

Pro-environmental Product Planning in a Dynamic Operational Environment Now and in Future - Methods and Tools (ProDOE)

Report Year 2007

1 The Research consortium members

At Helsinki University of Technology (TKK)

The Institute of Law at the Department of Surveying: LL.D Ari Ekroos, M.Sc. Mari Pajunen, M.Sc. Matias Warsta, M.Law Mari-Linda Harju

The Laboratory of Environmental Protection: PhD Janne Hukkinen, M.Sc. Olli Salmi , Lic.Tech. Helena Mälkki

TKK Laboratory of Environmental Technology : D. Sc. Olli Dahl, M.Sc. Gary Watkins

TKK Laboratory of Energy Engineering and Environmental Protection: Lic.tech. Carl-Johan Fogelholm, Lic.tech. Sebastian Teir, M.Sc. Sanni Eloneva, PhD Justin Salminen (started 1.9.2007), M.Sc. Jaakko Savolahti (1.1-23.11.2007)

TKK Laboratory of Mechanical Process Technology and Recycling: D.Sc. Kari Heiskanen M.Sc. Maaria Kinnunen

At the Oulu University (OY)

The Laboratory of Process metallurgy at the Department of The Department of Process and Environmental Engineering: D.Sc. Jouko Härkki, PhD Jyrki Heino, M.Sc. Esa Virtanen (Manager of CIRU)

2 Objectives and Hypotheses

The group will research the complex interactions between the setting of regulatory objectives and the choice of scale of the engineered industrial ecosystems to be regulated and managed as well as the complex interconnections, dynamics and relevant cycle specific boundary conditions. This will require research on eco-efficiency indicators to understand their variability and how the policies chosen interact with these variations. It will also need research on the physical and chemical possibilities for utilization of different streams in the ecological web.

Our research hypotheses are:

- (1) The closure (including optimisation) of resource cycles can only be achieved if all the chemical, physical, technical, economic, legal, administrative, environmental, and social issues are considered together in a systemic way.
- (2) The policy must be discussed from the perspective of all actors.
- (3) We need to understand the implication of the metrics and procedures used.

The general objectives of the project are:

- (1) To produce a position paper of the research group of the existing situation concerning the metal and fibre cycles and the interconnected energy cycle. We will assess the current policies, their spatial and temporal effectiveness and outline existing boundary conditions.

(2) To identify legislative and regulatory development needs in order to promote sustainable use of resources and the closure of material cycles. We will try to propose some effective policies and legal instruments related to material cycles (legal, technical and economic means to control the material flow).

(3) To provide new insights into the metrics of industrial ecology by developing further the deterministic indicators so as to better understand the temporal and spatial scales of ecological efficiency.

(4) To intensify the utilisation rate of side-streams or rejects in the three industrial ecosystems, while taking into account the aspects arising from legislation, management, economy, ecology, material properties and processing. The possibilities for cross-linking the cycles will also be explored.

(5) To develop a first generation systemic model (generically a model framework) for the chosen material cycles in terms of system interconnectedness and dynamics and use the developed model in conjunction with the results of all the groups to generate dynamic estimates for the effectiveness of the chosen environmental policy instruments.

3 Expected research results

- A general assessment publication of the current policies, their spatial and temporal effectiveness and boundary conditions.
- Analytical tools for investigating the influence of temporal and spatial scale on ecological efficiency.
- Multidimensional indicators of ecological efficiency and effectiveness.
- Improved utilisation rates of wastes and by-products in the three cases.
- Recommendations for environmental regulation or de-regulation promoting resource cycle closure.
- Systemic model for test cases for estimating effectiveness of environmental regulation.

3.1 First year results

Publications:

- Eloneva S., Teir S., Zevenhoven R. and Fogelholm C.-J., 2007. Reduction of CO₂ emissions for steel plants by using by-product slag for production of calcium carbonate. Oral presentation at CHEMRAWN XVII and ICCDU IX Conference (Greenhouse Gases: Mitigation and Utilization), July 8-12, 2007, Kingston, Ontario, Canada.
- Eloneva S., Teir S., Savolahti J., Fogelholm C.-J., and Zevenhoven R., 2007. Co-utilisation of CO₂ and Calcium Silicate-rich Slags for Precipitated Calcium Carbonate Production (Part II). In: Proceedings of ECOS 2007, Padova, Italy, 25-28 June 2007, Volume II, p.1389-1396.
- Heino J. 2007. Harjavalta industrial park as an industrial ecosystem to increase regional and global sustainability. Environmental management in networks course. University of Jyväskylä 22.3.2007. 26 pp.
- Heino J. ja Koskenkari T., 2007. Harjavallan suurteollisuuspuisto teollisena ekosysteeminä. Finnmaterial kongressi 9.-10.5.2007 Jyväskylä. 27 s.
- Heiskanen K., 2007. Mineraalisten raaka-aineiden materiaalivirrat, Kestävän kehityksen seminaari, Keynote presentation, GTK, (to be published)
- Hukkinen J. 2007. Sustainability Networks: Cognitive Tools for Expert Collaboration in Social-Ecological Systems. London: Routledge, (in press)

- Hukkinen J. 2007. "Kasvun rajojen määrittäminen" ("Setting the limits to growth") in Finnish, in K. Raivio, J. Rydman, A. Sinnemäki (eds) *Rajalla—tiede rajojaan etsimässä*, Helsinki: Gaudeamus, pp. 202-212
- Kinnunen M. Oja M. and Heiskanen K. 2008. Recovery of Scrap Metals from MSWI bottom ash Using Physical Separation Methods (Pending), International Mineral Engineering Congress September 2008, Beijing
- Leinonen V., Heino J., Makkonen H. and Härkki J. 2007. Towards sustainable development – nickel slag's way to product. 13th Annual Sustainable Development Research Conference June 10-12, 2007, at Mälardalen University in Västerås. Abstract, Virpi Leinonen's PowerPoint –presentation and preliminary paper.
- Martikka M., Dahl O., Vuorinen T., Pikka O., Tervola P ja Vehmaa, J., 2007. Organically bound chlorine in ECF bleaching: focus on the pulp bound fraction (OCI). *O Papel*, September 2007. p. 56-66.
- Maximova N., Dahl O., 2007. A set up of a modern analytical laboratory for wastewaters from pulp and paper industry. *Chem. Soc. Rev.*, 36, 2007. DOI: 10.1039/b515226g. Royal Society of Chemistry.
- Mälkki H., Salmi O. ja Heino J., 2007. Life cycle assessment and industrial ecology in an eco-innovation study to manage the resources cycles. SETAC Europe 17th Annual Meeting 20 - 24 May 2007 in Porto, Portugal. Poster presentation.
- Peltonen P. and Mälkki H., 2007. Overview on ProDesign Principles of the Environmentally Sustainable Products. Helsinki University of Technology Lahti Center. 13th Annual International Sustainable Development Research Conference, Track 11: The Sustainability of New Product Development Projects, Västerås, Sweden, 10-12 June 2007.
- Pöykiö R., Nurmesniemi H., Dahl O. ja Paama L., 2007. Assessment of environmental hazards of heavy metals in the fly ash from a new municipal district heating plant (32 MW) with respect to the Finnish criteria for utilization as a forest fertilizer and earth construction agent as well as for landfill disposal. *Eesti XXX Keemiapäevad - Estonian 30 th Chemistry days - Eestin XXX Kemian Päivät*, 16.11.2007. Abstracts of Scientific Conference, Abstract Nro: 59. Abstract Book, p. 127. Tartu Ülikooli Keemia Institute, Tartu.
- Pöykiö R., Nurmesniemi H. ja Dahl O., 2007. Concentrations of nutrients and heavy metals in cyclone fly ash from the grate-fired boiler at a small municipal district heating plant (6 MW). *Journal of Residuals Science & Technology*, 4(3), 127-136.
- Salmi O.H. and Hukkinen J.I., 2007. "Cultural contextualization of indicators of human-environment interaction: the case of the Kola mining network," *Environmental Sciences—Journal of Integrative Environmental Research*, Vol. 4, No. 4, pp. 209-228
- Teir S., Kuusik R., Fogelholm C.-J. and Zevenhoven R., 2007. Production of magnesium carbonates from serpentinite for long-term storage of CO₂. *International Journal of Mineral Processing*, 85(1-3), 1-15.
- Teir S., Revitzer H., Eloneva S., Fogelholm C.-J., and Zevenhoven R., 2007. Fixation of CO₂ by Dissolution of Serpentinite and Precipitation of Magnesium Carbonates. In: *Proceedings of ECOS 2007, Padova, Italy, 25-28 June 2007*, In: *Proceedings of ECOS 2007, Padova, Italy, 25-28 June 2007, Volume II*, p.1333-1340.
- Teir S., Eloneva S., Fogelholm C.-J., and Zevenhoven R., 2007. Carbonation of minerals and industrial by-products for CO₂ sequestration. In: *Proceedings of IGEC-III, 2007. The Third International Green Energy Conference. June 17-21, 2007, Västerås, Sweden*. ISBN: 978-91-85485-53-6 (CD-ROM).

- Warsta M., 2007. Ympäristölupajärjestelmän uudistamiseen liittyviä huomioita suhteellisuus- ja toissijaisuusperiaatteiden näkökulmasta. Ympäristöjuridiikka 2/2007 (in Finnish, Peer review article).
- Zevenhoven R. Teir S., Eloneva S., Aatos S. ja Sorjonen-Ward P., 2007. CO₂ sequestration by carbonation of minerals and industrial by-products in Finland. Invited presentation at R'07, Davos (Switzerland), Sept. 3-5, 2007

4 Activities of The Research Project

Seminars:

Institute of Law arranged the first international ProDOE-seminar held in October 25, 2007 in Otaniemi. The seminar was called “75 Years of Economic and Environmental Law at Helsinki University of Technology” to celebrate the institute’s anniversary. The seminar was an enormous success as such acknowledged European scientists as Dr., Prof. Ludwig Krämer, Dr., Prof. Geert van Calster and Dr., Prof. Christoph Bey were present as international key-speakers. In addition to these names, the most respected domestic specialists in environmental law also gave speeches lead by Dr., Prof. Erkki J. Hollo and Dr., Justice of the Supreme Administrative Court Pekka Vihervuori among others. Altogether seven Ph.D. students including Warsta from Institute of Law’s ProDOE research team presented their scientific work during the day.

Visitors:

The visit of Christoph Bey.

Visits:

- Eloneva S.: oral presentation at CHEMRAWN XVII and ICCDU IX Conference (Greenhouse Gases: Mitigation and Utilization), July 8-12, 2007, Kingston, Ontario, Canada.
- Eloneva S.: Participation at the French-Finnish seminar “Chemistry for the protection of the global environment”, arranged by the Academy of Finland and Centre National de la Recherche Scientifique (CNRS), September 6th, 2007, Academy of Finland, Helsinki
- Heino J.: Participation in 75 Years of Economic and Environmental law –seminar at Helsinki University of Technology 25. - 26.10.2007
- Heino J.: Participation in Mineraalisten raaka-aineiden kestävä käyttö –seminaari at 17 of October 2007
- Heino J. Participation in 13th Annual Sustainable Development Research Conference June 10-12, 2007, at Mälardalen University in Västerås.
- Hukkinen J.: European Society for Ecological Economics Conference, Leipzig, Saksa, 5.- 8.6.2007.
- Hukkinen J.: Furthering Sustainable Development through Integrated Planning in Municipalities, Lahti, 28.-29.8.2007.
- Hukkinen J.: Baltic Sea Action Group Workshop, Helsinki, 29.-30.11.2007.
- Kinnunen M.: Participation in R'07 World Congress, Recovery of Materials and Energy for Resource efficiency, Davos Switzerland September 2007
- Mälkki H.: ISO/TC207/WG7 (2005 - 2007), Revision of ISO Guide 64 "Inclusion of Environmental Aspects into Product Standards", in 2007 workgroup meetings in Sao Paolo and in Peking.
- Teir S.: session co-chair and oral presentations at ECOS 2007, Padova, Italy, 25-28 June 2007.

- Teir S.: oral presentation at IGEC-III, 2007. The Third International Green Energy Conference. June 17-21, 2007, Västerås, Sweden.

Other activities:

- ProDOE –workshop at Rautaruukki Raahe steel works at 10– 11 October 2007
- Bothnian Arc Industrial Ecology Enterprise “ZeroWaste” -application for EU’s Life+ funding program
- Heiskanen K.: Material, Minerals & Metal Ecology ’06 Special Edition, Minerals Engineering, guest editor
- Heiskanen K., Material, Minerals & Metal Ecology ’09, organising committee, co-chair.

5 Progress of The Research Project

Tasks of the Research Team	2007				2008				2009				2010			
	I-III	IV-VI	VII-IX	X-XII	I-III	IV-VI	VII-IX	X-XII	I-III	IV-VI	VII-IX	X-XII	I-III	IV-VI	VII-IX	X-XII
Workshop	x		x		x		x		x		x		x			x
PhD-course				x				x				x			x	
Seminar			x	x			x			x		x			X	
Meetings	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	x
Articles					x		x		x		x		x		x	
Communications	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Documentation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
National cooperation			x		x		x		x		x		x		x	
International cooperation		x					x					x		x		
Conferences				x				x				x				x
Steering Group Meetings			x		x		x		x		x		x		x	

5.1 Professor Ekroos’ research group

Institute of Law started the project by gathering information and analyzing existing legislation both on national and community level. In addition EU’s strategic plans were carefully reviewed. The research team is preparing a scientific article based on the findings and Prof. Ekroos gave a presentation on the theme during the workshop at Rautaruukki Raahe steel works. Institute of Law also went through all environmental permits granted to the Finnish forest cluster (one of the core fields of interest in the ProDOE-project) and acquired a lot of useful background information. The pros and cons of the current permit driven environmental instrument system were also studied in a published peer review article.

Institute of Law also arranged the first international ProDOE-seminar held in October 25, 2007 in Otaniemi. The seminar was called “75 Years of Economic and Environmental Law at Helsinki University of Technology” to celebrate the institute’s anniversary.

It is to be noted that Institute of Law's main research scientist appointed to this project, Mari Pajunen, spent the whole year on maternity leave. These saved resources are allocated to be used during the following three years.

5.2 Professor Hukkinen's research group

The aim is to address the interplay between industrial ecology and ecological efficiency by conducting an integrative, comparative and systems-level exploration of ecological efficiency related to industrial ecosystems. We aim to better understand the criteria of managing industrial ecosystems on local, regional and global levels.

Task	Method	Schedule	Researcher
Conceptualize specific case innovations in terms of products (innovation <i>scenarios</i>): The Bothnian Arc chosen as case region	Meetings with researchers from other sub-projects	2007	Salmi

5.3 Professor. Dahl's research group

ProDOE - Identification and investigation of industrial residue streams for innovative use/reuse - Pulp and paper industry - Bothnian Arc Region

Research on industrial residue streams in the Bothnian Arc region concentrating on the fibre industry. Achieve advances through the identification of specific candidate material streams for further investigation:

- Identification of the limiting factors hindering the current utilization of significant material streams identified, including characterizing stream impurities.
- Investigation of the technical feasibility of innovative uses and ways to overcome utilization issues presented by impurities or residue characteristics.
- Development of new ideas for new processes and new ways of connecting existing processes, especially in the fibre cycle, through investigating ways of reducing impurities, changing compositions or finding new ways of combining material streams.

Gross quantification of material flows - Survey of environmental licences for pulp and paper mills in the Bothnian Arc Region – **CIRU Report** – forms starting point for other ProDoe Groups' quantitative approaches.

Initial literature research on residual material properties and current material utilizations in the pulp and paper sector.

5.4 Professor Heiskanen's research group

Concentrating on getting acquainted with the useful tools for resource system model such as Simulink-Matlab toolbox as well as the related literature. Literature survey is on material efficiency, recycling, industrial ecology, materials and material classes interconnection, material cycles and processes involved and boundary conditions for materials recycling. Doctoral studies on applied mathematics and environmental studies.

First article is pending for International Mineral Processing Congress, Beijing 2008. The article is based on the research carried out during master's thesis, on recovery of scrap metals from MSWI bottom ash using physical separation methods. The article will include material efficiency considerations on the municipal solid waste incineration.

5.5 Professor Fogelholm's research group

The research work has focused on further developing methods for producing pure calcium carbonate from steel converter slag.

An extensive experiment series for solvent selection has been performed for steel converter slag. The results showed that while the acids tested were the most efficient solvents for dissolving steel converter slag, ammonium salt solutions were also efficient and extract calcium much more selectively. Ammonium nitrate solutions was found to be the best solvent for extracting calcium selectively from steel converter slag, followed closely by ammonium chloride and ammonium acetate solutions. The results indicates that if ammonium salt solutions are used as working media in a carbonation process there would be little need for additional separation measures of unwanted elements.

Scaled-up extraction experiments showed that leaching steel converter slag with ammonium salt solutions does not change the structure of the slag, but removes all of the free lime phases and part of the calcium silicate phases. Bubbling CO₂ through the filtrates caused very pure calcium carbonate (as calcite) to precipitate. This seems to be a cheap and environmentally friendly approach to produce synthetic calcite, because no virgin material or additional chemicals are required. Also, the large CO₂ emissions from calcination required in conventional carbonate production would be eliminated when using this method. Although the ammonium salt solution is in theory regenerated after carbonation, we have not yet tested the possibility to re-use the spent solution.

5.6 Professor Härkki's research group

According to research plan the researcher has with the help of many mutual meetings acquainted the research group of ProDOE and especially in the Innovative use of material streams subproject to utilize to the joint expertise in research group maximally. One very big effort has been ProDoe – IMS – Residual Materials Quality Matrix needed for inquiry concerning unutilised material residues from metallurgical, chemical, and pulp and paper industries.

As promised in ProDOE application additional funding was applied by making to EU Life+ Program a very big application Bothnian arc industrial ecology enterprise, where the main target is to improve material and energy efficiency through both intra and inter company development work utilizing the unutilised energy and material residues from Finnish and Swedish metallurgical, chemical, and pulp and paper industries around the Bothnian Arc region according to will be applied in the case this is approved

The literature research of new feasible utilisation possibilities beyond the conventional usage of copper and nickel slag as a raw material in the area of earthworks, road construction, coating of the dumping areas, sand blasting and roofing felt industry has been started in the laboratory of Process metallurgy. Also information and networking got from other ongoing projects in the Laboratory of Process metallurgy will be utilized.

Arrangements of the first ProDOE –workshop at Rautaruukki Raahе steel works at 10 – 11
October 2007