homes for tomorrow

Building Solutions for Tomorrow as a Reference for Today

Research programme

Application for grants for strong research environments – Formas

Homes for tomorrow (h42) is planned as a strong research environment which will support our future homes in the global era with new technologies, materials and spatial structures which radically reduce resource and energy intensity. The findings will also underpin the retrofit of current homes through new technologies and experiential developments.

The specific aim of this strong research environment is to bring together leading researchers on building and homes at Chalmers within interdisciplinary projects to create cutting edge innovations and a transdisciplinary arena with society to promote new approaches and applications.

The interdisciplinary environment will be based on an engineering and humanizing systems approach. Specifically the research will focus on:

- Active multifunctional building envelopes,
- Concrete composites with energy storage potential,
- Indoor water systems,
- Perceptions of homes – light and structures.

The transdisciplinary arena will be based on a design systems approach and will feature applications of the interdisciplinary research in ongoing reality studies with the external cooperative partners. The design approach will mimic that used in an iterative design process to consider candidate habitat designs for space applications including the moon and Mars (hence the involvement of JSC-NASA and the University of Houston).

Reasoning

The global constraint for present and future homes is carbon dioxide – a difficult challenge as present European homes consume 40% of the total primary energy production (Tommerup et al 2007) and globally homes contribute 8% to greenhouse gases (SoU 2007). Buildings also account for 40% of the materials consumed in the world economy (Rees 1999) and therefore new approaches to future homes have the potential to make a significant contribution to an estimated required 50% reduction in the material and energy intensity of global consumption. It is thought that the greatest economic potential for reducing greenhouse gases to 2030 is in the building sector and this is mainly based on currently available efficiency measures.

The interdisciplinary research within h42 therefore addresses new or adapted technologies for the retrofit of current homes or new home developments.

The Swedish Environmental Advisory Council on climate change followed the same efficiency line as in the UK, but were noticeably devoid of new ideas for the building sector in their report on a scientific basis for climate

policy (SoU 2007). The Delegation for Sustainable Cities (www.hallbarastader.gov.se) are including sustainable building in their 340 million SEK government initiative over the next two years, although the financial support has been granted to spatial planning projects in municipalities, rather than innovation projects. It seems likely that support for sustainable building will be in variations of the passive house concept, which are increasingly being planned and built today. The main focus of passive housing is on energy and does not deal with materials or water use, nor with the human perception qualities. The 2008 world conference on sustainable building (www.sb08.org), which was attended in Melbourne by the main applicant, demonstrated the importance of passive home technologies for new buildings and re-development of the existing building stock, but that there is a need for new ideas for low material, resource and energy intensity innovations that provide experiential values for the occupants.

The h42 research team will carry out research, in dialogue with the external partners, that will underpin real building solutions that can feasibly be implemented in Sweden and abroad.

Homes depend on resources and ecosystem services at increasing distance (Wackernagel et al 2006). It is known that present day urban homes exert a significant ecological footprint and Folke et al (1997) demonstrated that Baltic cities appropriate an area for resource consumption and assimilation some 10^3 their own area. However, the building ecological footprint can be reduced by thinking differently and it has been shown in many studies that the energy and material savings associated with high-rise apartments (compared to single family houses) significantly reduces the per capita urban ecological footprint. It is also well known that the major environmental burden of buildings is during the lifetime and Hördur et al (2001) demonstrated that 75% of the annual ecological footprint is from food and energy consumption.

Passive and other low energy homes have evolved from an industrial building tradition and are characterized by consideration of geometry, orientation, insulation and air tightness, passive solar energy ventilation systems with heat recovery and efficient heating systems (Tommerup et al 2007). This has attracted considerable interest in Sweden because of the economic incentive of energy savings in a cold climate (Smedes and Wall 2007).

h42 will demonstrate considerable reductions in ecological footprints for buildings through innovations in water systems, thin and active building envelopes and new concrete composites.

We argue that new innovations should have a low material and energy intensity (environmental sustainability) but also focus on the human experience (social sustainability) and be competitive and realistic (economic sustainability). Three inspiration projects will now be given to exemplify the need for a focused research environment with both interdisciplinary cutting edge technology research and transdisciplinary societal relevant research:

- The Eden project was built in 2001 in an exhausted China clay pit in Cornwall as a way to connect plants (inspired by English gardens but extended to global biomes) to humans (www.edenproject.com). The architecture is inspired by Paddington Station and Kew Gardens (both of Victorian origin) and represents an arena for humans to experience ecosystems and architecture in advanced lightweight global structures.
- Kuggen is a building under construction on the Chalmers Lindholmen campus, built by Chalmers fastigheter and designed by Gert Wingårdh, both of whom are external cooperative partners for h42. The applicants provided a neutral advisory platform during the design and contracting process and provided ideas for water-based cooling systems for the external façade. Once built Kuggen will provide an example for the communication

of research into both the architecture and civil engineering programs at Chalmers. A further example is the Johanneberg Science Park (also contracted by Chalmers fastigheter) which is a collaboration between Chalmers and the municipality – this is in the planning phase and h42 has been invited to provide the arena for new ideas.

- Moon and Mars habitat. Larry Toups (Habitation Domain Systems Engineer, Lunar Surface Systems) will be visiting professor associated to h42. His team at NASA has designed a light and compact, inflatable and durable habitat as one possible concept for living at destinations beyond low Earth orbit. A structural prototype was recently successfully deployed for one year at the Antarctic base. This experience and results from high fidelity simulations for Space can be a valuable contribution to features and characteristics desirable to homes on Earth.

The h42 research team will develop a transdisciplinary arena for systems design research, for real-life examples, for student learning and for communication.

Research

1. *Interdisciplinary projects*

Active multifunctional building envelopes

The aim of this project is to develop the basis for a new active multi-functional building envelope that will provide the Swedish building industry with solutions using less materials and better functions. The development of thin novel insulating materials and the smart design of building envelope components are important aims.

The building envelope represents the interface separating the indoor and outdoor environment. New materials and technologies can be incorporated as building envelope components for new and adaptive features. Environmental concerns are in this context heat, air, water/moisture, gas, sound and light.

Aerogel is a highly efficient thermal insulation material that can be used in order to reduce heat transfer through the building envelope (Shultz et al 2005, Baetens et al 2010). It is thought that the reduction in thickness of insulation compared to traditional materials could be as much as 8 times, although this requires a vacuum and carbon-black. Aerogel without vacuum or woven are alternatives that might find use in retrofit. Various designs of the building envelope with thin insulators will be studied experimentally and with the use of simulation tools for whole building performance analysis under different climatic conditions. There are weak spots that need to be investigated coupled to junctions between building components, air tightness, durability, robustness and maintenance issues.

Through the smart design of building envelope components the changes in the exterior environmental conditions can be used to beneficially modify the indoor environment. One approach is the use of materials with non-linear characteristics to provide diode effects; another is controlled ventilation for energy efficiency and moisture safety (Hagentoft et al 2008). Research on material properties will be performed through computer simulations for heat/moisture transfer and gas flow, accounting for materials structure, non-linear and anisotropic behavior. The simulations will be verified experimentally. Based on the material characteristics, various design solutions for the building envelope will be investigated with the use of simulation tools for the whole building performance and component analysis for different climatic conditions and building use.

Concrete composites with energy storage potential

The aim of this project is to develop novel concrete composites of modern engineered textiles with nano-modified and/or polymer-modified cementitious binders. Further by using the pore solution as electrolyte and the conductive polymer fibres as the anode (and reinforcement metals as the cathode) the next aim will be to develop a concept of energy storage in concrete structures.

There is an increasing interest in concrete composites for thin structures. Naaman et al (2005) studied high performance hybrid composites for thin cementitious products. In Germany a large collaborative programme has been carried out to develop textile-reinforced concrete (Schlesser et al 2006). Here the combination of technology and compatibility between different materials will be studied. Specific tasks include investigating and developing new binders as matrices for novel concrete composites. Further, textile structures which are compatible with cementitious or geopolymeric matrices will be studied as well as polymeric fillers with non-linear behaviour that can be triggered under specified conditions (e.g. moisture content) and technology for the combination of materials for pre-fabrication of components. Finally, the potential and limitations of the developed building components for application in the building system will be investigated.

Thermal energy storage is a known phenomenon (Zhang et al 2005) and concrete has a large heat capacity. Electrochemical realkalisation and electro deposition have been reported (Ichi et al 2003, Ryou and Monteiro 2004) and the fracture properties of fibre reinforced concrete and durability issues of polymer in concrete have been well studied (Löfgren 2005, Micelli and Nanni 2004). In this project the possibility to store electric energy in concrete structures will be studied experimentally. The pore solution will be modified and polymer fibres will be tested. These fibres will also be used for load-carrying purposes and thus reduce the need for ordinary reinforcement. The durability of energy storage concrete will be tested.

Indoor water systems

The aim for this project is new innovations in and concepts for indoor water systems which include water systems providing solutions for international water scarcity.

Household water circulation and treatment systems will be developed that meet future requirements for drinking water quality by adapting and developing existing leading edge technology to obtain (1) super high quality drinking water from different mains delivered water qualities (2) low energy technologies for recycling grey water within the home (3) efficient collection and treatment of wastewater in-home by combining biological processes with nanotechnology.

New membrane technologies, including nanofilters, can be used to remove substances from raw water sources (Van der Bruggen and Vandecasteele 2003). Systems will be tested in our laboratory pilot scale reactors. Nanotechnology will be used to tailor surfaces of membranes and nano particles with desired properties (Savage and Diallo 2005). Alternatives to generally used disinfection methods will be tested, such as photocatalysis on titanium dioxide coated surfaces or other catalytic surfaces (Adesina 2004, Duran et al 2007). For the wastewater treatment, small scale MBR systems will be investigated (Abegglen et al 2008) as these systems are particularly suitable for small scale systems with highly variable flow conditions. An assessment of ultra/nanofiltration and membrane-supported photocatalysis, as well as separation and recycling systems, will be carried out at laboratory and demonstration scales.

Perceptions of homes – light and structures

The overall aim of this project is to clarify the behaviour and psychology for humanizing technologies and innovations for future homes. Existing models of comfort and experience of quality cannot be directly applied to novel building concepts and materials since they have been developed for traditional construction processes. An important further aim is the creation of restorative environments using novel materials and building concepts.

With new materials and integration of indoor and outdoor environments, future homes will have acoustic, lighting, smell and indoor air/temperature characteristics that are different than those for existing passive houses. Since comfort is a multimodal experience (Fransson et al 2007, Västfjäll et al 2002) we need to consider the interaction between different sensory modalities in creating an overall impression of comfort (Broadbent 1971). We look for homes that are both comfortable to live in and nuture human well-being and positive health. Hence environmental quality and restoration are key experiential values. It is known that restorative spaces lead to long-term positive effects on health (Hartig et al 1996). Restoration is often closely linked to the experience of Nature and therefore restorative homes can use Nature as an inspiration for design and as a means for customizing a home.

One approach is the integration of the indoor and outdoor soundscapes in the urban context that qualify as restorative and recreational environments from a perceptional point of view. The semi-outdoor areas, such as courtyards, atria and balconies are of special interest, since they offer access to quiet Nature-enriched environments. The spatial acoustics of indoor-outdoor spaces will be studied using computation and scale models. Studies relating these physical properties with perception and indicators of restoration will be conducted through psychophysical studies. Both research methods will then be collated to extract design methods for the spaces.

A further approach is to investigate the potential and limitations of new technical solutions in an adaptive building envelope (such as the aerogel mentioned above) coupled to transfer of air and daylight through the building envelope, the distribution through the living space and the impact on occupants. Experimental studies will concern the use of transparent thermal insulations, optical fibre solutions, smart window technology, daylight chimneys and fluorescent materials. For air, experiments will focus on smart and sensor controlled ventilation, breathable membranes and indoor air flow patterns. The effects of the air and light variables on humans will be through psychophysical studies which will provide multimodal indices of comfort and restoration (Västfjäll et al 2010).

2. *Transdisciplinary arena*

Systems design arena

The aim of this project is to bring together innovations and experiential findings to provide an arena for (1) real life references (2) inspiration concept homes (3) well tested prototypes at scales from the detailed to the full-scale. A further aim is to provide new ways for the Swedish building industry to work and an arena for knowledge production and dissemination.

There is a widespread perception that the building sector incorporates research findings slowly and one issue may be that discipline oriented investigations may focus on problems irrelevant to real-life construction. This mismatch has been described theoretically (Gibbons et al 1994, Nyström 2002) in terms of the disciplinary, interdisciplinary and transdisciplinary

approaches presented in this proposal. The strategy for overcoming this mismatch is the creation of a common arena where the implication from design theory is that "everybody is a designer" (Papanek 1995). This arena for mutual learning creates a dialogue between researchers, practitioners and clients (Eden and Jönsson 2002) where product development then follows the identified processes (Lundeqvist 1995);

- production of models of the artifact,
- production of knowledge about the artifact in its future context,
- production of conceptual models about the artifact and the problem area connected to the production of the artifact,
- production of the artifact.

Coordinated architectural assessments in the arena have three foci. First, societal influences upon home design which include a review of available public and scientific data as well as conducting new surveys to determine social trends and conditions that influence societal home needs and preferences. The latter implies demographic population shifts, cultural/lifestyle changes related to technological and economic developments, evolving attitudes and practices about ecologically responsible sustainable design.

Second, psychological responses to design accommodations where user groups will participate in surveys and laboratory settings to determine responses to varied building layout and internal design features. An example is to explore and analyse minimum acceptable volume requirements for psychological comfort, assuming a decrease in future home sizes due to rising land, construction and energy costs. Further, different psychological requirements must be identified for the adaptive use of future homes for many different needs (work, restoration, play, social activities). Other studies will include research of human responses to various materials, to colour and lighting, to special acoustic treatments, to innovative design concepts. These studies will be instrumental in understanding how the quality of home experiences can be perceptually and psychologically improved with additional space and energy use.

Third, lessons from extreme environments. The arena will draw upon lessons from space missions design; such as the International Space Station, and high fidelity simulations of long duration missions beyond low Earth orbit. Experiences will also be gathered from extreme habitations on Earth to examine technical and psycho-social factors that guide new design. These lessons include ways to maximize the psychological acceptability and functional utility of small habitats.

List of participating senior scientists

The h42 strong research environment will involve a closely knit team of scientists within the new strategic area of advance in Built Environment at Chalmers. The researchers are within two departments, the department of architecture and the department of civil and environmental engineering. The department of production and product development is also represented.

Main applicant

Professor Greg Morrison (Water Environment Technology)

Co-applicants

Professor Lars O. Ericsson (GeoEngineering),
Paula Femenias (Architecture),
Sten Gromark (Architecture), associated for the VISURF network

Professor Kent Gylltoft (Structural Engineering),
Professor Carl-Eric Hagentoft (Building Physics),
Associate professor Karin Lundgren (Structural Engineering),
Associate professor Tang Luping (Building Materials and SP Borås),
Professor Maria Nyström (Architecture),
Professor Ulrike Rahe (Production and Product Development),
Barbara Rubino (Architecture), associated to h42
Assistant professor Lianne Thuvander (Architecture),
Associate professor Daniel Västfjäll (Applied acoustics and Psychology, University of Göteborg),
Associate professor Britt-Marie Wilén (Water Environment Technology)

List of external cooperative partners

Staffan Bolminger (Älvstranden Utveckling),
Johanna Engberg (White),
Lennart Hedström (CEO Chalmers fastigheter),
Agneta Kores (CEO Familjebostäder),
Claes Roxbergh (Skanska),
Gert Wingårdh (CEO Wingårdhs),
Larry Toups (JSC-NASA),
Professor Larry Bell (Sasakawa International Centre for Space Architecture, University of Houston)

Description of the strategic relevance of the research programme

Homes for tomorrow will have a significant strategic relevance at Chalmers as a flagship programme for the new area of advance "Built Environment".

Eight areas of advance have recently been announced at Chalmers as cross-cutting areas of identified research excellence of strategic importance. We propose that the transdisciplinary arena of h42 will provide a demonstration of how strategic societal research can be organized within disciplinary oriented universities.

The scientific competence of the h42 team is broad and mainly comprises researchers in architecture and civil and environmental engineering. However, this simplification belies the many disciplines entering the h42 arena and does not do justice to this multidisciplinary team. The h42 team is a well clustered group demonstrating scientific excellence (see CVs, Appendix C and publications, Appendix D).

There are many national and international networks in the area of sustainable building. However, most are directly interested in energy efficient buildings, rather than looking for future innovatively designed homes which consider the environmental, social and economic aspects of sustainability. In this sense h42 is somewhat unique. The following is a list of networks and competence centres whom we wish to contact and cooperate with starting in the first year of the programme to provide important strategic reference points for h42:

- Building, living and property management for the future is a national Swedish dialogue project between companies, municipalities and the Government for a sustainable building and property sector in

Sweden. Researchers in h42 are involved and the initiative will be followed at the programme level.

- Nordic-Baltic Researcher Network VISURF (Visions of Residential Futures), Nordforsk 2008-2011. Researchers in h42 are involved in the consortium.
- The researchers in h42 have identified opportunities for collaboration and conference presentations within the networks of CIB, iiSBE (the International Initiative for a Sustainable Built Environment), SASBE (Smart and Sustainable Built Environments) and PLEA (Passive and Low Energy Architecture).
- Erabuild is a collection of networks in Europe, arranged by the EU, where each country chooses to be represented. Sweden is represented through the Formas-BIC programme Sustainable Building which collates all their research projects. We will request Formas-BIC to include h42 to be linked to Erabuild.
- Greenbuilding is an EU labeling system introduced in 2004 which has been adopted by Swedish building companies and consultants, the main focus being on energy efficient measures. Developments within Greenbuilding will be followed and a link provided to the h42 website (if permitted).
- Green building council of Australia which promotes the design and production of environmentally friendly buildings through their Green Star certification. Similar initiatives exist in the US (LEED) and UK (BREEAM). Researchers in h42 have personal contacts.
- The Alliance for Global Sustainability is a partnership of Chalmers, ETH-Zurich, MIT-Boston and the University of Tokyo. The AGS has launched an Urban Futures initiative through a series of global webcast seminars. As a partner of the AGS, Chalmers researchers will be able to directly disseminate h42 results on the AGS platform.

Description of the potential use of the intended research results

An important characteristic of the proposed strong research environment, h42, is the development of the potential use of the results on the transdisciplinary arena from the outset.

The planning of h42 has involved a number of meetings between involved researchers and the external cooperative partners named above. For this purpose we have framed the requirements and demands of individuals (healthy and comfortable), society (low carbon dioxide energy effective, water balancing) and industry (cost effective, customer attractive).

From our interaction with the external cooperative partners the added value of the programme for the user can be expressed in terms of;

- exploration of new technologies and processes,
- ideas for their ongoing projects,
- brainstorming for specific projects,
- cultivating learning and competence development for employees, as well as for their future employees who are our current students.

The external cooperative partners have proposed a series of reality studies which will form the basis for interactions on the transdisciplinary arena.

We provide three examples below:

1. Kulturhuset, Bergsjön. Kulturhuset is a re-development of a housing estate where there are some 90 nationalities present (giving as many

kitchens). During the programme preparation the CEO of Familjebostäder has discussed our programme with the planning group. The Eden project mentioned above has been a particular interest as one could envisage gardening areas that bring together the nationalities and kitchens. It has been decided to name the project as a "future home" and test different conceptual ideas through cooperation with h42. Kulturhuset provides an ideal test bed for the transdisciplinary arena and can be followed up in the next few years with 400-600 planned flats where the interaction of h42 and Familjebostäder will continue to develop.

2. Älvstranden. The North and South Älvstranden areas of central Göteborg are being developed through to 2030. h42 will become a platform for running pilot projects and it is usual that Älvstranden AB has at least one such project each year as the areas develop and the contact person indicates that they are always looking for new ideas and inspiration. As an example new projects are currently being developed as passive houses. There is a special interest in the Kville area which has a high incidence of criminality and it is felt that bringing the human dimensions (humanizing technologies) into the development will be important.
3. Knowledge exchange programmes. During discussions with the external cooperative partners it was realized that it is normal to have knowledge development programmes. For example, in White architects there are 12 competence areas, three of which can be directly related to h42; building technology, environment, homes. The h42 transdisciplinary arena will provide a contact point to plan internal seminars and to request external experts and researchers to present their ideas, inspiration and research. Half day workshops will be planned for knowledge building on the transdisciplinary arena, as well as the exchange of researchers and cooperative partner staff.

Popular scientific research communication plan

h42 is uniquely poised for external communications through the concept of working in reality studies with the external cooperative partners.

The reality studies will be beneficial to the external partners, providing them with a competitive advantage as they will work with the research front and test new technologies and knowledge. Likewise real-life studies will be challenging to the researchers. When researchers succeed in providing solutions that are useful and profitable to the external partners, they will provide mutual understanding of each others perspectives. Closing this gap provides a background to a successful communications plan.

A communications plan has been discussed within the h42 team and it has been recognized that this needs to be more than just a series of popular science articles. The following activities will be included in the communications plan;

- contact lists and acquisition of a website (a domain has been reserved). The website will serve to inform, explain and market h42 to other scientists, practitioners, the general public and media,
- inspiration seminars and workshops with an open annual showcase workshop (whole day) aimed at practitioners, but also a limited section for the general public. The white papers collated from these meetings will be converted to a newsletter that will be sent in pdf format to the contact lists and posted on the website,

- logotype and graphic profile (as illustrated in this proposal),
- fundraising events where companies in the building sector are invited to special events with the researchers. The specific aim will be to provide leverage for asking for significant sponsorship at the CEO level for interested companies,
- a publications plan for period reports to Formas, for scientific publications and for popular science publications,
- plan for a significant presence at the world conference on sustainable building (the next conference has been moved from 2010 to 2011) which attracts some 2000 delegates, including a very significant building industry presence.

Internal organization, collaboration and communication

The programme will be guided by a reference group consisting of selected members of the external cooperative partners, an appointed observer from Formas, the main applicant as Director of the programme and the administrative support person (see below). One of the co-applicants will be asked to attend to balance the representation of design aspects with the technical innovations. The whole reference group will have an even gender representation. It is anticipated that decisions on the distribution of funds for research between the projects will be made in this group on the basis of recommendations from the programme Director.

The programme will require qualified administrative support and a 20% position is proposed. The person who will fill this position, Yvonne Young, has long experience in the Chalmers administrative and economy system, with EU and other project reporting and has administrated Sida training programmes. It is important that the person who fills this position can work within the programme and fulfill Formas financial and research requirements, keep track of the communications plan, and be able to work across the departments of Architecture and Civil and Environmental Engineering with faculty in diverse research environments.

Collaboration between researchers will take place both at the interdisciplinary research project and transdisciplinary arena levels. The arena is for the whole research group and for the external cooperative partners where quarterly seminars and the annual showcase workshops will be important events. The quarterly seminars will be available for the senior researchers who are applicants, but also for all postgraduate students at the research schools within Architecture and Civil and Environmental Engineering. The even gender distribution of the applicants will serve as a model, a good example, in the building area which has a male dominated tradition. Within the arena, innovative research ideas will be discussed and launched to inspire solutions for both the reality studies and concept homes. This will be a truly interactive process to inspire researchers and practitioners to adopt and find new and innovative ideas, but building on sufficiently (but not too) frequent seminars and workshops to allow feasibility in a way that we know works in a creative academic environment.

The transdisciplinary arena will also act as an internal communication platform where three coordination seminars will be arranged with a senior research officer from Formas. The kick-off meeting will be held with the external cooperative partners and other potential users (contacts and agreements for collaboration have already been made with Färgfabriken, Swedish Industrial Design Foundation, Institute for Futures Studies, Asko Cylinda, Electrolux, The Swedish Society of Crafts and Design, The Passive House Centre, Chalmers Innovation, Dunkers Kulturhus). The aim of the kick-off meeting will be to establish the initially funded interdisciplinary and transdisciplinary

projects, based on the needs for agreed reality studies and as decided in the reference group.

The intermediate seminar will be the mid-term (2.5 year) touchdown with the attendance of an external evaluation committee, presumably appointed by Formas in collaboration with the reference group. As the first round of research projects come to a conclusion this should provide an important advisory platform for launching new interdisciplinary and transdisciplinary projects and for assessing the success of the reality studies approach. At this point we should have seen some success with the fundraising strategy to allow complimentary funding from the building industry, but also from other related research applications within the programme research team.

The final seminar will be a wrap-up event for the Formas funded research and allow a synthesis of the findings to aid the writing of the final report to be written in collaboration with the Department of Communications at Formas. It is anticipated that the fundraising strategy will have provided sufficient funding and interest in the results at this stage to permit the continuation of the h42 programme at a similar level of funding. It is also anticipated that h42 will be recognized at this point as a world renowned and attractive centre for inspirational research on the technologies, human dimensions and real-life applications for future homes and the retrofit of current homes.

The team of h42 has a very large capacity for infusing the ideas and results of a Formas funded h42 programme into the educational programmes of Architecture and Civil Engineering at Chalmers. It is estimated that the co-applicants together represent some 30% of responsibility for the basic courses during the first three years (Bachelors level in the Bologna system) and close to 70% for the more research intensive and specialized fourth and fifth years (Masters level in the Bologna system). Both the Architecture and Civil Engineering degrees have very high application intensities and are nationally renowned, providing leading architects and engineers to the Swedish building industry. Further the transdiscplinary arena will provide important examples of real-life studies, facilitated by balanced gender teams, to incorporate into and enrich the rather traditional Architecture and Civil Engineering programmes. This will aid ongoing pedagogical projects to incorporate sustainability into these two programmes.

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