

Centre for Arctic Gas Hydrate, Environment and Climate (CAGE)

Scientific output

The design of CAGE's seven workpackages portrays the centre's excellence in an impressive setup. This is the only interdisciplinary centre world-wide studying all aspects of gas hydrate including its regional and global climate impact. They focus on gas hydrate formation, distribution, dissolution and related biosphere interactions. This important biological aspect is being developed more in the next phase, however, the centre has already managed to expand its expertise in this direction.

Compared to the stated intentions, as outlined in the proposal (that were already very ambitious for a scientific field that is not easy to tackle) CAGE has done exceptionally well, well above what may have been reasonably expected. Major, innovative technological developments have been made, partly in collaboration with others, both industry and academia, national and international. The scientific outcome in published papers is impressive.

The centre has achieved, in a short time, wide international visibility and impact by a high number of scientific publications and conference contributions. Starting from 4 faculty positions, the centre has grown to almost 60 total staff, which illustrates the positive and excellent research dynamics.

Organisation

The organisational and managerial structure of CAGE is 'lean' and 'clever'. There is no heavy administrative overhead, and the leadership is collaborative and inspiring; it deals pragmatically with challenges. This type of management style is highly effective in such an interdisciplinary environment, which also mixes pure science and advanced technological development. The management team seems to be driven by a sense of common purpose and has managed to cope with a large expansion in the number of people and size of budget in a short period.

The CAGE leadership has found several ways to support research of excellence. The clever management style drives the whole consortium in the direction of scientific excellence as witnessed by many papers in high-impact journals such as Nature and Science. The overall scientific quality is guided by an international scientific advisory board, consisting of established leaders in their field and a national steering committee. In addition, CAGE is very well embedded internationally.

In terms of science outreach and communication, there is visionary leadership shown, with impressive results (both quantitatively and qualitatively) co-ordinated by a dedicated communications manager. For example, the presentation of the Mid-term Report and the visualisation of scientific results was exemplary. There is a particular emphasis on outreach to children.

The Centre already makes a considerable contribution to the international policy agenda on climate change and sustainability but there are opportunities to expand this further to communicate with stakeholders in government, industry and society.

The training of junior researchers is supported by a well-governed AMGG research school as well as by university courses and a mentoring programme. The PhD community is generally very well-served by the Centre, although there are some issues of intra-Centre communication. It is notable that the majority come from outside Norway but many wish to find a further position in the country.

Leadership has been shown with regard to investments in research infrastructure, including ICOM, the contribution to the development and building of a new research ship, and the way in which a database-management system was set up to cope with the tsunami of data and the commitment to making this open-access.

CAGE seems very well embedded in the local host university. There is evidence of support from the local university authorities, financially and in terms of human resource management, as well as in infrastructure support. However, such cross-disciplinarity can be challenging for university leadership.

Although a point of concern raised by the committee was about the succession of the current Director, this issue is currently being dealt with satisfactorily. There is no significant gender imbalance; for this particular scientific field, it is exemplary and has resulted from strong direction from the leadership.

In conclusion, the leadership, vision, management and organisation of CAGE are outstanding.

Future Plans

All seven WPs have in common to aim to better quantify the processes under study, both in data acquisition and in modelling. This is extremely ambitious, since the quantification of fluxes is technically challenging. Examples are: quantification of CH₄ sources (biogenic, thermogenic, abiogenic), long term in situ observation, quantification of seasonal, annual, decadal and millennial variability, quantification of sea air fluxes, or advanced model development, to name but a few. Such a quantification approach will lead to a more comprehensive understanding of the controlling influence of CH₄ on climate and life in the past, present and future, which is of the highest societal relevance. This demands a great degree of integration between WPs. Special attention has to be paid to the increasing role of microbiology. This requires contributions from other disciplines, such as detailed pore-water and sediment characterisation, and assessing source, site and quantities of potential methane generation, and its release into the water column. Such more extensive study of the microbial contributions will potentially also lead to increasing scientific integration of the WPs. This integration is also highly recommended for the Ice Cold Micro-organisms Lab (ICOM) and should not only be restricted to data input for the Lab's operations. The evaluation panel also appreciates the collaboration and integration with other institutions, such as the Bergen and Oslo groups, and national research infrastructures.

The outlined scientific approach for the second phase is challenging but feasible for this excellent scientific team, provided that continuing and even increasing integration and collaboration can be achieved. CAGE has the necessary expertise and excellent technological support in-house and additionally is targeting consolidation and expansion of new and existing collaborations. ERC-grants have been and are being submitted; the evaluation group was very pleased to hear that measures exist to grant permanent positions/professorships to successful applicants. There are also plans for expanding into integrated ocean drilling programme (IODP) initiatives.

One concern is that full continuation of WP7 depends on additional financing for which, later this year, a proposal will be submitted to RCN. However, even if not granted, the envisaged ship-based measurements for WP7 will continue.

Although started already during the last period of the first phase, there will be a broadened emphasis on the microbial interaction on seabed and water column methanotrophy, applying innovative lander systems and long term monitoring. The new establishment of the ICOM lab will

allow a better understanding of these microbial processes in combination with in situ experiments on the seabed. The comparative study of past warm periods will strengthen the modelling of future developments. These new directions, including the further development of 4D seismics, are extremely beneficial for the overall goal of CAGE and well justified.

The new directions are a continuation of a successful path and broaden the research in a most comprehensive way that will strengthen CAGE's global leadership and position as world class research centre.

Summary

This is an excellent centre with an outstanding programme of research that is ambitious and yet fulfilling those ambitions. The scientific outcome in published papers is impressive, there are many papers in high-impact journals such as Nature and Science. The programme is clearly structured but operates as an integrated whole, thanks to insightful leadership, careful organisation and a research question-driven approach. Young researchers (PhDs, postdocs, and early career researchers) are enabled to become autonomous researchers and collectively they offer the prospect of continuing and spreading the CAGE legacy. Engagement with the wider public is exemplary and there is scope for expanding that with policy-makers. There are strong plans in place for the next five years and for after the CoE funding ends; the support of the University plays an important role here.

Overall assessment: **Exceptional**

List of recommendations

1. CAGE should ensure that the use of the planned ICOM Lab is fully integrated into the work of CAGE, across the different workpackages, during the second phase.
2. The University leadership should recognise that cross-disciplinary research, particularly across faculties, offers a lot of opportunities but simultaneously poses certain challenges (e.g. allocation of PhD positions, professorships and resources).
3. Some attention needs to be given to improving the regular communication within CAGE so that it reaches all research students, young researchers, etc.
4. Efforts should be made to equalise, in so far as it is possible, access to conference funding for all research students including those affiliated with partners.

Conclusion

The midterm evaluation committee recommends continued funding of CAGE.