all, the “Viking mentality” is strong: i.e. researchers are able to reach consensus and work together to jointly solve problems. Consensual leadership is engrained in the hearts and minds of the researchers. The collaborative ethos should mean that researchers at KTH are particularly adept at working in multidisciplinary teams on challenge led research.

Furthermore, the staff and students are generally very able and their research is excellent. In some areas people already successfully work together in multidisciplinary teams on SD research. Furthermore, enthusiasm to work on SD challenges is widespread, even among researchers whose work does not currently focus on SD topics.

Finally, KTH has an outstanding track record in working with industry.

4.2. Weaknesses
However, KTH also has some significant weaknesses. As regards the SD challenges, a major weakness is the widespread confusion which the advisors observed about what sustainability means: within the institution there is a mixed understanding of sustainable development and a shared vision on sustainability is lacking. This represents a major impediment to moving ahead. This is reinforced by the lack of skills in systems thinking: researchers cannot properly put their own work into a systems
perspective. As a result, many researchers lack insight into how their own research fits into the bigger systems perspective of SD.

Moreover, communication skills are lacking to represent the research, both within KTH and to the outside world, as contributing to the broad sustainability agenda. Therefore, opportunities are missed to reach out externally and communicate about the way in which KTH contributes to major SD challenges. Related to this, the team of reviewers saw very little evidence of a pro-active attitude among most researchers in building links with government and funding bodies, so that KTH is missing out on the possibility of influencing the research agenda of government and funding agencies.

A final weakness is the lack of incentives within KTH to engage in multidisciplinary research.

5. Observations

5.1 Organizational culture and structure
In order to embark on sustainability research, skills should be available to provide the basis for developing system thinking and hence deriving technological roadmaps leading to research projects.

At present these skills are not present across enough of KTH. The culture in many Departments favours research which remains within conventional academic disciplines. For instance, researchers are encouraged to concentrate on publishing in conventional mainstream journals in their own primary discipline with less appreciation of multidisciplinary research, even published in highly ranked journals. In addition, budgets are allocated to Departments, further reinforcing the predominance of disciplinary work. Core funding is based on historical reputation and status within the KTH organization, which reinforces the conventional distribution of budgets. Departments which came into existence recently, including Departments pursuing research in SD, find it difficult to flourish because they receive less funding than longer established Departments. This provides further pressure for staff to retreat back to conventional disciplinary research.

5.2 The PhD experience
Some of the students we met expressed their appreciation that they “enjoy being part of something bigger”. However, many students, including some of those who professed an interest in sustainability, showed a partial and, in some cases, distorted understanding of the concept. Even the idea that sustainability is a system concept with techno-economic, environmental and social aspects appeared to be unfamiliar to many students. As might be expected at an institution like KTH, the social aspects present particular problems. Some students working on research projects with obvious relevance to sustainability did not think in broad system terms and were unaware of the context within which their work lies, so that they had not even considered that their research might represent a contribution to sustainability.

KTH is to be complimented on offering modules for PhD students on “Sustainability Science” and systems thinking. However, the above observations show that this is not sufficient or sufficiently effective. Many students were unaware that these courses exist. This is an instance of a general feature, which detracts from the PhD experience at KTH: there appears to be no current listing of available courses. It was a frequent comment that students only find out that a course is to be offered a few weeks (sometimes only two weeks) before it actually starts. This makes it very difficult
for them to plan which modules to take. It is also raises questions over how well adapted the
courses are to helping PhD students to meet the sustainability challenge; as a specific but critical
example, some students who considered themselves to have a background in system thinking were
unaware of the concept of a “wicked problem”.

We saw signs that students find some difficulty in identifying students in other schools who are
working on projects with common aspects and challenges. Students are frequently left to
themselves to identify and find access to expertise needed for their research outside their home
department; some but by no means all do manage to do this.

5.3. Funding mechanisms
There are a number of funding problems to get challenge-led, multidisciplinary research in SD off the
ground.

First, PhD students sometimes start their research with finance guaranteed only for the first three
years; they need to mobilize additional funds for the remaining 1-2 years needed to finish their PhD.
There is an element of chance in whether this funding is secured and it is sometimes linked to short-
term research which may have a different focus from the original direction of the PhD. This can lead
to stressful situations for both the supervisor and the PhD student and reduce the productivity and
impact of a PhD.

Secondly, the structure of applying for research funds does not stimulate cooperation among
different research groups and hampers multidisciplinary research. There are no incentives built into
the system that encourage researchers to sit together and systematically review the sustainability
challenges they can tackle in multi-disciplinary teams. A phrase heard from many of the researchers
with whom we met was: ‘We don’t have time for that’ (i.e. open-ended multidisciplinary
discussions). As a result, KTH cannot be proactive in promoting and addressing the major
sustainability challenges on the broader political agenda, and misses opportunities to influence the
research agenda of Swedish funding agencies. Many of those interviewed also expressed the view
that: “Swedish funding agencies do not fund challenges!”. We question the accuracy of this
perception within KTH, in view of the observation that other institutions achieve a better balance
between challenge-driven and curiosity-driven research.

A third major problem is the short term orientation of most of the research funding. It was frequently
stated that funds provided by companies usually have a short term focus and concentrate on
incremental improvements. Industry might very well be interested in more long-term forward
looking research carried out by KTH, and might even be willing to finance such research. However,
given the culture at KTH which we have described, industry is generally unlikely to recognize KTH as a
potential partner in more speculative longer-term research. To change this, and position KTH as
encouraging and shaping the future research agendas of both industry and funding agencies,
represents a significant challenge for KTH. Government funding agencies inside and outside Sweden
usually have a longer time horizon. EU research programs in particular deliberately focus on the main
societal challenges, of which SD is an outstanding one. While the value of disciplinary research
should not be underestimated, to deny the trends towards funding more multi-disciplinary research
on broad challenges would mean missing the opportunities presented.
6. A way forward

Curiosity-driven research is to be encouraged and will always form a large part of individual research portfolios. However, many of our greatest current research challenges require the best researchers to work together, across disciplinary boundaries, to deliver new knowledge. KTH needs to encourage and provide positive inducement for its researchers to work in this way and ensure that this has and is seen to have a positive impact on careers. Integrating mechanisms provide the most cost-efficient lever available to KTH and could encourage a wider set of researchers to bring in new research funding within a reasonable time.

Therefore we conclude that KTH should invest in integrating mechanisms rather than research projects. The integrating mechanisms should be designed to increase co-operation across disciplines in tackling major challenges and to promote system-level understanding and thinking. From this increased understanding we expect the quality of research bids to improve, thereby increasing the quantity of research funding while focusing that additional funding on key societal challenges. It would be reasonable and helpful to allocate resources to support increasing the quality and reducing the difficulty of forming multi-disciplinary proposals that tackle society’s greatest challenges: research is essentially a voluntary activity, so that developing this kind of approach will need positive incentives and cannot be imposed in a top-down manner.

7. Recommendations

7.1 KTH Integrating mechanisms: grand challenges and lighthouse projects

Recommendation 1: Create lighthouse projects and roadmaps under 2-5 grand SD challenges.

A key integrating mechanism is to support the formulation of a small set of grand SD challenges. These are the 2-5 main externally recognizable challenges that KTH wishes to tackle in addressing sustainability. A grand challenge cannot ever be a single project, but forms an image of part of a sustainable future that provides focus for projects and plans. An example grand challenge might be ‘the transition to a low carbon Swedish economy’.

The primary integrating mechanism is multi-disciplinary ‘lighthouse projects’ (see Figure). These bring researchers together to deliver new knowledge that offers the potential to unlock new levels of system performance. KTH-S should actively support the creation of lighthouse projects by offering process support and skills. External expertise can be hired to guide the process of developing these projects. The existing KTH-S budget should be sufficient to cover the costs.

Recommendation 2: The process of creating lighthouse projects must be inclusive and attract staff to participate in the creative process

Specifically, we expect each potential lighthouse project to develop a system map of the key variables and interactions in the system to be studied. This can only be done by bringing together KTH experts and actively involving them in this creative process. Jointly they can develop draft system maps and then encourage inputs from industry and from policy and funding agencies. Development of these maps is an iterative process: their development needs process support from KTH-S and also academic time. Based on a system level understanding of variables and interactions, the emerging research team should be encouraged to propose technology road-maps that describe a
desirable and feasible future vision and a set of projects that can deliver that vision. From these two maps the particular research objectives for each project are distilled, which then form the basis for project proposals to outside agencies. We believe that such challenge-led, multidisciplinary projects are a key research trend and will increase KTH’s impact and reputation.

The act of creating these system maps and technology road-maps is integrative. Initially this should be within KTH, but when good maps exist they should be developed further by involving a broader constituency including industry, policy-makers and research funders. This can be a strategic way to influence funding thinking and hence funding decisions, as well as demonstrating KTH leadership in a manner observable both by citizens and by KTH staff & students. These mapping techniques are based on the mechanisms used by funding agencies such as the EU.

We suggest that system mapping and road-mapping are skills that can be taught as part of the PhD program and the teachers of these skills should also be available to faculty. At least one senior academic and at least one PhD researcher should take the facilitating lead for developing each lighthouse project mapping activity. It is often effective to have the most central subject researchers NOT acting as the facilitating lead, as they need to concentrate on taking full part developing in the content. We also observe that busy, mid-career faculty members are typically poorly positioned to invest effort in such work.

**Recommendation 3: Examine how to encourage new and existing staff to participate in challenge-led multidisciplinary research**

As stated in the observations, the incentive to work on challenge-led, multidisciplinary lighthouse projects is presently lacking. The researchers’ first response was often that they have “no time for such activities”. Incentive structures should be adjusted to create a positive encouragement to get involved in this creative process. Patience, skill and some small funding is needed to enable this critical activity. Our analysis is not sufficiently deep to offer a direct solution and further investigation is needed here. The skills needed here also form part of the PhD development improvements mentioned below, and should therefore be available easily.

**7.2 PhD support (including teaching)**

**Recommendation 4: Provide compulsory, introductory courses on sustainability and systems thinking**

A KTH-wide course providing a general introduction to sustainability and sustainable development is essential, as a required credit for all students who claim to be engaged in sustainability-related research and available as an option to all PhD students. This course might correspond to or might subsume the current module on “Sustainability Science” but we are not able to make a more specific recommendation both because we have not reviewed the content of the current module and because the content should in any case reflect the KTH institutional interpretation of the sustainability agenda which has yet to be developed and articulated. The course would also provide a mechanism to help students involved in sustainability research to meet fellow students with whom they should interact.

Teaching in systems thinking is also needed, delivered as distinct courses from a module or modules focussed on sustainability but designed so that the two areas are complementary and reinforce each
other. This taught material should also be required for students involved in sustainability-related research but some material might be tailored to specific areas of conventional science and technology; e.g., students in biotechnology and ICT have some common concerns but equally some different needs.

There is also a specific need for teaching on social aspects and qualitative research, perhaps in the form of an introduction to social research methods.

There are already staff in place at KTH who could deliver these modules. Furthermore, at least part of the required modules may already be offered (albeit not well published). However, it may be necessary to recruit more contributions from academics whose disciplinary backgrounds are outside the common scientific and technological disciplines.

**Recommendation 5: Create a PhD meeting place and communicate available courses within SD**

PhD students clearly appreciate more interaction and communication among themselves. KTH-S can provide a meeting place for these students, both personally and via internet. Moreover, PhD and Master courses related to SD are ill known. The current information about courses on SD is badly distributed and if available, the information is distributed too late. Here too, KTH-S can play a facilitating role. However, the Departments should provide up to date information and be helpful in making all relevant course information available and in time.

In general, we also support a suggestion made by several of the students we met that, in all schools, PhD students should be able to take more credits on topics which are outside their immediate specialisation; a minimum of 10 credits of electives was suggested by several students.

Clustering PhD research around “lighthouse projects” should help students to identify and collaborate with students involved in research with similar and complementary aspects and to promote transdisciplinary thinking and research.

**7.3 Funding mechanisms**

**Recommendation 6: Increase stability for faculty and PhD researchers and encourage multidisciplinary co-operation**

Firstly it is critical for SD research to provide stability in faculty posts so that staff can consider the longer term when developing their research ideas. At present, the more recently established Departments are thought to be hampered in devoting time to develop long term oriented projects and to keep post docs due to limited core funding. To help create stability, KTH should investigate the potential for return on investment that would occur if core funding should meet the average.

Secondly, the funding of activity that ends before the researcher completes their PhD creates a strain on the system and encourages short-term thinking. We propose that KTH-S make small funds available that can reduce the pressure on PhD students and their supervisors during such stress situations by providing the chance to request KTH ‘bridging money’ for 3 months. This gives them an extended opportunity to search for funds that are properly attuned to their research topic.

Thirdly, we recommend a joint process of preparing research proposals by staff with different disciplinary backgrounds in a creative and cooperative atmosphere. This could lead to a growing
number of multidisciplinary project proposals and also catalyse development of relevant competence. A little seed money to facilitate this process and to support integrating mechanisms would be helpful. This could also form part of the education efforts in systems thinking.

**Recommendation 7: KTH-S should allocate a small budget to facilitate the process of defining grand challenges, technology roadmaps and lighthouse projects**

To promote the process of defining roadmaps for grand challenges and specific lighthouse projects, a small budget should be allocated to finance this process. This includes defining the specific grand challenges that can be derived from the research activities (a bottom up process in close collaboration with the researchers), including the description of a number of lighthouse projects. From the KTH-S budget the initial process can be funded, as well as 1 or 2 lighthouses a year. When this initiative leads to successful projects and generates more need for lighthouse projects, additional seed money will be necessary, but the return on investment will already have been proven.

**Recommendation 8: KTH-S should allocate some money for communication on SD among PhD and Master students**

Finance is needed for up to date information on SD Master and PhD courses and networking among Master and PhD students across disciplines, both virtually and personally. KTH-S can facilitate this process within its current budget. The newsletter which KTH-S already distributes, about e.g. SD research funds, is valuable and should be continued.
Informed by, and in discussion with, the other KTH platforms, KTH-S will hold responsibility for teaching modules, for PhD support toward SD and systems thinking competence and will particularly support the development of skills for and delivery of roadmaps and winning bids that are exciting and multi-disciplinary (the lighthouse projects).

As knowledge of the lighthouse projects emerge it becomes increasingly possible to draw out the 2-5 Grand Challenges which can be communicated as the key focus for SD research at KTH.

8. Conclusions
Our conclusions are simple.

1. That KTH has an extremely fertile competence in SD research. Disciplinary excellence, links to industry and society, and ability to work together are higher than the external norm.
2. That this potential is being delivered in a number of instances, but is not happening consistently. KTH has ample potential to increase reputation, increase funding and increase impact on Swedish and international society.
3. That challenge-led projects are increasingly the norm outside KTH. They attract large-scale funding and this will continue to rise. Sustainable Development research has a higher than norm proportion of such projects. The potential to bring many more challenge-led SD projects to KTH exists but must be tackled directly and not allowed to rely on organic responses.
4. That it is possible to deliberately set out a programme of support that encourages high-quality, multi-disciplinary research without forcing individual researchers to join. Such programmes are attracting good researchers and make future recruitment easier as well.
5. That KTH is currently at the early stages of a systematic attempt to support such activities and must now take the opportunity to build on this and increase the institutional competence at finding and delivering challenge-led, multi-disciplinary SD research.
6. We have offered specific suggestions for improving this competence, initially with only a very limited impact on university resources. We believe that KTH should urgently implement the recommendations given above. Greater investment than the minor amounts indicated may not seem feasible but should be considered as the return will be correspondingly greater and the need to seize the timing opportunity in terms of external agenda is critical.
7. KTH has much to be proud of in this area. We believe that it can be much more pro-active in influencing industry and funding agency research agendas and should use the existing successes to explain why more is needed.

We would like to thank the many staff and students we met, as well as the organisers and senior administration. KTH is a welcoming and exciting university that has many ingredients that other similar institutions would be envious of. We look forward to viewing the accelerating development of the KTH sustainability programme from afar.
## Appendix 1

### Sustainability relevant updates of the RAE self-evaluation report

<table>
<thead>
<tr>
<th>Name of Unit of Assessment</th>
<th>Number of Unit of Assessment</th>
<th>Responsible for this update (name and position)</th>
<th>Date</th>
</tr>
</thead>
</table>

### Please answer following questions – with maximum ONE PAGE

1. **Describe major changes that have occurred since the self-evaluation was written in 2012.**
   - a. Major organisational changes
   - b. New and crucial recruitments
   - c. New research projects
   - d. New and crucial cooperation within KTH or outside KTH (national and international)
   - e. New infrastructure
   - f. Any other potential change of importance

2. **Plans and visions for the future**
   - a. What are you aiming for in the research of environment and sustainable development? Where do you want to be in five years/ten years?
   - b. How are you planning to reach your goals for the future? Please consider following points:
     - i. Need for cooperation and links to other parts of KTH
     - ii. Need for external cooperation
     - iii. Other requirements to be able to reach your goals
Appendix 2

Roland Clift is Emeritus Professor of Environmental Technology and Founding Director of the Centre for Environmental Strategy (CES). His research specialization is in the broad field of Environmental System Analysis, including Life Cycle Assessment, Industrial Ecology and Sustainable Energy Systems. Professor Clift was previously Head of the Department of Chemical and Process Engineering at the University of Surrey for 10 years. He is a Fellow of the Royal Academy of Engineering, of the Institution of Chemical Engineers and of the Royal Society of Arts, and an Honorary Fellow of the Chartered Institute of Waste and Environmental Management. He is also Visiting Professor in Environmental System Analysis at Chalmers University, Gothenburg, Sweden and Executive Director and Past President at the International Society for Industrial Ecology. Professor Clift has acted as Expert Adviser to an enquiry by the House of Lords Science and Technology Committee in “Energy Efficiency”.

Jacqueline Cramer, is director of the Utrecht Sustainability Institute and professor in sustainable innovation at Utrecht University. Before she was Minister of Housing, Spatial Planning and the Environment (February 2007 – February 2010). Professor Cramer has worked with more than 100 companies on the implementation of sustainable entrepreneurship and was also director of the consultancy firm ‘Sustainable Entrepreneurship; strategy and innovation consulting’. She has a long experience from various national and international advisory boards of the government, industry and nonprofit organisations for example Board of the World Wide Fund for Nature (WWF)/Netherlands, the University Maastricht and the Hogeschool Arnhem-Nijmegen and member of the Nonexecutive board of Shell Netherlands, FMO (Finance for Development Bank) and the sustainability funds of ASN Bank.

Steve Evans spent 12 years in industry, rising to become engineering systems manager at Martin-Baker Engineering, the world leading manufacturer of ejection seats. Professor Evans has been professor of life cycle engineering at Cranfield University since 1998. More recently, he joined the Institute for Manufacturing at the University of Cambridge where he is director of research at the national EPSRC Centre for Innovative Manufacturing in Industrial Sustainability. Professor Evans’ research seeks a deep understanding of how industry brings environmental and social sustainability concerns into its design and manufacturing practices, with a duel emphasis on urgent & practical change now and system level change that offers hope for a sustainable future. His work includes amongst others sustainable factories, food systems for people with reduced access to food, and sustainable design. Professor Evans has acted as specialist adviser on waste reduction to the House of Lords, is board member of the Centre for Sustainable Engineering and is a partner in two cleantech start-ups.