

Annual Report 2009

Industrial Ecology Programme



NTNU
Norwegian University of
Science and Technology



TIME magazine has termed the '00s (the naughties) "The decade from hell", appropriately seeing the 9/11 bombing of the World Trade Center as the defining moment and the financial crisis as a confirmation. Other commentators have reflected on the tremendous success of Osama bin Laden, who has managed to so fundamentally influence your life and mine. The degree of attention and public resources devoted to the fundamentalist threat is way out of proportion compared to the potential damage these can do, that is, if we manage to keep nuclear material safe. More important threats are being overlooked.

No doubt, for the environment this has been a lost decade. We have seen greenhouse gas emissions rise to levels

much higher than in the most pessimistic IPCC scenarios. Politicians have gotten away with symbolic gestures. We have become accustomed to another set of emissions-causing conveniences. At the same time, the science of climate change has been largely confirmed. New findings suggest that we may have erred on the side of caution rather than on the side of alarmism, as climate skeptics would have us believe. Scientists have specifically underestimated the potential sea level rise, both in terms of rate and magnitude. In addition, climate feedback mechanisms normally not included in climate models seem more threatening today. In other areas, many see the "peak oil" hypothesis confirmed. The availability of specialty metals has recently caused industry concern. A recent analysis by Graham Turner shows that our development largely confirms the "Limits to growth" standard run, which implies a major environmental and resource crises in the coming decades.

Environmental and resource issues are now back in the public attention, and as a result, IndEcol has experienced a good year. Our Masters program attracts an increasing number of good international and Norwegian applications (120 in all for 15 spots). We have a new, very active student organization, Symbiosis. Our courses attract a significant number of students from various programs, including exchange students. Our PhD program is slowly growing. Our research groups have strengthened their basis. We have seen a tremendous rise in peer-reviewed

journal publications. We attract more media attention, also from outside of Norway. These good results are no reason to become complacent, however. The solution to the environmental challenges we face requires that industrial ecology knowledge becomes the road-map and catalyst for change in the way industry organizes production and in the way society organizes communities. While our scientific results are increasingly considered in attempts to understand the larger challenges we face, they are not yet part of routine decision making. The Environment Day saw many of our graduates return as company representatives trying to attract new talent. Yet as we see more demand for industrial ecologists in industry and organizations, we experience less industry support for the program directly. Understanding the possibilities for our common future and effecting change are fundamental challenges for Industrial Ecology, a discipline firmly rooted in empirical analysis.

What we at IndEcol have to work with is the dedication and enthusiasm of the young people who come to us, the methods, tools and findings of a still-young scientific field, and the generous support of NTNU. Not a bad basis! Effective for sustainability – IndEcol's vision for the 2010s.

Programme director Edgar Hertwich
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Industrial Ecology programme

IndEcol is a matrix organization coordinating teaching and research in industrial ecology at the Norwegian University of Science and Technology, NTNU. The programme was initiated in 1994 on suggestion of Norwegian industry. A comprehensive educational curriculum was launched in 1999 and turned into an international MSc programme in 2005. Faculty and PhD students affiliated with IndEcol also belong to disciplinary departments where they are employed.

In 2009, 10 MSc degrees were awarded and 3 Master of Technology (MT) students

completed their theses at IndEcol. 17 new MSc students and 1 MT student were admitted. During 2009, 2 dissertations were successfully defended. 23 PhD students, 5 Post Docs and 2 Research Assistants were affiliated with IndEcol. 5 book chapter, 30 journal papers, and 1 IndEcol report were published.

Advisory Board: Harald Rensvik (Secretary General, Ministry of Environment), Frederic Hauge (founder and leader of environmental NGO Bellona), Kjell Øren (industry representative), Ingvald Strømman (Dean, Faculty of Engineering Science and Technology; leader), Olav Fagerlid (Vice Dean, Faculty of Social

Science and Technology), Bjørn Hafskjold (Dean, Faculty of Natural Sciences and Technology).

Faculty Committee: Rolf André Bohne, Casper Boks, Helge Brattebø (MSc programme director), Gunnar Fermann, Annik Magerholm Fet, Edgar Hertwich (Programme director), Elin Mathiassen (Coordinator), Anders H. Strømman and Kjell Øren.

Student Representatives in 2009: Elin Staurem and Rayson Ho.

PhD/PostDoc representative: Stefan Pauliuk.

Cover photo: Elin Fugelsnes/NTNU Info

PEOPLE NEWS

There has been a steady stream of babies to IndEcolers. The group of young parents is joined by Troy and Carin Hawkins, Hogne Nersund Larsen, Christian Solli, Carine Grossrieder, Stig Larssæther and Øivind Hagen. Congratulations to all!

Winners of the publication prize for 2009 were PhD student Venkatesh GOVINDARAJAN, PostDoc Richard WOOD, and Associate Professor Anders Hammer STRØMMAN in their respective categories. The number of publications on our publication list has increased steadily, with all groups contributing to this increase. The number of publications in the higher "level II" category of journals has also increased, especially since the Journal of Industrial Ecology is now included in this illustrious selection. Congratulations to the prize winners!

Associate Professor Ander Hammer STRØMMAN has become NTNU's manager of the Bioenergy Innovation Centre (CENBIO), one of eight new national Centres for Environment-friendly Energy Research (FME) under the Research Council of Norway.

IndEcol thanks Bodil Flo MALVIK for her eight year long contribution to the running of the programme as Office Manager. To take over for Bodil, IndEcol welcomes Elisabeth GILL as our new part-time Executive Officer. Elisabeth holds a MA degree from the Department of Interdisciplinary Cultural Studies at NTNU.

Architect Anne Sigrid NORDBY is an architect, and completed her PhD thesis in 2009 about architectural design that facilitate reuse and recycling. She now continues this research as a Post Doc with professor Casper Boks at the Department of Product Design. Sustainable building materials are investigated both theoretically, through analyses of carbon impact in the lifecycle - and practically, through designing reusable components. In a collaboration with industrial designer Kristin Støren Wigum, Anne Sigrid is developing a self building system of reusable blocks based on reclaimed wood.

IndEcol welcomes Post Doc Tao WANG.

Tao obtained a BSc and a MSc in chemical engineering from Tsinghua University in China and recently completed his PhD at the Center for Industrial Ecology at Yale University in the United States. Tao joined the Material Flow Analysis group at IVM in March 2009, where he is analyzing the dynamics of the global iron and steel cycle.

Francesco CHERUBINI comes from Siena in Italy. He has a Post-doc Fellowship at IndEcol and the Department of Energy and Process Engineering. He is currently involved in the CenBio project (sustainability assessment of bioenergy systems in Norway). In 2006, he got a master degree in Chemistry for Sustainable Development at the University of Siena (Italy). In 2009, he received his PhD in Technological Sciences from the Graz University of Technology (Austria), upon defending a thesis on the application of LCA methodology to biorefinery systems. From 2006 to 2009, he worked at Joanneum Research (Graz, Austria), Institute of Energy Research, where he undertook research activities in the field of LCA of bioenergy, biorefinery and biomass systems, with a special focus on greenhouse gas and energy balances.

Geoffrey GUEST comes from Vancouver Island which is just off the south west coast of Canada. After completing his Bachelor's degree in Chemical Engineering at UBC in Vancouver he decided to go to Östersund, Sweden, where he studied his Master's degree in Ecotechnology and Sustainable Development at Mit-tuniversitetet. His PhD is in life cycle analysis of bioenergy systems. Within this area of research Geoffrey is particularly interested in small scale combined heat and power applications in both developed and developing world contexts. His study duration is from fall 2009 to fall 2012.

IndEcol welcomes Roja MODARESI as a new PhD student. Roja received a BSc in surveying engineering from Khaya Nasir University of Technology (KNTU) in Iran and a MSc in Environmental Engineering from Luleå University of Technology (LTU) in Sweden. She also completed course work in a MSc program in spatial planning at the Royal Institute of Technology (KTH). In August 2009, Roja joined the Material Flow Analysis group at IVM to analyze the

dynamics of the global aluminium cycle.

Johanne HAMMERVOLD started her PhD in System Analysis and Environmental Indicators for Sustainable Infrastructure in the fall 2007. Last year she took 6 months leave from her studies and was engaged at the Norwegian Public Road Administration. Here she participated in the project Methodology for calculating energy use and climate gas emissions for road projects. When new road projects are planned, a cost-benefit analysis is performed comparing one or more road route alternatives to a zero alternative. Currently, GHG emissions related to changes in the traffic is included in the cost-benefit analysis. This project, aiming at also including GHG emissions related to construction and operation of the infrastructure, was launched as a response to political signals. Johanne is still engaged in a 20 % position at the road administration to assist further in development and testing of the methodology and the integration for its use. She is also assisting the Norwegian National Rail Administration in the development of a similar methodology for rail infrastructure.

IndEcol said goodbye to Ola Moa GAUSEN in the Fall 2009 as he left Trondheim to begin work with Sweco AS in Oslo. Ola had worked as a Research Assistant since completing his MS degree in Industrial Ecology in 2008. Ola contributed to the EXIOPOL and E-Car Projects. He has continued work on assessing the impacts of electric vehicles in his new position at Sweco.

IndEcol welcomes Helene SLAGSTAD as a new PhD student. Helene received her Sivilingenier degree in environmental engineering in 1998. Afterwards she completed one year of economics at NTNU, and has been working at the Norwegian State Housing Bank since. In October 2009, Helene started at IVM to analyze critical factors of infrastructure design and operation for carbon neutral settlements.

Kjartan STEEN-OLSEN joined IndEcol as a research assistant in the fall. Kjartan works both on the E-Car and OPEN:EU projects. In April 2010, Kjartan will start

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SYMBIOSIS, THE NEW STUDENT ORGANIZATION

Symbiosis, the student organization for the Masters students in the Industrial Ecology programme, was officially founded on February 17th, 2009. The goal of Symbiosis is to create a meeting place and a voice for a growing student body in the program. The organization is sponsored by the Industrial Ecology programme and maintains close ties to the programme and administration. Additional sponsorships were received from SiT and companies participating in Miljødagen.

We had an excellent and eventful first year of operation in 2009; we started with a ski trip to Oppdal, where students went cross-country skiing, snowboarding and downhill skiing, with cozy evenings in a cabin.

To welcome new students to the programme, and old students back to school, a welcoming week was held in mid-August. Welcoming Week was full of events designed to help the new class to get to



Master's students manning a stand at Kreator.

know each other and the old class, and to get to know Trondheim.

Soon after the Welcoming Week, a weekend cabin trip was organized. Students went fishing and mushroom hunting. The highlight of the weekend was a local-food dinner, with fresh mushrooms, fish and potatoes all harvested from the area by Industrial Ecology students.

Symbiosis also organized the second annual Miljødagen – an environment-

themed career fair. Companies with an environmental focus, from many different industries had stands and held open presentations. The company participants included Rambøll, Statkraft, Veolia and Avfall Norge, among others. The event was well attended by both Industrial Ecology students and students in other programs at NTNU.

Held in conjunction with the career fair was the first annual Redesign competition. Participants submitted entries showing prototypes or designs of products that were constructed of reused or repurposed materials. Entries were judged by company representatives from the Industrial Ecology programme, Rambøll, Veolia and Cultura Bank, with prizes provided by Rambøll, Veolia and Symbiosis. The competition was a great success, with many worthy entries.

We finished off the year with a juleverksted – a Norwegian Christmas workshop

Continues on next page.



Happy cabin trip participants.

INTERVIEWS WITH MASTER'S PROGRAMME STUDENTS

Fatima Kiboub



From the Saharan desert to the icy Norwegian winter, Fatima is not deterred by challenges. She wants to use her skills in developing her country, Algeria, and environmental concerns are at the top of her list. «To start with, there is a lot we can do to improve waste management and the pollution of rivers and coastlines», she says. «And then we have all the environmental impacts from the oil industry».

After earning a bachelor's degree in Microbiology from University Saad Dahlab of Blida, Fatima worked for several years in an oil and gas company in the desert. As a Health, Safety and Environment (HSE) consultant, first with the catering contractor and then in the construction department, a main part of her job was to introduce safety routines. It was a tough job, working as the first and only

female on the field, often outside in up to 50 degrees Celsius. But after she managed to convince the workers that the HSE efforts were in their own interest as well, the number of accidents in the field went down to a record low of zero. «I could have stayed on in the company, but I wanted to learn more», she explains.

She considered several different masters' programmes from various countries. «When I finally came upon the MSc programme in Industrial Ecology, I felt that it was exactly what I had been looking for, and that it would give me the opportunity to combine my background in biology and ecology with the industry perspective. Another advantage is that it is a two-year programme, and I feel that two years would give a better foundation than a one-year programme. Also, tuition is free. But I have to cover the living costs, which are quite high compared to Algerian salaries». The Norwegian oil company Statoil was a partner in the oil and gas company where she worked, and her Norwegian co-workers recommended NTNU as well. «I had a favorable impression of my Norwegian colleagues, and some have become my good friends. Still, I thought maybe I would meet prejudices because I am a Muslim and an Arab, but luckily that has not happened. I have found it easy to make friends in the programme, although the first semester I had little time for socializing». From now on she plans to take

part in more of the activities arranged by Symbiosis, the student organization. The first adventure will be a weekend trip to the ski resort Åre in Sweden.

Due to a delay in the visa process, she had only two months left of the first semester when she arrived in Trondheim. That meant a lot of hard work in order to catch up with the class, but both her fellow students and the teachers were supportive and understanding. She finds the courses useful and relevant to her industry experience. «Sometimes courses can be very theoretical, but here I can see how the methods and theory I learn could be put into practice in a company or a governmental organization», she says. Her favorite course so far is the Industrial Ecology course, as it presented a new way of seeing production and consumption connected with each other and in a life cycle perspective. As elective courses she has chosen Solid Waste Management and Ecotoxicology, which both team up well with her educational background and plans for the future. «There are many interesting courses to choose between, I only wish I had the chance to take more of them», Fatima says. «The only really difficult part of studying here is to be so far away from my family. But it is my dream to do this master's degree and my family supports me wholeheartedly».

where we listened to Christmas carols, made ornaments, decorated the reading room and ate cookies and drank tea and hot chocolate.

In addition to these major events throughout the year, Symbiosis has held smaller, regular events and one-time endeavours. Some regular social activities included the weekly Onsdagpils, or Wednesday beer social. Students gathered to relax, have a beer, coffee or tea at a local café, and talk about school, upcoming social events and seminars, and catch up on life in general. Occasional movie nights

were also held for students to relax, take a night off and hang out with fellow classmates.

Over the summer, the first edition of the student handbook was written to help Industrial Ecology students, especially international students, familiarize themselves with Trondheim, Norway, and student life at Industrial Ecology.

A new Symbiosis board will be elected in February, and we look forward to another great year of events in 2010!



IndEcol students and students from other programmes at the Veolia stand at the career fair "Miljødagen".

INTERVIEWS WITH MASTER'S PROGRAMME STUDENTS

Lars Gunnar Furelid Tellnes



Second year master's student Lars Gunnar Furelid Tellnes was born in Bodø, but grew up in Asker, right outside the Norwegian capital city. In 2004 he arrived in Trondheim to begin his bachelor degree in Economics. After three years of studying he felt that his studies were "lacking" some elements of technology understanding and environmental and natural resources issues. Therefore, when searching through NTNU's websites, he was excited to come across Industrial Ecology's Master of Science programme. Having heard about the programme also from other students and after attending an information meeting about it, he decided that this would be the perfect complement to his Economic studies.

Lars Gunnar thinks that the master programme has a good combination of both method and background material, and his favourite part is that he can see how relevant and meaningful these studies are in today's society. He's now writing his master thesis on the management of food and garden waste, and how to implement different energy solutions to improve today's situation. He's studying how different actors influence new solutions, and he tries to involve a technical and economic view on it, but also a human perspective.

In connection with his master thesis he just spent 20 days in Mumbai, India where he interviewed different key figures dealing with waste management, like hotels, the local government and waste treatment facilities. In India the general tendency is that people are very good at cleaning their own property, but when it comes to public places they care less and acquire a mindset of "out of sight- out of mind." However, many Indians collect recyclable waste/plastic and either sell it on the streets or donate it to charity. This market driven recycling reduces the amount of waste that needs to be collected, and shows that there already is a solution to recyclable waste. However, there is still a strong need for a

food and park waste solution. To prepare himself for the trip to India, Lars Gunnar visited the Vienna University of Technology and their Institute for Water Quality, Resource and Waste Management to learn from their experience in research on solid waste management in developing countries.

When asked of what he plans to do with his degree after he is finished, Lars Gunnar says that he wants to find meaningful work. He wants a job dealing with problem-solving, preferably related to waste management and environmental system analysis. He says he doesn't have a specific "dream job"- but as long as the work revolves around solving environmental problems- he's happy. Lars Gunnar thinks that Trondheim is a wonderful city, he likes the size of it and how student friendly it is. In his spare time he likes to hang out with friends and other students, participating in different debate meetings and cultural events. He has also been quite active in ISFiT – The International Student Festival in Trondheim, which is the world's largest student festival with a thematic focus. This experience has left him with an international network and a lot of intercultural understanding- which could be useful in today's tough job market.

MASTER'S THESES PRESENTED AT THE AWARD CEREMONY 2009

Stian Rein Andresen	Environmental Assessment of European Silicon Production
Olivier Baboulet	Path Exchange Method for Hybrid LCA
Håkon Selvig Bratland	Food-related Biomass Management in Norway - Potentials and Limits of Energy Recovery
Caroline Yeng-Ting Cheng	Managing Corporate Social Responsibility in Global Production Systems: A Review of the Applicability of the Hexagonal Balanced Scorecard Approach
Joakim Auflem Eriksen	Energy Recovery from Municipal Solid Waste in Blantyre, Malawi: System and Actor Perspectives
Lisa Marie Erlandsen	Systems Analysis of Commercial Waste Recovery Options
Thomas Gibon	Environmental Input-output Assessment of Integrated Second Generation Biofuel
Børge Andreas Johansen	Environmental Assessment of Scenarios for Silicon Based Photovoltaic Electricity Generation in Europe
Even Nybakke	Modeling Contaminant Flows from the US Iron and Steel Sector
Kjartan Steen-Olsen	Environmental Assessment of Aluminium Production in Europe - Current Situation and Future Scenarios
Karen Elise Sundelin	Aluminium Recycling of the Norwegian Building Stock System
Tore Sjøiland	Competitive advantage through CSR strategies: The Ulstein Group and Pon Power as case companies
Åsa Grytli Tveten	Life Cycle Assessment of Offshore Wind Electricity Generation in Scandinavia
Monica Vlad	Development and Application of Mathematical Programs for Contribution Analysis in Life Cycle Assessment

Christine Hung



Second year master student Christine Hung grew up in Ottawa, the capital city of Canada. With a big interest in the environment, she decided to move across the country to Vancouver to start her undergraduate studies in chemical engineering. Her studies had an environmental focus, and it was here that she first learned about Industrial Ecology. She became inspired to pursue a master's degree within this field after hearing about a graduate from her own program that had done an industrial ecology program at another university, and then came back and started her own consulting business. Christine thought this was an innovative

and interesting field that she wanted to be a part of, and that's why she ended up at NTNU in Trondheim.

Christine enjoys living in Norway so much that she wants to stay here after finishing her degree. She says that life seems more laid back here in Norway. For Christine, life in Norway feels more relaxed and honest.

In writing her master thesis, she is cooperating with the environmental NGO Bellona, writing about natural gas. She is examining whether it is environmentally better to export the natural gas to be burned for energy in another country, or to use it in Norway in the metals processing or petrochemicals industry, in place of 'dirtier' feedstocks. After finishing her degree, Christine hopes to find work in consulting where she can help companies become greener through LCA.

Christine finds that the courses in the programme teach you what you are supposed to know: «The tools we learn are very up and coming in the business world, and this makes us valuable to companies». The courses also have a good vari-

ety, and she thinks that the differences in background of the teachers and students add something special to the programme. Since she is working and studying with people of different disciplines – not just engineers – Christine also feels like she gets a better understanding of how it would be like working for a company in the «real world».

In her free time, Christine has been active as the vice president of Symbiosis – the student organization for the Masters students in the Industrial Ecology – but now she is retiring. She thinks that the best part of studying at IndEcol has been the good social basis: «All classes are really close, and they feel like a family, so even if you're not at home there is always someone to talk to and hang out with». Christine also lives in an apartment with two of her classmates – a trilingual household where the conversation goes in English, Norwegian and French. Last, but not least, Christine enjoys the Norwegian outdoors, skiing and going on interesting trips. «I'm always surprised when a Norwegian says "I'm hung over – I'm going skiing!"».

Ayodeji Ericson Oyewole



Ayodeji is from Nigeria and grew up in Lagos. He completed his undergraduate education in Zoology in Obafemi Awolowo University in Nigeria, after which he got a position in a bank. Ayodeji says he loves science so much, so he wanted to continue his master's studies in that direction. He started to look for programmes that were aimed at environmental analysis and assessment. «I learned about NTNU from a friend (who has a friend in the University of Stavanger) in Nigeria and I decided to check out the programmes I would be qualified for on the website. I took interest

in industrial ecology because I had always wanted to do a postgraduate study in environmental technology».

The close link between life cycle impact assessment and ecology made the courses relevant to his background in zoology. That the tuition is free in Norway was also an advantage, but Ayodeji finds that the interdisciplinary aspect is what he has enjoyed the most so far. «About half the courses in the programme are electives, and you can effectively choose between courses from all faculties at the university, provided the courses are relevant for you and hence approved by the programme director. And you can study more than the required number of courses if you have the capacity to do so», he says. He also enjoys the easy access to facilities and the faculty members. «The distance between students and professors is much smaller than I am used to».

In fact, much of the Norwegian culture turned out to be quite different from what he was used to in Nigeria. «Living in Norway has given me a new horizon to

human relationship, and I can appreciate different ways of doing things. I found out that Norwegians are quite friendly and always willing to help. This has really made my integration and subsequent stay easier than expected». Ayodeji would like to increase his international experience further, either through continued studies or work. «I would like to establish my own consultancy firm when I get back home to Nigeria, but it would be an advantage for me if I had a couple of years of experience in the consultancy business in Europe before doing that», he says. «I can bring new knowledge to business and industry in Nigeria. The industrial ecology courses have exposed me to system thinking, and I now look at issues from a system perspective by considering the whole and not just the parts».

But studying in Norway has not been just about reading. «Symbiosis, the student organization, has really been good at arranging all sorts of common activities and outings, and including everybody in the social gatherings», he says. «Maybe one day, I will even learn how to ski».

INDECOL SIGNS AGREEMENTS TOWARDS POLITICAL SCIENCE AND PSYCHOLOGY

From now it will be easier for our MSc in Industrial Ecology student to specialize in the social sciences, due to our new agreements with the Department of Political Science and Sociology and with the RIPENSA programme at the Department of Psychology.

In January 1996, the University of Trondheim was reorganised to the Norwegian University of Science and Technology, with a national mandate for research and education in the fields of natural sciences and technology. This mandate, decided by the Norwegian Parliament, also emphasised the challenge of exploring interdisciplinary problems and building bridges across the "two cultures", natural science and technology on the one side and social sciences and humanities on the other. When IndEcol was launched in 1998, we were one of the first groups to systematically implement this cross-cultural challenge in our research and education. You can easily see this from our successful broad portfolio of PhD candidates during these 12 years. You can also feel the distinct flavour of "soft sciences" in our International MSc programme, where we recruit students with a BSc level degree in social sciences, parallel to those in natural sciences and technology, and where the first group of students can specialize in the Environmental Politics and Management (EPM) direction whereas the second group of students normally specialize in the Environmental Systems Analysis (ESA) direction.

Despite this fact, NTNU's Industrial Ecology Programme has its strongest sides in the quantitative analytical and technological disciplines. This is where we recruit most students, where most of our professors and PhD or postdoc fellows work, and this is where NTNU is indeed respected for its quality and research contributions internationally. When IndEcol in 2004 was evaluated by an international expert panel, the conclusion was that we had a world leading position as an academic programme in industrial ecology. However, the experts also recommended us to strengthen the social science dimensions of the programme, due to the importance of implementing

industrial ecology principles in society overall, not just in industry, and to bridge sustainable production and sustainable consumption in a more holistic way.

We have to admit that it has not been easy to develop as much as we wanted our IndEcol activities towards the social sciences. We have not really succeeded in involving many new professors from the social sciences as active faculty in our programme, beyond a few dedicated (initial) friends from political science and economics. We have also not really been able to offer a well planned route of specialisation in social sciences to our own masters' students. Finally this is now to be solved!

In January this year, IndEcol signed an agreement with the Department of Political Science and Sociology. This agreement gives our students a guarantee for taking a master's pre-thesis project and thesis in the field of political science, with a course code at their department and with supervision from one of their professors. The requirement is that the student holds a bachelor's level degree in political science before entering the industrial ecology programme, and that the student follows a minimum of mandatory social science courses as part of their study at NTNU. Likewise, we made an agreement

with the Department of Psychology, so that masters' students at IndEcol can now take courses from the RIPENSA programme, and vice-versa. This programme is on risk psychology, environment and safety, and is, of course, closely related to the industrial ecology issues. Hence, our students may now specialise in risk psychology, with a masters' thesis supervised from there. And, RIPENSA students may incorporate industrial ecology thinking (and methods!) as part of their learning.

We really appreciate these new agreements and positive will of our friends at NTNU Dragvoll, and we are convinced that we will now have a much better foundation for extending our focus towards the social sciences. Most important is the fact that we can now be more specific in how we recruit new students and support existing students who want to specialise in the intersection of industrial ecology and political science or risk psychology. Interested students can read more about the details on our website – and please understand – you are more than welcome to join any of these new initiatives!

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MSc programme director Helge Brattebø
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Welcoming week for new students: Testing the bicycle lift.

PRESENTING HÅVARD BERGSDAL: Dynamic modeling and analysis of stocks and flows in building systems



In the initial phase of my PhD work I aimed to study the generation and treatment of construction and demolition waste. However, as often happens in research,

the final product can be less of what you pictured and more about something else. Not that the final thesis became totally different, but the main focus would not be on waste and waste treatment, but rather on the drivers for waste generation and material use related to buildings. It was known from the start that waste generation was, to a large extent, determined by previous construction activity and the timing of demolition. Looking at construction activity in a historical perspective, it quickly becomes apparent that the past cannot be neglected if we want to find out possible development trajectories for the future. This is particularly relevant for long-lived products like buildings. The major part of my PhD work was therefore devoted to modeling and studying the metabolism of the built environment, i.e. the activities of construction and demolition, the demand for building stocks, and the associated drivers for change. This is again the drivers for waste generation

and material use.

Unfortunately, the data we need are rarely as readily available as we would like them to be. I therefore needed to model the behavior of the building stock and its inputs and outputs. My co-supervisor, Daniel Müller, was already early on kind enough to share his work on building stock dynamics and recently developed model for this. The model was adapted to Norway, and the figure shows the main results from what I have called the medium scenario for residential buildings (UFA = Useful Floor Area). Building waste is already an important contributor to society's waste generation, and the main part originates from demolition activity. However, residential buildings generally have a long lifetime, and the demolition activity (measured in m²) has not been high compared to construction activity. But can we expect this situation to persist in the future?

In the post-war era, Norwegians have experienced dramatic improvements in living standards and welfare, and this has had obvious effects on the way we live; both in terms of living space and quality. As seen from the figure, construction activity increased considerably as the population demanded a larger building stock. However, demolition has remained low as buildings have a long lifetime (residential buildings in particular). As the

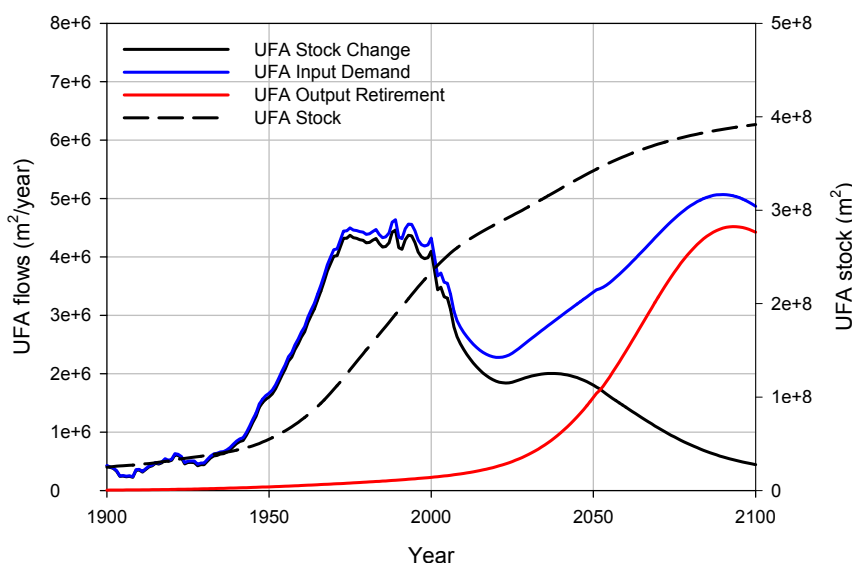
building stock ages we can expect to see more demolition activity in the coming decades, and a corresponding increase in waste generation. Unless we lower our need for floor space, we can also expect an accompanying increase in construction activity to make up for what we demolish. This has obvious implications for both waste treatment and materials demand. Materials are needed for new construction, and waste treatment systems have to be able to handle increasing waste flows. Since we have also put hazardous and toxic materials into our buildings, waste treatment also has to deal with a continuing outflow of these substances. A case study for PCB shows that even if we terminated PCB use in the late 1970s, PCB is still present in the building stock, and will continue to contaminate waste flows for many decades to come.

One aspect of the last decades' construction activity and aging building stock is already starting to have an effect, and that is on renovation activity. Maintenance is required after some time for functional reasons, but to a large extent simply also because we like to change and upgrade the surroundings in which we work and live. In my thesis, I try to understand and model the drivers for, and metabolism of, the built environment, and the associated effects on waste generation and material demand. I apply the modeling to some case studies with different spatial boundaries, and for materials of special interest due to their size or characteristics.

My supervisors for the thesis work have been Professor Helge Brattebø and Professor Daniel Müller, both from the Department of Hydraulic and Environmental Engineering.

The dissertation was successfully defended on 18 December 2009.

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Stocks and flows of residential floor area (UFA) in Norway.

PRESENTING ØIVIND HAGEN: Do Socially Responsible Brands Lead to Socially Responsible Companies? Understanding Change in Expressive Organizations

In the wake of increasing focus on a business's contribution to sustainable development, concepts that until recently have been antagonistic to the common business language are now being incorporated into the corporate stories companies use to express identity. Industrial ecology and its related concepts, such as 'factor 10 improvements', 'LCA', 'de-materialization', 'loop closing' and 'radical environmental innovation', are examples of the words of wisdom used by many companies to express who they are and, not the least, who they claim to be on their way to becoming.

With this rising corporate expressiveness and increasing globalization of the economy, the social responsibility of a business has been commercialized and become part of the brand. A socially responsible brand gives the company legitimacy and maintains the customers' attention. A third aspect of the use of social values in brand building that is gaining less attention, is the retroactive effect the message has on the company sending it. Internal stakeholders' interpretation and sense-making of an external message could be

a driver for organizational change and innovations.

Based on a longitudinal case study of the Norwegian manufacturing company HÅG, I discuss how communicating social responsibility externally may be a driver for organizational change and innovation in this dissertation. Three questions are being discussed:

1. What are the driving forces behind the increasing corporate expressiveness?
2. What can explain the renewed interest in business social responsibility?
3. How may external communication from a company be a driving force for organizational change?

HÅG was followed through a period of six years, from 2000 until the end of 2005 in a research project called Responsible Companies, which was part of the research programme P2005. The methods used to generate the data ranged from participative observations, different forms of company contacts, action research, text analysis and qualitative interviews with 29 informants.

I use concepts like auto-communication, corporate saga and enactment to shed light on the relationship between external communication and organizational change. I argue that HÅG's use of social values in the brand building is part of the company's drive to appear as a proactive business actor. Through the profiling, HÅG has actively taken part in constructing the very environment it has to face and deal with. Paradoxically, the extensive use of environmental values in brand building and corporate storytelling has both enhanced and hindered the environmental work in the company. On the one hand, the proactive image has led the company into self-fulfilling processes and stimulated incremental environmental innovations. On the other hand, it has led to processes of self-seduction and hindered the radical environmental innovations implied by the bold language used in the image building.

This dissertation represents a criticism of the dominating entitative perspective in organizational theory. I argue that the environment is not a fixed body existing outside an organization, but a result of how organizational actors define it and act on this definition. External communication from a company plays a key role in this construction of the environment by constituting a part of the information the company uses to make sense of the environment and by creating stakeholder expectations. More research should be done on the effects of increasingly more companies profiling themselves as proactive and what triggers a shift from self-fulfilling prophesy to self-seduction when change is stimulated by auto-communication. Fruitful perspectives could be found in combining insights from organizational studies and marketing disciplines.

The dissertation was successfully defended on 14 March 2009.

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APPLYING INDUSTRIAL ECOLOGY TO URBAN INFRASTRUCTURE

At the Department of Hydraulic and Environmental Engineering (IVM) we have engaged ourselves in making use of industrial ecology methods for the evaluation of the sustainability of (urban) infrastructure. This approach proves to be very promising, due to the fact that infrastructure systems are closely related to society's energy and material turnover (metabolism) and this will again strongly influence the economic, environmental and social performance.

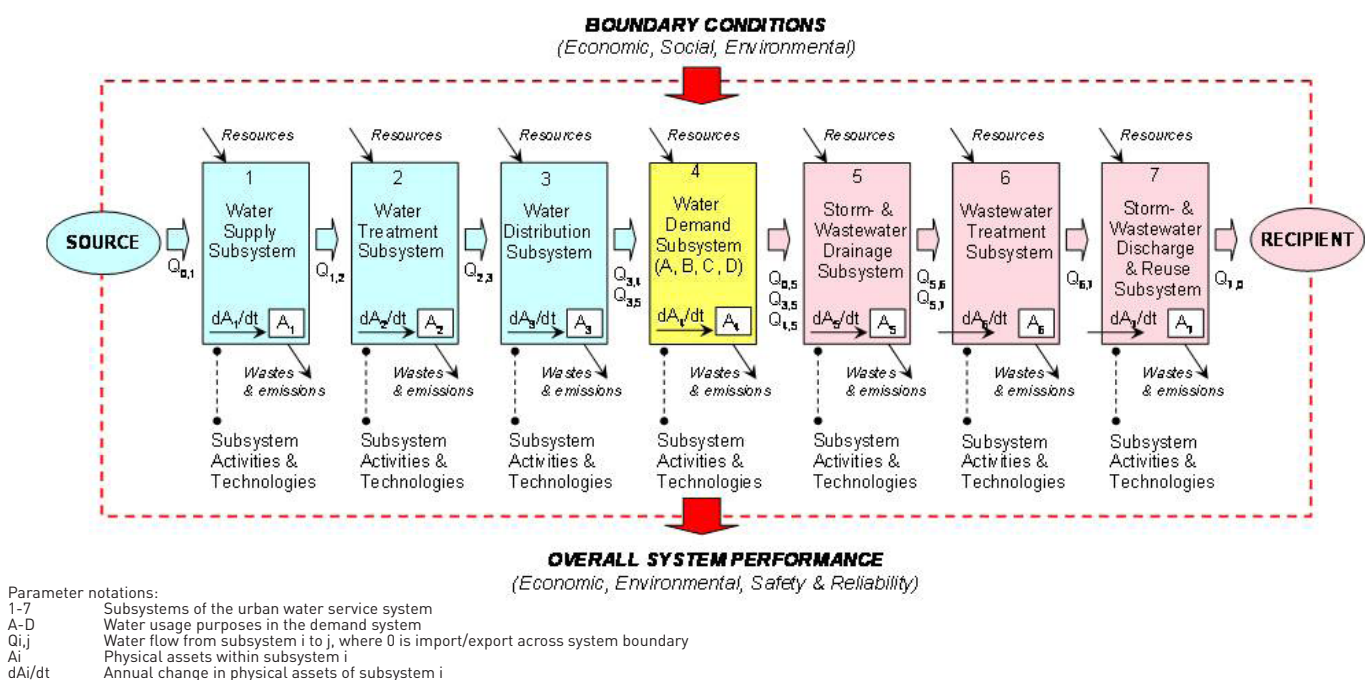
For a couple of years now, we have worked on analysing urban water cycle systems (water supply and sanitation), residential building stocks, solid waste management and recycling systems, district heating systems, and road bridge systems. Our approach is to classify and quantify the infrastructure stocks in such systems and how they develop over time (the age-time matrix classification), how they pull on resource inflows (materials, chemicals, energy) and push on outflows (emissions and waste), during their full service life, while providing service to the population at a given quality standard. We then assess the sustainability performance of the system by calculating life cycle cost and environmental impact indicators in order to rank different technological options for how such systems could be improved in the future. One example is our present research towards developing a metabolism and

performance model of urban water cycle systems (UWCS), outlined in the figure below, and recently proposed as a project to the EU 7th Framework Programme. The metabolism concept is referring to an examination of type-age characteristics of the physical assets (such as pipe networks, pumping stations and treatment facilities) in the various subsystems [1-7], as well as the characteristics of water, stormwater and wastewater flows within the system. The metabolism model then identifies and quantifies the (metabolic) flows of resource inputs (i.e. energy, materials, chemicals) and waste and emission outputs, according to what is actually the metabolic turnover needed in order to operate the urban water system under given boundary conditions. When the physical metabolism of a given urban water system is modelled in qualitative and quantitative terms, it is possible to carry out a performance evaluation of the system, with respect to given economic, environmental, and safety and reliability performance criteria.

The rationale of the methodology is that any UWCS system serves a function to society (the city and its population) under given boundary conditions, by providing water of given quantity and quality (cfr. Q3,4) in the above figure, to the various water usage purposes, such as A: Residential (i.e. households), B: Industrial, C: Commercial (e.g. shops, hotels) and

D: Critical (e.g. hospitals). This function is directly provided by supplying inflows from the water source (Q0,1) and by getting rid of supply water leakages (Q3,5), storm water generation (Q0,5) and wastewater generation (Q4,5) in the system, discharged or reused from the system as outflows (Q7,0). These flows are made possible by the existence of various physical infrastructure assets (A1 to A7) in the seven subsystems, each with a given mix of technologies of different types, ages and qualities, from water collection to wastewater discharge. In other words, a given asset is capable of handling a given through-flow in terms of its quantity and quality. Furthermore, each subsystem asset and its corresponding activity is pulling on resources, inflows of materials, energy and chemicals and pushing on outflows of wastes and emissions, vertical to the water through-flow. Energy, non-drinking water and recycled materials can also be produced in the subsystems. Hence, the various subsystem assets, and the flows mobilized by these assets, directly contribute to the function of the system. The model also demonstrates how the UWCS works as an integrated cycle with regard to production and use of resources.

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EXIOPOL Project

Improving the scientific basis for environmental policy requires the development of datasets and models capable of measuring the status quo and the potential impacts of alternatives. The EXIOPOL Project, begun in 2007, is a major step in the development of the data infrastructure needed to evaluate the national and international implications of consumption patterns. Over the past 2.5 years the Industrial Ecology Program has worked with project partners to pull together the data and methods necessary to create a state-of-the-art, global, environmentally-extended, multi-regional input-output database capable of determining a wide variety of environmental impacts associated with consumption. Troy Hawkins has led the development at NTNU of a harmonized database describing production and consumption of European and major world economies pulling together a wide variety of disparate data sources including Eurostat, the International Energy Agency, the U.S. and British Geological Surveys, and many national statistical offices amongst others. During the past year he finalized the cleaning and harmonization of these datasets to allow for their integration.

The Industrial Ecology Program welcomed Richard Wood to the EXIOPOL

Project in January 2009. Richard brings to the project considerable skill in the creation of environmentally-extended input-output datasets from his experience working with the Australian input-output accounts. Richard has been responsible for the development of an optimization routine for creating the detailed supply and use tables based on the harmonized datasets. The Industrial Ecology Program released a beta version of the EXIOPOL national supply and use tables this fall. Revisions are pending and the final version of the dataset is due for release in 2010. From there, the dataset will be transferred to project partners for trade-linking and completion of the environmental extensions.

Meanwhile, Faye Duchin and Nat Springer have been implementing the EXIOPOL beta version with the World Trade Model. During the past year, Nat has developed scenarios describing possible changes in diet in the developed and developing world. In the next year, Faye and Nat will seek to understand the affect of decreasing meat consumption in the developed world and increasing meat consumption in the developing world.

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OPEN EU

How can we measure the sustainability of an economy? Traditionally, the success of economic policies has been measured in terms of growth in industrial production or gross domestic product (GDP). Increasingly, policy-makers are under pressure to consider environmental performance indicators as well. Improving the reliability of these indicators is crucial for making them more central in the policy debate.

The OPEN EU Project aims to improve upon the methods used to calculate three commonly used indicators, ecological footprint, water footprint, and carbon footprint and to create a network to support the use of footprint indicators in policy formulation. The ecological footprint describes the amount of land area required to support a certain level of consumption. The amount of land used to produce food factors heavily into the calculation but considerations related to forestry, fisheries, and the vegetation required to sequester greenhouse gas emissions also play a role. Similarly, the water footprint and carbon footprint describe the amounts of water and the level of greenhouse gas emissions associated with consumption patterns.

The OPEN EU project was approved for 1.3M Euros over 2 years under the EU 7th Framework Program for Research. The work is funded under a call for research which supports the activities of non-governmental organizations. The project is led by WWF UK and includes as partners the Global Footprint Network, the Water Footprint Network, Stockholm Environmental Institute, and the Ecologic Institute, all of which are non-profit organizations involved in bringing footprint indicators into the public debate.

The project kickoff was held at WWF's Panda House in Brussels, Belgium 22-24 September with representatives of all project partners in attendance. During the meeting partners met in person for the first time to firm up plans for carrying out the work.

The Industrial Ecology Program will be involved in the development of a tool based on the EXIOPOL database for calculating ecological, water, and carbon footprints.



Participants enjoying a mug of gluhwein after completion of the EXIOPOL Project Meeting in Vienna on 11 December. From right to left Maaïke Bouwmeester from University of Groningen, Netherlands, Thijmen Van Brie from TNO, Netherlands, Richard Wood from NTNU, and Walter Manshanden from TNO, Netherlands.

This tool will integrate existing methods for calculating footprints with a multi-regional input-output modeling framework. The final method will incorporate the strengths of both methods by maintaining the high level of detail used in current ecological and water footprint calculations while improving the representation of the contribution to the overall footprint associated with product supply chains.

The final tool, the EU Resource and Energy Analysis Program (EUREAPA), will allow decision-makers in the EU to evaluate scenarios related to development in their region and determine the associated footprints based on country-specific data.

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E-CAR



Post Doc Troy R. Hawkins.

Is it possible to replace a large share of Norway's conventional vehicles with electric vehicles? Anders Hammer Strømman, Troy Hawkins and others in the Industrial Ecology Programme together with partners at Sintef Energy Research, NTNU's Centre for Technology and Society, Miljøbil Grenland AS, and a consortium of Norwegian electric utilities are investigating the many aspects of this question as a part of the E-Car which officially began this fall. The main objectives of the project are to analyze the consequences for the environment and the power sector of substituting a substantial part of fossil energy used in road transport with electric energy in Norway in 2020, and to form a strategy for road transport electrification.

Kickoff Meeting

Project partners met 9-10 September at Trondheim's Radisson SAS Hotel for the

E-Car Kickoff Meeting. Partners presented preliminary findings of work they had begun in connection with the project and made plans for next steps. For the Industrial Ecology Program Anders presented the overall plan for our work and Troy presented the results of our review of studies of the environmental impacts of electric vehicles. Sintef Energy Research presented their background work on identifying reasonable scenarios for the adoption of electric vehicles in Norway. Eidsiva Energi presented their plans for calculating the effects of widespread electric vehicle charging on their grid infrastructure. And Miljøbil Grenland AS presented their business plan for the introduction of an electric vehicle based on the Tata Indica to the Scandinavian market.

Review of Environmental Impacts of Electric Vehicles

Although project partners only gathered for the first time in September work at IndEcol was already underway. Researcher Ola Moa Gausen began a review of existing studies of electric vehicles during the summer and Troy Hawkins has continued the work during the fall. In a review of 51 studies addressing environmental aspects of electric vehicles, we found that it is surprisingly difficult to piece together an overall picture of the environmental impacts of electric vehicles. Most existing, publicly available studies deal with a short list of greenhouse gases focusing efforts primarily on the production and use of electricity.

The overall impacts of electric vehicles are highly dependent on the source of electricity. In a country like Norway with a high percentage of hydroelectricity, overall emissions from electric vehicles are smaller than those of conventional vehicles. For electricity produced using

coal, the impacts of electric vehicles are about the same as those of conventional vehicles. In this case, vehicle production accounts for roughly 20% of the overall greenhouse gas emissions, while production of electricity makes up the remaining 80%. Our results suggest electric vehicles can offer lower greenhouse gas emissions in many places and that they can contribute to reducing human exposure to vehicle emissions. We also find that there is a gap in our knowledge about electric vehicles because of the lack of data used in existing, publicly available life cycle assessments. The outcome is a paper by Troy Hawkins, Ola Moa Guassen, and Anders Hammer Strømman to be submitted for publication shortly.

MSc Project – Environmental Assessment of Batteries for Electric Vehicles

During the fall term MS student Guillaume Majeau-Bettez has also completed a series of 3 life cycle inventory studies for the nickel metal hydride and lithium-ion battery technologies most likely to be used in electric vehicles. Guillaume plans to submit this work for publication in a peer-reviewed journal.

Generalized Model of Environmental Impacts of Vehicles

Kjartan Steen-Olsen, who began work with the Industrial Ecology Programme this fall, has also participated in the E-Car Project. Working half time with E-Car, Kjartan has compiled the findings of a number of LCA studies of electric vehicles into a generalized model which will be applied in the environmental assessment of electric vehicle options.

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BUILDING A ROADMAP FOR ENVIRONMENTAL MANAGEMENT AND CLEANER TECHNOLOGY IN BHUTAN

A team from the research group on EM&CSR from the department of Industrial Economics and Technology Management visited Bhutan in March. The team included Annik Magerholm Fet, Cecilia Haskins, and Uno Abrahamsen. This trip was conducted as a follow up visit after a delegation of 15 persons from the Ministry and different industries visited NTNU in November 2008 to discuss Cleaner Production. During the week in March, the NTNU researchers visited nine industrial companies within the sectors of Mining, Steel, Food, Wood, Ferro Alloy and a recently established industrial park. Each visit included a presentation and a company tour. Based upon the information collected, the team did a preliminary assessment of possible cleaner production options. Suggestions included options for energy saving and recovery, as well as the use of natural resources, waste treatment, emissions of dust and other pollutants. A one day seminar for

25 participants, representing about 20 companies took place at the conclusion of the visit. The day's program included presentations on cleaner production methodologies, and an introduction to the principles of environmental management, industrial ecology and corporate social responsibility (CSR).

A new project started in August 2009 and will last until June 2010 to address Cleaner Technology and Environmental Management (CTEM) in Bhutan. Through this project, NTNU shall train seven industrial sectors in environmental management and cleaner production. The outcome will be sector specific guidelines, national capacity building and support to the Ministry. The final report will address the ongoing need to balance the economy versus ecological priorities, and provide assistance to the participating industries and the Ministry by identifying low cost and viable solutions for implementing

CTEM. Through these efforts, NTNU is establishing a network with the Ministry and industries for future co-operation. Future collaborations may include development of an environmental management plan for the Pasakha Industrial Estate with focus on waste management.

An initial training program took place in Thimphu in November 2009 conducted by Fritz Balkau (former UNEP) and Professor Annik Magerholm Fet. The project is also supported by sector experts from Denmark in addition to Associate Professor Uno Abrahamsen and Post Doc Cecilia Haskins.

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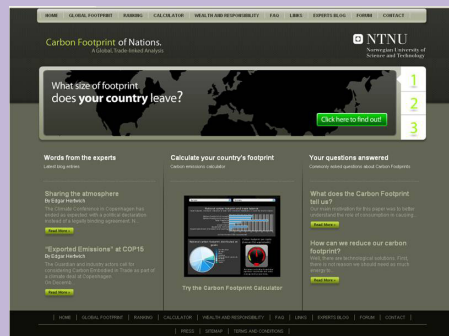


Researcher Uno Abrahamsen (NTNU), Sonam Tashi (Ministry Bhutan), Professor Annik Magerholm Fet (project leader, NTNU), Dr. Cecilia Haskins (NTNU) in front of the Ministry Building during their visit in March 2009.

CARBON FOOTPRINTS OF NATIONS

In June, for the first time, we released a website together with a scientific paper. The website displays data on the carbon footprint of different countries in the form of a “carbon calculator”. The application, developed by Christian Solli at MiSA based on data in the paper, displays the greenhouse gas emissions caused by the consumption of a selected country in terms of consumption categories such as construction, shelter, nutrition, and mobility. It also shows emissions embodied in imports and exports.

The paper by Edgar Hertwich and former PostDoc Glen Peters investigates the importance of these consumption categories and of the public sector, households and investments for the national carbon footprints. It demonstrates a strong correlation of per capita carbon footprints and levels of wealth. It shows that the most important consumption categories shift from nutrition in poor countries to mobility and manufactured products in rich countries.



The web site is a new tool for public science communication for scientific findings that we thought would be of broader interest. Indeed, the website was popular, attracting 13000 unique visitors spanning most countries in the world. The highest number of visitors came from the United States, Norway, and the United Kingdom. The website has maintained a certain level of interest, attracting about 50 visits per day. It also contains Edgar Hertwich's monthly blog.

The website and paper have also attracted

a fair amount of media attention, mostly from science-specific outlets such as Alpha Galileo, Science Daily and forskning.no, but also Verdens Gang (largest newspaper in Norway), as well as Neue Zürcher Zeitung and Sonntagszeitung of Switzerland. Our plan is to slowly build the webpage using new research, for example based on the EXIOPOL project.

The paper was selected as the Top Environmental Policy Paper in 2009 by Environmental Science & Technology, the highest-ranking environmental journal. This is the second time for both Hertwich and Peters to be thus awarded by ES&T (in 2005 and 2007, respectively).

<http://carbonfootprintofnations.com/>

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PEOPLE NEWS

Continues from page 3:

a PhD. Kjartan graduated from NTNU in June 2009 with an MSc in Energy and environmental engineering. In his thesis, he applied hybrid input-output modeling to analyze the environmental impacts of European primary aluminium production.

Edgar HERTWICH spent the academic year 08/09 on a sabbatical at the Swiss Federal Institute of Technology (ETH) in Zurich, visiting the Ecological Systems Design group of Professor Stefanie Hellweg. He wrote a paper on the carbon footprint of nations and a report for the International Panel for Sustainable Resource Management. He also worked on dynamic inventory analysis for life-cycle assessment. ETH is originator of the EcolInvent database project, the most comprehensive and widely used life-cycle inventory database, and Professor Hellweg's group

continues this work while developing methods for regionalizing inventory and impact analysis, among others. Hellweg and Hertwich now collaborate on two EU research projects. Edgar has also had good interactions with the Institute for Environmental Decisions (Profs. Renate Schubert and Roland Scholz) and the Energy Science Center community (including Thomas Rutherford and Volker Hoffmann). Edgar would like to thank ETH and especially Stefanie Hellweg for the hospitality.

NTNU ranks No.2 in Engineering Education for Sustainable Development

The Engineering Education Observatory has evaluated the sustainability-oriented education and research of 56 Technical Universities in Europe and ranks NTNU as the second best in a report, confirming our leading role in the field.

www.upc.edu/eesd-observatory/

DESIGN FOR SUSTAINABLE BEHAVIOUR AT THE DEPARTMENT OF PRODUCT DESIGN

Within the area of sustainable product design, or ecodesign, human and social aspects have received relatively little attention for quite some time. Until recently, research has focused on the means to consumption (the product) instead of the practices involved in the consumption itself. Granted, research into sustainable consumption has resulted in a wide body of literature – IndEcol itself has contributed significantly to this in recent years – but this research has had relatively little connection to ecodesign and the product level – also in terms of research community; the topics have attracted interest from scholars with distinctly different backgrounds and academic perspective. Within ecodesign communities, strategies related to the usage stage had, of course, been considered from the early days of ecodesign, but most of them were based on indirect material and end-of-life considerations; life time extension, for example, appealed to postponing the end-of-life stage, and avoiding the need for material use.

It has been realised for some years now that the traditional focus on material choice and end-of-life has resulted in environmental improvements, but that these only partly achieve the ultimate goal of a product design without avoidable environmental impacts.

Realising that impacts during the use phase often contribute considerably to the total environmental impact, an increased focus on energy consumption – traditionally not the focus of designers – can be observed, by design of energy-efficient solutions and by considering alternative power sources such as photovoltaics and human power. However, designing technological solutions is not a solution in itself. To actually exploit the potential of lower environmental impact, consumers have both to choose products that use less energy than the ones they replace, and use them effectively. This insight has inspired further research not only among research groups that traditionally were involved with sustainable product design research, but also increasingly among researchers from, for example, interaction design,

who are ‘discovering’ sustainable product design as an interesting and relevant research area. This essentially provides input to three main research directions:

- Further understanding why consumers might reject environmentally preferred solutions, and how to make these attractive for them;
- Further understanding why and how consumers inappropriately use products, and how to develop solutions that are more likely to be used appropriately;
- Understanding rebound effects, so they can be avoided in solutions derived from the first two research directions.

Research into possibilities for design intervention has identified opportunities that can be described in terms of distribution of control, ranging from providing feedback and information, to persuasion and steering, to blocking and/or forcing behaviour. This emerging field of research draws on and evaluates the adequacy of tools and methodologies which are core to industrial design engineering. It focuses on empirical studies on how users behave (ethnographic and behavioural studies, usability testing), what users prefer (consumer research/marketing), and on what enables users (system design, back-casting). When applied jointly, design dilemmas and trade-offs addressing consumer behaviour and preferences, commercial interests, and environmental benefits can be identified; indeed a triple bottom line perspective.

At the Department of Product Design, we are shaping up to become an important player in the research domain of “Design for Sustainable Behaviour”. Together with the main research groups in this area (to be found mainly in the UK, the Netherlands and Sweden) a research community is forming with extensive sharing of ideas and mapping out future research agendas. As of this moment, two PhD students, Ida Nilstad Pettersen and Johannes Zachrisson, focus their research on design for sustainable behaviour. Our group was prominently present at the

biannual Ecodesign conference in Japan, with several papers and a keynote lecture.

We aim for our research to be relevant for the IndEcol community as well. Ida has previously teamed up in a publication with Edgar Hertwich, Hogne Nersund Larsen and Christian Solli to discuss Climate Calculators and Expert Systems; information and feedback systems to increase user’s knowledge of the environmental consequences of their actions clearly link sustainable consumption and sustainable design research interests. Now it is our joint task to investigate in which contexts and under what conditions other, perhaps more appropriate, control and feedback mechanisms are worth exploring. With IPDs design creativity and understanding of users, and IndEcol’s understanding of environmental impact assessment, all the necessary conditions for excellent research are already there!

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ALUMINIUM AND STEEL IN A CHANGING ENVIRONMENT

The metals industries are exposed to three large trends that shape the conditions for their long-term development.

1. Population growth and industrialization move resources from the ground to products in use. As more and more people raise their standard of living, new infrastructures, buildings, vehicles etc. need to be built. The net growth in physical material stocks cannot be accomplished through secondary resources (recycling of scrap), but inevitably leads to resource consumption based on primary (ore) resources. Population growth and industrialization are taking place mainly in developing countries and emerging market economies, and these countries are therefore expected to contribute most to the primary resource demand over the coming decades, while developed countries have an increasing potential to recycle the scrap from retiring stocks that were built up over the past decades.

2. Globalization moves resources and production-related emissions around the world. Trade liberalization and sharply declining transportation and communication costs, combined with increasing specialization, have led to rapidly growing international trade in a wide variety of goods and services. As goods are shipped around the world, so do the

materials they are made of. By importing final products instead of producing them domestically, countries may obtain valuable secondary resources once these products reach the end of their life, and they can indirectly export energy use and emissions to the countries that produce these goods. Trade in critical resources also creates new dependencies between countries and contributes to the re-shaping of the geopolitical conditions. For example, to ensure access to raw materials, China has developed close ties with African countries and has invested large amounts of money into building new infrastructures.

3. Climate change is changing the metal cycles in many ways. Mitigation strategies require new, energy and emission saving technologies for metals production. For many metals, recycling and reuse are by far the most effective measures to significantly reduce energy demand and emissions. For example, aluminium recycling reduces energy consumption by about a factor of 20 compared to the production from bauxite (ore). Mitigation strategies also involve new technologies in energy infrastructures or final products such as low-energy buildings or fuel-efficient vehicles, which may require different materials. In addition, adaptation strategies also involve developing

new infrastructures that require metals in various amounts.

These long-term trends are likely to shape the conditions for future resource management, and they are, therefore, important factors to be considered by governments and industries who are newly positioning themselves in the global economy. A robust understanding of the global metal cycles, their drivers, and their links with energy and greenhouse gas emissions can facilitate this process. The MFA research group aims at supporting long-term industry and government strategy development related to aluminium and steel as case studies. Our research focuses on temporal (analyzing the dynamics of resource stocks and flows and developing long-term scenarios) and spatial aspects (analyzing the global multi-level cycles with a focus on changing trade patterns) of the metal cycles, as well as the link between the metal cycles and energy use (direct energy use in the use phase and indirect energy use needed to produce the materials).

In doing this, we have established a close collaboration with industry partners. In 2009, we received funding from Hydro Aluminium (PhD Roja Modaresi) and ArcelorMittal (Post Doc Tao Wang) to strengthen our analysis of the aluminium and the steel cycles. In June 2009, we organized a workshop in Brekstad (about one hour by boat from Trondheim) with participants from industry, non-government organizations, and other universities, under the topic "aluminium and steel in a changing environment".

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Participants of the Brekstad meeting in front of the Guldteigbrygga in Uthaug: Gang Liu, Roja Modaresi, Daniel Müller, Even Nybakke, Mak Dehejia, Julian Allwood, Rachel Milford, Catherine Izard, Helge Brattebø, Peter Furrer, Georg Rombach, Magnus Fröhling, Galultier Massip, Stefan Pauliuk, Tao Wang. Not in picture: Marlen Bertram, Jean-Pierre Birat, Jirang Cui, Karen Sundelin, Venkatesh Govindarajan.

MEET GUEST PROFESSOR YASUSHI KONDO

The Industrial Ecology programme is pleased to welcome visiting Professor Yasushi Kondo among our faculty. He and his family have exchanged Tokyo for Trondheim for two years. Yasushi is a Professor at the Department of Economics under the School of Political Science and Economics at the renowned Waseda University, one of the biggest private universities in the country.

While Political Science usually is organized under the Faculty of Law in Japan, in Waseda University they have a long tradition for uniting Political Science and Economics, recently resulting in a new Department of Global Political Economy. Yasushi specializes in Microeconometrics including Input-Output Analysis (IOA). His work on the economic analysis of

waste management in Japan led to an interest in Material Flow Analysis (MFA) and the wider perspective of Industrial Ecology. Japan has a large population on a relatively small geographical area, so in contrast to Norway, the issue of waste management receives the same level of attention as climate change does.

Yasushi and his colleague, Professor Shinichiro Nakamura, have developed a novel accounting and analytical framework called the waste input-output analysis (WIO), which is an extension of the conventional IOA for properly dealing with both the flow of goods and the flow of waste in the economy, and applied it to hybrid life cycle assessment (LCA) and MFA. The basic concepts of IOA and WIO and some of their recent research results

can be found in the book they recently published, *Waste Input-Output Analysis: Concepts and Application to Industrial Ecology* (Springer, 2009).

As is explained in their book, IOA is a basic tool for Industrial Ecology, especially for hybrid LCA and MFA, and it is the thriving group of researchers working with IOA, as well as the material flow analysis group at IndEcol, that brought Yasushi to Trondheim. He is looking forward to obtaining research results by collaborating with the faculty and the young researchers at the programme, which he considers to be among the best in the world.

Upon arriving here, Yasushi realized that he had heard about Trondheim once before. He graduated from Waseda University the same year as Kenji Ogiwara, who won the Nordic World Ski Championship in Trondheim in 1997. At the time, he could hardly imagine that he himself would be living in this town 12 years later. «As a keen Nordic ski spectator, I am looking forward to the Nordic Combined World Cup event in Trondheim next season», Yasushi says, «for the event in this season was, unfortunately, moved to Lillehammer due to lack of snow».

Speaking of cold weather, Yasushi has not had any problems with tackling low temperature or snow, although winters in Tokyo usually bring just a few days of snow. He and his family take pleasure in exploring the outdoor life in Trondheim as well as Norwegian culture. «I really enjoy traveling with the tram in this city», he explains, «it has a good feel to it and reminds me of trams in the cities where I have lived before». They are also venturing into the landscape of Norwegian food, and Yasushi, bravely enough, has tried to cook «lutefisk» – stockfish that has been soaked in lye for two days and two nights, and then rinsed in fresh water for 24 hours before it is cooked. Yasushi finds the variation and tasty quality of the fish available in Trondheim a pleasurable discovery.

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AN OFFICE WITH A VIEW - MEET PROFESSOR ELLEN MATTHIES

From her new office on Dragvoll campus, Ellen Matthies enjoys a forest view, and in winter, when the trees have no leaves, even a glimpse of the sea. «I can boast to my old colleges in Germany about going swimming in a nearby lake during lunch break», she says. Originally from Nordrhein-Westfalen, she has moved to Trondheim to work as a professor at the Department of Psychology, at the Centre for Risk Psychology, Environment and Safety (RIPENSA). Before coming to Trondheim, Ellen worked as an associate professor of Applied Psychology at the Ruhr-University of Bochum, RUB. She has guided several research projects related to fields of applied social psychology and environmental psychology, e.g. on the role of personal and social norms in resource consumption, on development and evaluation of interventions to promote pro-environmental behavior and health protection (mainly funded by the German Science Foundation and the German Federal Ministry of Education and Research). From 2003 to 2009, she was member of the board of the Environmental Psychology Division within the German Association of Psychologists (DGPs), and from 2007 to 2009 she was chair woman of the division. Her current research interests are in the field of resource consumption, particularly travel mode choice and energy consumption behavior.

The RIPENSA research group, combining the perspectives of risk psychology, environmental psychology, and societal safety, was established in 2007 and their master's programme in 2009. Despite a growing demand for environmental psychology knowledge, there are few positions available. In fact, the professorship at NTNU was the first in Europe in 15 years. Moving to a new country is a big change, but she enjoys the facilities at NTNU. «Student rooms and lecture halls are less crowded than in Germany», she says, «and I have direct online access to a much larger selection of journals and other resources than before».

Ellen is involved in teaching both master's courses in the RIPENSA programme and the PhD level course in Sustainable Consumption, which is part of the Postgraduate School of Industrial Ecology II (PSIE



II). «We have established a new exciting collaboration with the Industrial Ecology programme, so that from the Autumn semester 2010 students in the RIPENSA master's programme can choose industrial ecology courses and vice versa, as well as write an interdisciplinary master's thesis», she explains. The PhD course on Sustainable Consumption builds on the EU Marie Curie series of research training courses that were completed in 2008. She will co-teach the course together with Associate Professor Christian Klöckner, also at the Department of Psychology, and Edgar Hertwich from IndEcol. «I enjoy interdisciplinary work», she says. «If environmental psychology wants to contribute to an increased understanding of environmental challenges, we need to take into account what other disciplines can teach us. For instance, what are the most salient issues? Traditionally, there has been a focus in environmental psychology research on topics like recycling or donating money to environmental causes, but when decisions about buying a new car, investing in a new heating system or insulating our homes differently have a much bigger environmental impact, then that is what we should focus on».

On the other hand, environmental psychology has much to offer with respect to understanding user behavior, constraints in technological solutions and technol-

ogy transfer, perspectives that are often lacking in engineering based research. «People in Europe are not aware where they could start downsizing their consumption with minimum effort and maximum effect», she explains. «People need to learn about this in order to understand decisions made by their governments and to begin to take action». Knowledge is a prerequisite for changing behavior, but it is not enough. Ellen points to empirical studies that show that situational constraints need to be altered in order to bring people to change their lifestyle. But raising a general awareness of environmental problems and how to live more sustainable is important because so many different behaviors are relevant. Some subgroups in every culture will be more interested in environmental issues based on their social norms and personal motives. But, for other groups convenience, monetary costs, rewards or regulations will be what influences their behavior.

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