DALARNA UNIVERSITY

UNIVERSITY OF GÄVLE

MÄLARDALEN UNIVERSITY SWEDEN

Knowledge Foundation

THE RESEARCH SCHOOL

Reesbe

Resource-Efficient Energy Systems in the Built Environment

Ewa Wäckelgård,
Program Director Reesbe,
Professor Dalarna University and
University of Gävle

Per-Arne Vahlund
Chair in Reesbe steering group,
E.O. Gavlefastigheter

Reesbe is an industrial PhD school run conducted by the University of Gävle in cooperation with Mälardalen University, Dalarna University and several companies in the three regions of Gävleborg, Dalarna and Mälardalen. The PhD School is funded by the Knowledge Foundation, and the companies and institutions involved in PhD the school.

The PhD School's goals are:

- Education of doctors and specialists within the companies
- Research in the competence fields of, and in co-production with, the companies
- Academic research developing in the collaboration between the three universities
- New collaborations between the companies as a result of the doctoral students' research collaborations

The Knowledge Foundation

The Knowledge Foundation is the research financier for universities with the task of strengthening Sweden´s competitiveness.

We finance research and professional development at Sweden's new universities and colleges. The Knowledge Foundation requires that each project, in addition to having scientific height, has the industry and commerce contributing to it with a value that is equal to that of The Knowledge Foundation's funding. This co-production is aimed at new knowledge and competence, new products and applications, and process improvements.

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Text: Stefan Westrin
Photo: Stéfan Estassy

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Reesbe

The world faces a major challenge in terms of how we cope with climate change. It has become increasingly clear that humans on earth, through our processes, have an effect in climate change.

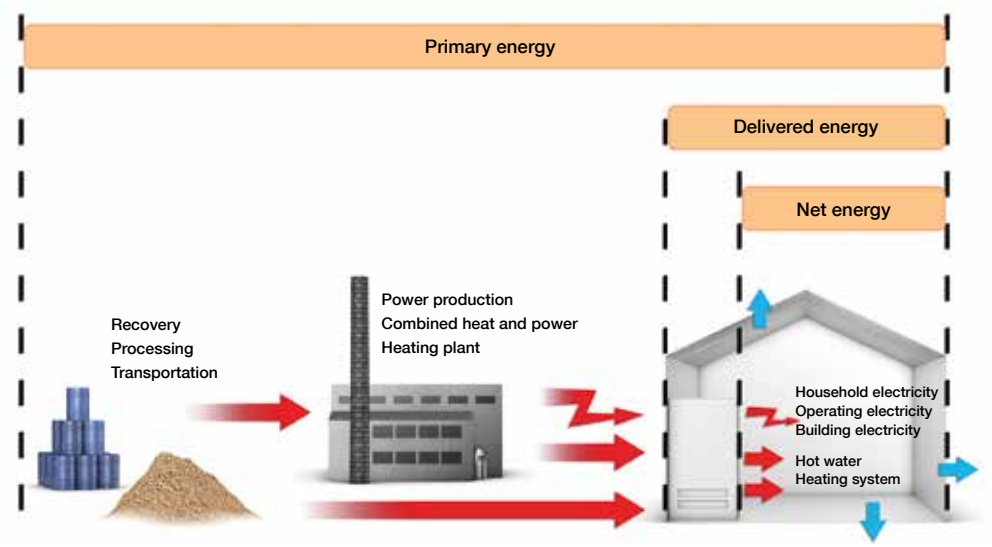
One important reason is considered to be the use of fossil fuels, which increase the concentration of carbon dioxide in the atmosphere. The situation is aggravated by the fact that we do not use our energy efficiently enough. There have been improvements in recent years but much remains to be done. This requires new knowledge, innovations, entrepreneurship and developed processes implemented in reality. Essentially, politicians must set goals for what should be achieved, while the role of researchers is to produce relevant documentation for them to rely on when making decisions.

In Sweden, we have come a long way in developing and using energy efficiently. More can be done, but we have a good platform to stand on. Reesbe shall provide proof of business benefits, industry benefits, and benefits for the society as a whole.

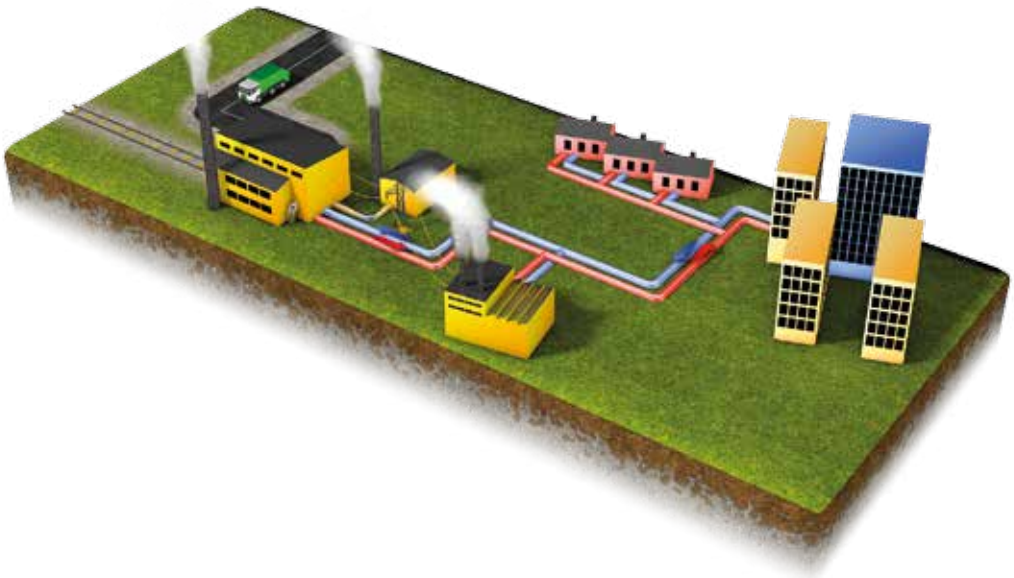
The aim of the research in Reesbe is to identify measures for a more efficient use of energy in homes and public buildings connected to the district heating system. The research is not just about energy-saving technologies, but also about business models where energy and housing companies interact. It is of particular interest to study solutions for implementing solar technology to reduce the use of finite resources and support a decreased impact on the climate and the environment.

The research aims to:

- significantly improve efficiency in energy supply systems
- significantly reduce the use of energy in buildings
- improve indoor climate for both existing buildings and new constructions in the district heating network
- increase the share of renewable energy in district heating areas through the installation of solar energy systems



Energy systems comprise entire chains from primary resources, energy conversion processes, and the distribution and use of energy.

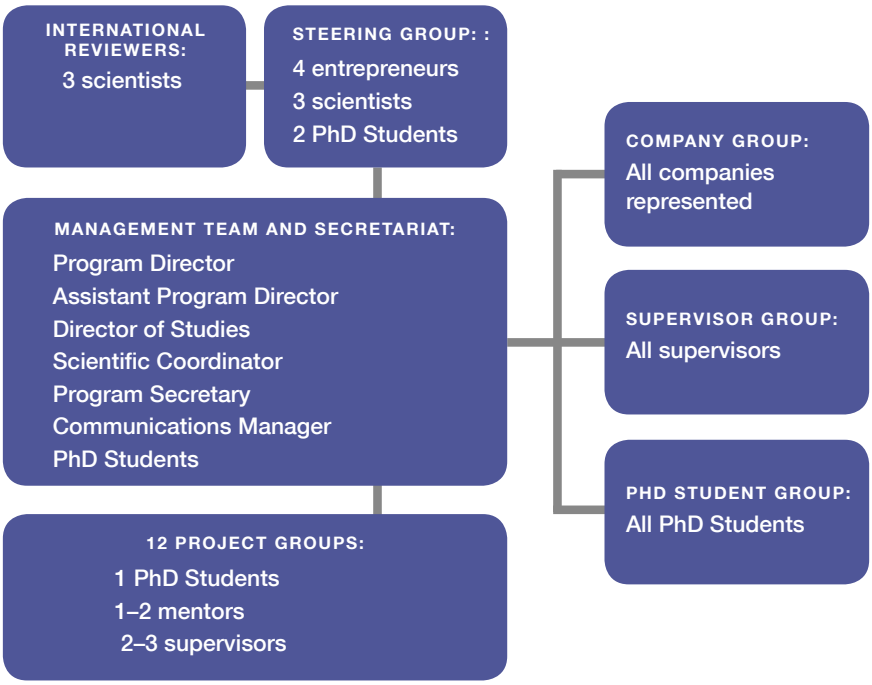


The research of Reesbe focuses on energy-efficient systems in buildings within the district heating network.

Reesbe is an abbreviation of "Resource-Efficient Energy Systems in the Built Environment". The doctoral students started September 1 2013, and the goal is for all students to hold a PhD before 2018. The PhD school offers structured doctoral studies with common courses, seminars and other activities, such as field trips and study tours both nationally and internationally. The fact that the PhD school is an industrial PhD school means that the doctoral students› research projects are carried out in co-production with the participating companies, and that most of the PhD students are employed in the companies as industrial doctoral students. The PhD school also provides good opportunities for research collaboration between students, and collaborations between the participating companies.

Reesbe includes 12 PhD students and 17 supervisors from the three participating universities, as well as 25 industrial mentors and industrial leaders from the 17 participating companies. In total, Reesbe involves 65 people, counting also the direct administrative support. The Board reports directly to the Vice-Chancellor of the University of Gävle. In order for the PhD school to successfully achieve its objectives, commitment from all the participants is required. That is expressed in the forums established in the mentoring group, the supervisory group, and the doctoral student group. The daily activities are handled by the management team under the leadership of the Program Director. The entire PhD school meets twice a year in spring and fall autumn meetings.

Organisation chart of Reesbe



Course program provided through Reesbe

TERM	COURSE 1 (CREDITS)	COURSE 2 (CREDITS)	COURSE 3 (CREDITS)	COURSE 4 (CREDITS)	TOTAL CREDITS
AUT 13	*Seminar Course 5 cr.	*Energy systems (7.5)	Energy efficient buildings (7.5)	District heating and cooling (4)	19.5
SPR 14	0.5 cr. each semester	Science for engineers (10)	Energy optimization for buildings (7.5)	*Corporate responsibility and sustainability (5)	23
AUT 14		Energy systems simulation and optimization (5)	Advanced measure-ments techniques for energy and indoor climate in buildings (5)		10.5
SPR 15		Solar thermal Design (6)	Design of PV- and hybrid systems (5)	Philosophy of Science (7.5)	11.5
AUT 15					0.5
SPR 16					0.5
AUT 16		*Sustainable innovation processes and systems (7.5)			8
SPR 17					0.5
AUT 17					0.5
SPR 18					0.5

** = Mandatory course*

They are researchers at universities and also employed in companies. These PhD students have an extremely important task ahead of them.

We meet the twelve PhD students of the industrial PhD school Reesbe in a conference centercentre in Västerås, Sweden, where they are just about to conclude a two-day research meeting. They all have different approaches to the research, and the conditions are slightly different for each one of them. Some have been employees of their companies for a long time. For them, the challenges have often been to decouple themselves from some of their previous duties to make time for research. Others were employed by their companies at the time they started their research. For them, the challenges have been more in the line of finding a natural place in the company. But now they have all been in this project for just over a year, and they begin to feel that they have found their places.

David Larsson, Solkompaniet

When he first heard about Reesbe, David Larsson already worked at Solkompaniet, a company that installs solar cells. He saw the opportunity to do research in the company's field as a chance to reach further in his job.

– Here I get the opportunity to work more long term, with more height and more exciting development, he says.

He tells us that an environmental perspective is what pushed him throughout his whole career, and with doctoral research, he can do more to reduce the environmental impact.

– Sure, you can mount some solar panels here and there, but I want to do more.

Mattias Gustafsson works at the energy company Gävle Energi. He fills in that taking the step of becoming a PhD student is personally stimulating.

– Of course, you want to move forward all the time and not just do the same things over and over again. Reesbe presents challenges on several fronts, we're going to be at the forefront and bring new knowledge to the whole society.

Mattias Gustafsson, Gävle Energi

In their first year, the PhD students have familiarized themselves with their fields of research, studied courses and attended seminars. They have also started to get their own research projects going. Jessika Steen Englund's research is on sustainable renovation and is carried out along with real estate companies Gävlefastigheter and Gavlegårdarna:

– It takes a lot of time and effort just to get acquainted with what is expected of a PhD student, she says.

One thing they all have to face up to is parrying the expectations on them, expectations that vary quite a bit depending on whether they come from the companies or whether they come from the scientific community.

– The companies would love to obtain their business benefits as soon as possible, but the focus of the PhD work is of course to write scientific papers and conduct scientific research, Jessika Steen Englund says. Mattias Gustafsson, Gävle Energi.

– Of course, the fact that the scientific community and the companies meet through doctoral work implies a lot of benefits, but there is also the risk that the PhD students are seen as consultants that

perform different assignments for the companies. I think the most important business benefits will show over time when these postPhD years are over and we can present a common vision based on our results.

David Larsson says that the most stimulating thing about Reesbe is the knowledge exchange between all the PhD students. During these two days in Västerås, they have had lots of discussions. For these PhD students, there is no risk of feeling lonely at work, because they have constantly the opportunity to break their visions and perceptions against the others, and thereby get new ideas. In David Larsson's phrase, the PhD students are building a "joint force".

The point of Reesbe is to search for ways to use energy more efficiently in the built environment. The driving force behind it is of course the climate issue, which makes the PhD students' research particularly urgent. I ask David Larsson: What will happen if we don´t get any solution to the climate crisis?

Jessika Steen Englund,
Gavlefastigheter and Gavlegårdarna

– Storms, disasters, famine, climate refugees, war ...

Moa Swing Gustafsson, who is also a PhD student in the group, and is linked to Falun Energi & Vatten, continues:

– Nobody knows exactly what will happen, but it is a basic principle that you have to be economical with the resources you have. As things looks now, we are not, and that situation is bound to have consequences.

– What the scientific community agrees on is that the situation is much more acute than the general public and the decision-makers understand, concludes David Larsson.

Moa Swing Gustafsson,
Falu Energi & Vatten

Mattias Gustafsson, Harald Andersson, Lukas Lundström, João Gomes, Corey Blackman, Tina Lidberg, Moa Swing Gustafsson, Jessika Steen Englund, Jingjing Song, Ricardo Ramírez-Villegas, David Larsson

The companies involved in the project get a greater understanding of each other and of how everything is interconnected.

Mikael Söderberg, Mimer

– We get the possibility to see beyond our own operations, to see the entire social structure, Michael Söderberg, one of the industrial mentors in the project, says.

Since Reesbe is an industrial PhD school, the students are not only academic PhD students, they are also employees of various companies in areas related to their research. The companies have mentors, who function as points of contact, and also formulate what the companies want from their research.

The fact that companies have staff who do academic research is not unique, but it is usually reserved for really big companies to afford such things. For small and medium-sized enterprises, this is much less common. But since the companies can share the costs with the Knowledge Foundation, some of them have taken the step to conduct their own academic research

– We are a small family run business and we do not have the resources, Matthias Kranz, CEO of the company Repus ventilation, says.

– If it wasn´t for Reesbe, this would not had been an option for us

The same applies to residential housing company Mimer, Technology and Environmental Manager Mikael Söderberg says. He is very positive about this opportunity to take a leap into the academy.

– Our companies are an important part of the social structure. We have about 22,000 tenants and their behavior and their habits make a difference. Therefore, it is a good thing that we are also able to influence the academic research.

Malin Karlsson is the Director of Energy Services in the energy company Borlänge Energi. She points out that her company has always worked with the parallel dimensions of business benefit and social benefit. And they have always asked themselves the kinds of questions that they are now researching. The difference is that previously, they did not always have the clear structures needed to work withapproach them.

– And these are complex issues,: major infrastructural and social issues that should be addressed in the long term. With an industrial PhD school like this one, we are suddenly in the position of moving them forward. We have the opportunity of analyzing them thoroughly.

Matthias Kranz agrees that these are issues in which their companies can drive progress and produce new knowledge. Now they can find out the facts and put clear figures on things.

– That gives as a completely different emphasis when we tell our clients: "Here you are actually wasting a lot of energy. Change it, and you will save this much money, and this much carbon dioxide.

Mikael Söderberg sees an additional value in participating in the project: the company´s exposure to the academic world.

– We are no longer beyond that world, but a part of it. Some may think that the housing business is just about lawn mowing and snow shovelling, but it is actually much more complicated than that.

Mattias Krantz, Repus Ventilation

– And competence is a scarse resource, Mattias Kranz fills in.

– We have already involved the gradual students of Reesbe, and the fact that we are seen and heard in this context means that we can attract even more expertise from the academia.

Mikael Söderberg likes the fact the fact that his brain also gets challenged with issues of the project. Not as thoroughly as the brains of the PhD students, of course, but after all, he is taking part in the discussions.

– The big challenge for all of us is to think in an overall logic. In doing so, we will are able to see beyond our own operations: to see the whole social structure.

Malin Karlsson, Borlänge Energi

Matthias Kranz says that a side benefit of this collaboration is seen in a knowledge transfer between the companies participating in the project. They see and understand each other and each other's challenges, and that also contributes to the overall view.

Malin Karlsson points out that, for example, that there can be measures that amounts to a saving for the company, but a cost for the society as a whole.

– This project invites us to see problems from a multitude of angles and to have a system discussion. It's about difficult questions that will lead to big and important conclusions and long-term solutions.

– These may involve obtaining new incentives and new regulations, concludes Mikael Söderberg.

– In that way, we can make best use of the money.

Anders Tenggren, Mälarenergi; Mats Tiger, Byggpartner; Mattias Krantz, Repus Ventilation; Malin Karlsson, Borlänge Energi; Jan Andhagen, Mälarenergi; Mikael Söderberg, Mimer; Jan Akander, Gavlegårdarna and Gavlefastigheter; Goran Ugrenovic, Stora Tunabyggen

Reesbe involves many PhD students, companies and universities. That means strength, the supervisors involved in the industrial PhD school say.

Behind each PhD student, there is always at least one supervisor. Some of the supervisors who are engaged in Reesbe are Mats Rönnelid from Dalarna University, Eva Thorin from Mälardalen University, and Bahram Moshfegh from the University of Gävle.

They all consider the fact that Reesbe is designed as an industrial PhD school to be advantageous.

– *That means that the researchers can learn from each other, Mats Rönnelid says.*

– *It enables them to get a much better overall view.*

Right now, housing companies throughout Sweden are facing renovations of the so-called "Million Programmes", which were built in record time between 1965 and 1974. Many of the students are researching how these renovations should be performed, what are the best ways to go about if you want to make them as energy efficient as possible?

– *Some of them are worried that they'll start researching the same things as some of the others. Then it is our job as supervisors to ensure that they cooperate, but also to make them ask themselves: "What's interesting in my particular research?" Because we know that the total exchange will provide something that is much bigger, Mats Rönnelid says.*

Eva Thorin points to another important advantage in gathering several students to a PhD school. The results that such a group reaches can have a completely different impact, both nationally and internationally, than individual and fragmented research.

– *It provides us with credibility, and also makes it much easier for us to reach out.*

Another positive effect of Reesbe is the fact that the program is managed in collaboration between three universities. This has led to more frequent contacts between them.

Mats Rönnelid, Dalarna University

Bahram Moshfegh, University of Gävle

Eva Thorin, Mälardalen University

Fredrik Wallin (MDH), Frank Fiedler (HDa), Björn Karlsson (MDH, HiG), Mats Rönnelid (HDa), Ola Eriksson (HiG), Eva Thorin (MDH), Mathias Cehlin (HiG), Louise Trygg (HDa), Thomas Olofsson (HDa), Chris Bales (HDa), Thomas Persson (HDa), Bengt Stridh (MDH), Erik Dahlquist (MDH), Bahram Moshfegh (HiG), Erik Dotzauer (MDH)

– We enrich each other, scientifically and experientially. For example, we can use each other's laboratory equipment and premises, Bahram Moshfegh says.

Mats Rönnelid agrees:

– We get to know each other's different resources and show more interest for each other. If we encounter a problem we can now address the others: "We have a problem here - do you think you could help?" That would probably not have come to our minds the same way a few years ago.

Yet another benefit of the collaboration is the fact that they can get financing for big projects, such as Reesbe.

– There are a lot of financiers who finance a few, but big, projects. Our universities are all comparatively small, and individually, we may not be strong enough to make these kinds of effort. Therefore, it is important that we can reach each other and form alliances. That provides us with the muscles to operate a project like this one, Bahram Moshfegh says

They are all excited to be working with such exceptionally live issues.

– This is what everybody is talking about right now. How should we go about to renovate our Million Programme areas? How do we reduce our energy dependence? We are able to help the companies that drive this progress with various tools, methods and guidelines, Bahram Moshfegh says.

The fact thatr Reesbe is an industrial PhD school, in which the students are employed in the participating companies, provides the project with a direct link to the industries.

– That makes the benefits of the research much clearer, Eva Thorin says.

– If you just sit in your office and research by yourself, the research may often have little effect on the world outside, but this knowledge will be put into practice immediately.

Both companies and policy makers need knowledge-based, concrete facts that they can act on to make decisions, and they need it as soon as possible.

– Today´s world is screaming for research in this field, Mats Rönnelid says.

– The fact that there are recipients who can´t wait to grab and use this research immediately is a great motivation, not only for the students but for the whole group working on this.

The first year of big project is an important phase. So far, the results have been beyond the expectations of the Reesbe management team.

When we meet the two representatives for the Reesbe management team, PhD students, supervisors and mentors are beginning to put on their coats and leave the convention centercentre one by one. Two days of presentations and discussions are over.

The project will continue to have this type of coordination for everybody involved twice a year. The PhD students will all be finished within five years. If you are a full time researcher, you are expected to reach your PhD in four years. The Reesbe PhD students spend 20 % of their working hours carrying out other tasks in their companies, and devote 80 % to post-PhD studies, hence the five years in all. After their first year, they have reached further than the management team had dared to hope, member Björn Karlsson says.

– So far, they have exceeded our expectations. They have taken a lot of courses and they have already started to conduct a little bit of research.

Björn Karlsson, University of Gävle and Mälardalen University

The program director of the project, Ewa Wäckelgård, likes the way the students have settled in on the special circumstances that an industrial PhD school entails.

– They do not conduct academic research for its own sake. The results of their efforts will involve a developing knowledge for various operators to quickly benefit from.

Björn Karlsson thinks that it is probably more difficult to be a PhD student of the Reesbe project than being just an ordinary PhD student:

– Since they are employees of the companies, there is a pressure on them to also work with other duties, but the research requires them to devote 80 % of the time, and it also requires the companies to accept that, and I think they are doing it well..

Parts of the management team of Reesbe have previously collaborated in other PhD schools and have found good models to make it work. They had thought about trying to establish a PhD school for research of energy issues for a long time.

– We thought it was important to get the companies behind us right from the start. This is knowledge that needs to be applied practically, Ewa Wäckelgård says.

Björn Karlsson is also pleased with how everything has fallen out.

– These are not companies that keep secrets for each other, as it has sometimes been in other contexts. They are not competing firms. On the contrary, they benefit from each other.

A man who has been very important for this project is Per Laurell, former chairman of the Reesbe Board and CEO of energy company Gävle Energi, who was recently forced to resign from both missions due to illness. He stressed that it was important to Mälardalen University, Dalarna University

Ewa Wäckelgård, Dalarna University and University of Gävle

and the University of Gävle to cooperate and that companies in the relevant industries should be included.

– And he was right! We have an important task and none of us would have been able to deal with it alone. In this way, we tie ourselves closer to each other, Björn Karlsson says.

The first year is an important phase, and so far it seems to be going well. The PhD students have started industry-related projects, making the companies feel that they are part of the game. The next step is more strategic: the companies need to follow the project beyond their own investment horizons. Also, there are plans for an expansion of the project, Ewa Wäckelgård reveals.

–- We hope to get another batch of PhD students, and even more companies, she says.

–- We intend to call it Reesbe +.

Management team, upper row: Åsa Karlsson, Mathias Cehlin, Per Jernberg, Eva Wännström.
Lower row: Harald Andersson, Jessika Steen Englund, Björn Karlsson, Ewa Wäckelgård

COREY BLACKMAN,
DALARNA UNIVERSITY AND
CLIMATE WELL

Cost effective optimization of thermal heat pump systems

Since it is desirable to increase she share of renewable energy, the interest in solar energy has grown increasingly in the construction field recently.

It is quite common to produce heat from sunlight during the winter months – mostly in fall and spring – but in order to use the full potential of solar electricity, it is also possible to convert sunlight into cooling in the summer.

ClimateWell has developed a thermal heat pump that may function as a supplement or an alternative to disctrict heating and provide both heating and/or cooling when needed.

The question is: How should such a facility be modeled and modified for freestanding houses, apartment complexes, hotels and hospitals? What energy sources will be the most cost effective and environmentally friendly in the future? How should we design the system to maximize the cost-effectiveness?

The aim of the doctoral project is to optimize heat pump components and heat pump systems through:

- Studying the current and future energy needs in buildings
- Modeling and simulating components for heat pumps
- Building and testing components
- Evaluating heat pump systems (using simulation)
- Making an estimate of the most cost effective ways to construct thermal heat pump systems

I started my project by making models, simulating and developing components for heat exchange in a heat pump integrated in a solar panel. I also tested various prototypes. In recent months, the study has focused on measurement in a large-scale demonstration facility designed to supply cooling and hot water in the summer, and indoor heating and hot water in the winter. The results are showing promising performance of the sun cooling and heating system.

MOA SWING GUSTAFSSON,
DALARNA UNIVERSITY AND
FALU ENERGI & VATTEN

Increasing the effectivity of the energy system from a system perspective

My doctoral project is a technical, economical and environmental study of how a more cost-effective and resource-effective way to use energy in apartment buildings and district heating networks can come about. I hope to show that the use of primary energy for living and working in the future of housing can sink to close to zero.

Primary energy is the total amount of energy consumed when taking into account every stage of the energy chain, from extraction, production, and distribution to the final use of the purchased energy (electricity or heat).

There are international, national, and local targets for using energy more efficiently. What they all have in common is that they are there to create a better future environment with less impact on the climate. Climate change is a global problem, and to bring about a change, it is important to have a system perspective where all the stages of the energy chain are taken into account in order to define the total global impact of the used energy. Therefore, this project focuses on primary energy, instead of the final use of energy.

In the initial part of the project, I will explore the concept of ”primary energy” and find methods to make it calculable. I will then evaluate different methods to find a cost effective way of making the local energy system effective.

My hope is that my project will highlight the importance of district heating as a part of creating a future with a more efficient use of primary energy. But also that it will show how important it is to think from a system perspective, thereby finding cost-effective ways to reduce energy use.

Group-wide optimization and increased efficiency of energy systems

My project aims to improve and increase the efficiency of the use of energy in Borlänge, in terms of how the energy is produced, distributed and used.

The results of my doctoral project will demonstrate practical possibilities to optimize energy production, distribution and use, in a way that will be useful for both the energy company Borlänge Energi and the society as a whole.

Over the past year, I have studied one of the Million Programme housing areas in the housing stock of the municipal housing company Tunabyggen. I have constructed a model of a building in a simulation program, and with the help of this model, I have simulated different types of renovations. Following this, I have used the results to examine how the different types of renovations affect Borlänge›s district heating system. For this purpose, I have used another tool in which I have built a simplified model of the district heating system. The results of this study are published in a method article that describes how this method can provide an indication of the importance of exploring different renovation scenarios with more detailed methods. In September, I made a presentation of my work at the conference DHC14 in Stockholm.

Presently, we are working on a survey of the energy system in Borlänge. After that, I will construct a more robust model of the energy system. The model will be used for further studies of the energy system. We will use economical, environmental, and resource perspectives in examining in which ways energy may be used for the best effect.

TINA LIDBERG,
DALARNA UNIVERSITY AND
STORA TUNABYGGEN AND
BORLÄNGE ENERGI

Sustainable and careful restoration of the Million Programme.

By the year 2020, all EU countries have agreed, the building sector must have reduced its energy consumption by 20 %. Meanwhile, it is estimated that 80 % of the population of that year will live in homes that exist at the present.

In Sweden, 80 % of the buildings are built before 1975, and many of them were built in the so-called “Million Programme”. This fact makes a question arise naturally: How do we improve the energy performance of buildings erected in the record years?

My doctoral project begins with a general survey of the most common construction systems. Then, I will do a more detailed examination of some of the systems used by Byggpartner, a company involved in the project.

I will explore the environmental and economic consequences of factors such as how the energy is produced, what kind of materials that are used for the buildings, what kinds of installation systems that are used, and how the efficiently the energy is used. I will use quantitative methods, such as simulations using technical and economic data, as well as qualitative methods, such as surveys of the experiences of various operators.

At the DHC14 conference in Stockholm, I and Tina Lidberg presented a study on how to exercise influence on the production and distribution of district heating through a more efficient use of energy. Using different kinds of simulations, we could calculate how various measures of improving energy efficiency would affect the district heating system in Borlänge. Based on these results, we developed an interesting model that can help to determine what kinds of measures to increase efficiency that are most reasonable, seen from a system perspective.

My project will help the construction industry to make renovations that are economically viable and designed to meet the required energy and climate goals.

RICARDO RAMÍREZ-VILLEGAS,
DALARNA UNIVERSITY AND
BYGGPARTNER

DALARNA UNIVERSITY

HARALD ANDERSSON,
UNIVERSITY OF GÄVLE AND
REPUS VENTILATION

Analysis of ventilation devices for optimized comfort and minimized energy consumption in properties, focusing on users and managers.

My doctoral project aims at making models exploring in what ways the designs of ventilation equipment affect the indoor environment and the amount of energy that is needed for the ventilation. The models will then be used to reduce the building´s energy consumption and ensure a good environment for the people that are living in it.

During the spring, the company Repus Ventilation AB has designed and tested a new range of ventilation products in the lab rooms of the University of Gävle. The series is specially designed for the renovation of the old headquarters for the company Vattenfall in Vällingby Park City in Stockholm, where the old offices are being rebuilt into 1200 new apartments. When renovating old buildings, the old ventilation system must be replaced and redesigned to meet today›s tougher requirements for air quality and noise levels.

A new study from Swedvent, an organization for the Swedish ventilation business, shows that six out of ten municipalities does not complies withabide the law regarding ventilation requirements in schools. In the fallautumn, we will perform field studies at a school in Gävle, where Repus has installed some of its new ventilation equipment. The objective of the field studies is to examine ways to improve the indoor environment and reduce energy consumption in Swedish schools.

The Repus ventilation equipment will soon be installed in the university lab rooms again for further detailed studies. The aim is to find the best ways to adjust the size of the ventilation equipment to reduce energy consumption.

JOÃO GOMES,
UNIVERSITY OF GÄVLE AND
SOLARUS

Development and system-integration of concentrating PVT collectors

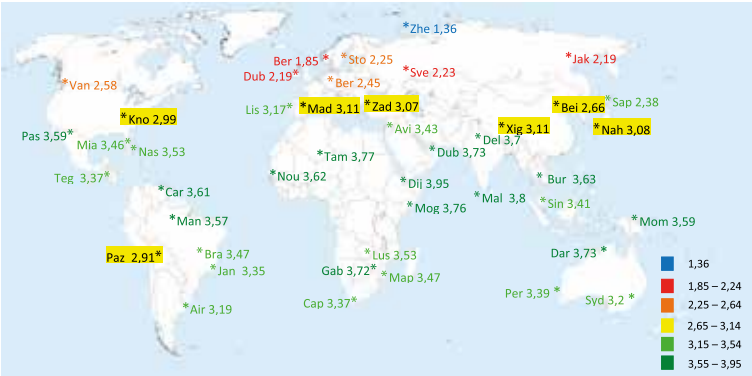
My doctoral project concerns thermal solar collectors, also known as PVT. They can produce both heat and electricity from the same surface.

I am employed as an industrial PhD student at Solarus. The idea behind Solarus´ PVT is to concentrate solar radiation to a small area to reduce system costs.

A subproject in my research concerns comparing solar modules for power generation to with solar panels for heat and studying the relationship between them.

In Stockholm, for instance, a solar panel working at 50 °C produces 2.5 times more heat energy than a solar cell module installed at the same spot produces in terms of electrical energy.

The figure below shows how the solar panels always produce more energy than solar cells, and the closer we get to the equator, the greater the difference. However, it is important to point out that electricity is often valued higher than heat, and that the two systems do not have the same cost. Further on in my research, I will develop methods to compare the costs of various systems.



Improved energy efficiency in the district heating network – how does that affect the production systems?

Every heating system is unique in its construction. The district heating system of Gävle has an unusuallyis distinguished by a high proportion of residual heat, low proportion of fossil fuels, and a joint venture with a biomass-fired CHP plant (Bomhus Energi AB) along with BillerudKorsnäs AB

In my research, I examine how future energy-efficiency improvements in, for instance, the Million Programme, will affect the different units that produce various kinds of energy within the district heating network, and what environmental effects these developments entail.

As the system contains electricity production, this is also affected by the efficiency improvements, and the issue is brought to a head when I use various methods to calculate the environmental impact of an increased and a decreased electricity generation, respectively. The work will become a part of the prospective analysis of Gävle Energi, and used in the adaption of the company´s energy system.

A mix from the various production units goes into the district heating. Exactly what that mix consists of depends mainly on the power demand and the market price of electricity, which varies constantly. The calculation method I use is based on the use of district heating in Gävle and can calculate, hour by hour, which of all the combinations that is the optimal one.

Moreover, I have simulated a house property and various energy-efficiency measures in a simulation program. The program may be used to, calculate changes in energy use, also on an hour-by-hour basis.

The future research will continue to analyze the opportunities and challenges in improved energy-efficiency, but in a broader perspective than just one individual property. Consequences for the distribution system will also be addressed.

MATTIAS GUSTAFSSON, UNIVERSITY OF GÄVLE AND GÄVLE ENERGI

Cost-effective and energy-effective renovation of buildings in the district heating area

My doctoral project is about exploring energy-effective and cost-effective ways to renovate buildings within the so-called Million Programme.

The starting point is to examine the renovation of selected buildings, apartment buildings and purpose locations in the housing stock of Gavlefastigheter and Gavlegårdarna. Later on in the doctoral project, various measures for improved energy-efficiency in the buildings will be studied from an overall perspective, in which the primary energy and environmental impacts are included in the studies.

In my first year, I have investigated a school belonging to Gavlefastigheter. The school property was built in the 1960s and consists of six buildings. An extensive renovation will begin in the fall autumn of 2015.

Models of some of the school buildings have been made in a tool for energy simulation, and calculations of, among other things, air tightness, indoor temperatures, electricity and heating in the school property have been initiated. Simulations of energy-efficiency measures have begun and further on, an optimization tool for life cycle costs for the studied proposed measures will be used for optimizing the life cycle costs for of the studied measures.

In my project, I will also examine some of the apartment buildings in the housing stock of Gavlegårdarna in the district Sätra in Gävle. These buildings are built as part of the Million Programme and will be gradually modified and renovated over the next few years.

By simulating and optimizing energy-efficiency measures in the buildings, measures that are both cost-effective and energy-efficient can be developed. These results are useful for the coming renovations in the housing stocks of Gavlefastigheter and Gavlegårdarna. The impact on climate through carbon dioxide emissions will also be studied.

JESSIKA STEEN ENGLUND, UNIVERSITY OF GÄVLE AND GAVLEFASTIGHETER AND GAVLEGÅRDARNA

UNIVERSITY OF GÄVLE

DAVID LARSSON,
MÄLARDALEN UNIVERSITY
AND SOLKOMPANIET

How can solar cells become an important part of the energy supply?

In recent years, the prices of photovoltaic systems have fallen drastically, and we can observe an increased interest in the technology from individuals as well as big property owners. Theoretically, the sun's energy is sufficient for covering the human needs many times over, but how do we get there in practice?

Photovoltaics are more than just another way to produce electricity – it is a small-scale technology that is typically placed directly onto buildings. This allows the solar cells to be seen not only as a measure for a more efficient use of energy, but also as a building component. They also impose new requirements on the regulatory framework for electricity generation.

My doctoral project is divided into two sections:

- How can solar cells become a natural part of the electrical system of the building and the electrical system in general?
- How can solar calls become a natural part of architecture and construction?

Initially, I have focused on studying the profitability and environmental benefits of solar technology. I have contributed by developing a method to assess the cost of electricity production during the life cycle of the photovoltaic system.

The method is developed for Swedish conditions, regarding the current regulatory framework and support systems. I have also analyzed the environmental benefits by studying the way in which the share of renewable energy in the European electricity system is affected by the Swedish photovoltaic installations and compared it to with other building-related measures.

The results from this work shows that solar cells are one of the most efficient construction measures for increasing the share of renewable energy in the energy system, and that an installation of solar cells is often profitable in the long term.

GUNNAR LENNERMO,
MÄLARDALEN UNIVERSITY
AND WSP

Solar heating systems connected to district heating systems

There are about 30 solar heating systems in Sweden that are connected to district heating systems in a way that allows them to heat what comes back in the return line of the district heating system to the right temperature, and then push it into the district heating system again.
For various reasons, some of these district heating plants are rebuilt every year. In every plant, there is a systematic error that causes the temperatures and the heat output to vary.

In my doctoral research, I examine the conditions of the access points for heat production plants placed in various locations within district heating systems. When the heat in a district heating system is pumped into the piping, the central pump must provide a certain pressure in order to give the flow enough energy to move through the entire system. The pressure difference between the output and input is called differential pressure, and is probably the parameter that affects the district heating networks´ output of heat the most.

I will make measurements of the differential pressure where solar heat installations are installed to control some other features as well, but they are not included in this sub-project. I will also examine what equipment is needed and how it should be controlled in order for the heat to be pumped out in the best way possible.

The aim of this work is to develop a better principle for output of heat produced in various locations in the district heating network outside the central heating plant. This heat may be solar, but heat from industrial waste and other types of locally produced heat are of interest as well.

The measuring project is a part of my more comprehensive work, dealing with solar heating and district heating.

Improved energy efficiency in the district heating area of Eskilstuna

In my doctoral project, I study improved energy efficiency in Eskilstuna, focusing on the housing stock of Eskilstuna Kommunfastigheter.

Research issues of the project:

- What types of energy efficiency measures are preferable with respect to environmental impact and economics onat the corporate, group and societal level?
- How do energy efficiency improvements affect the future demand for heat from the district heating supplier Eskilstuna Energi och Miljö?

The district heating production of Eskilstuna is comparatively environmentally friendly as most of the fuel derives is based on from biomass fuels, and as a large portion of the district heating is co-produced in a combined heat and power plant that also produces electricity.

If the demand in district heating is reduced due to energy efficiency improvement measures, the possibility to co-produce electricity in the combined heat and power plant will be reduced as well, which. This could have a negative environmental impact, if thise electricity is then produced in a dirtier way elsewhere.

Different energy efficiency measures affect the energy system in different ways. A study we presented at a conference last fall autumn shows that measures such as additional insulation lead to reduced CO_2 emissions in Eskilstuna, since the measure is favorable to the district heating network due to the fact that the heating demand becomes more evenly distributed over the year, while exhaust air heat pump leads to higher CO_2 emissions, since the electricity consumption increases and the measure is not as favorable to the district heating network, since no evening levelling out of the heating demand energy is achieved.

LUKAS LUNDSTRÖM,
MÄLARDALEN UNIVERSITY AND
ESKILSTUNA KOMMUN-FASTIGHETER AND
ESKILSTUNA ENERGI OCH MILJÖ

Strategic pricing models for reduced environmental impact within the district heating field

My doctoral research concerns price models for district heating, an important issue for energy companies as well as real estate companies.

Every district heating system is complex and unique, involving many actors, including district heating producers and district heating users. Energy companies have a responsibility to optimize their production of district heat and thereby reduce their environmental impact.

By using strategic pricing models, energy companies can also affect the usage patterns of their customers, which leads to a direct impact on the district heating production.

In the first stage of my PhD project, I have identified various effects of energy saving measures in district heating systems. Last spring, I co-wrote a conference paper showing that different energy saving measures have different effects depending on their different energy saving profiles.

We came to the conclusion that the various measures to improve energy efficiency should be linked to the level of CO_2 emissions. This may be achieved through price incentives: measures that reduce the use of energy during in the winter should give a higher cost saving than those that do it during in the summer.

Further on in my research, I will develop a pricing principle. Initially, it will be used to reduce the use of energy in certain Million Programme areas that are to be renovated, and then it will be used more widely by energy companies as a means of affecting customer behavior. In the end, it will contribute to society as a whole using less fossil fuel, and thus to a reduced environmental impact.

JINGJING SONG,
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