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RESOPT - A Multidisciplinary Consortium for Resources Use Optimization

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Abstract

RESOPT is a multidisciplinary consortium committed to address the issues of resources use optimization. Waste minimization and utilization activities in Northern Ostrobothnia region of Finland were analyzed, with an aim to achieve an eco-efficient flow of resources. RESOPT's main sphere of interest is waste minimization, clean technologies and by-product utilization; however, theoretical issues such as improving waste definitions, motivation for waste minimization and Waste Management Theory development have also been addressed. This two-year project started in July 1st 2003, and was financed by the Eco-efficient society programme of the Ministry of Environment of Finland.

1 Introduction

It is, still, largely the case that the rules of international laws are, with few exceptions, aimed at regulating the disposal of waste rather than addressing and preventing its generation. Even when conventional environmental and waste policy approaches have succeeded in attaining their own specific objectives, they have not been sufficient toward overall waste reduction. Recycling has been increasing, but without waste prevention efforts, the amount of waste generated will continue to grow. It is so because recycling addresses only the disposal of the material included in the product, but waste minimization addresses the whole production chain. While it is true that the principle of waste prevention is universally accepted, the practice has lagged far behind. Robert Ayres, he who coined the term "industrial metabolism," has concluded that 94% of the materials extracted for use in manufacturing become waste before the product is even made, and 80% of products are discarded after a single use (Ayres and Ayres 1996). Researchers of the German Wuppertal Institute estimate that 10% of the Earth's population currently consumes 50% of its resources (Schmidt-Bleek 2000). In has been 18 years since the Brundtland Report alerted the world to the urgency of making progress toward economic development that could be sustained without depleting natural resources or harming the environment. It is still maintained that social equity, economic growth and environmental maintenance are simultaneously possible, and each nation can achieve its full economic potential whilst enhancing its resource base. To this end, an efficient use of resources is of paramount importance and a moral responsibility of industrialized countries to secure a global equity for future generations.

2 The purpose of the consortium

This consortium has committed itself to address issues of resources use optimization to achieve and eco-efficient flow of resources. The consortium seeks to:

- Join forces of research-, industrial-, administrative- and regulating bodies toward the goal of resources use optimization.
- Promote Best Practice in local industry by implementing waste minimization and clean technology. To this end investigate the applicability of tools developed by the UK ENVIROWISE programme.
- Promote integrated resources management through the utilization of secondary materials.

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- Provide a co-ordinated approach to addressing the issue of finding a proper definition for waste.
- Provide and encourage communication between researchers and practitioners such that scientific advances can be more readily understood and adopted.
- Bring together the supply and utilization sides of secondary material use, to foster a greater understanding of the benefits of by-product synergies.

The University of Oulu was ready for this challenge, as environmental issues are one of the focus areas of the university. The use of clean technologies for waste prevention, separation processes to recover valuable compounds from waste and biomaterial, catalytic processes vital to resources use optimization are being studied. As well, Industrial Ecology, Green Chemistry and Green Engineering, waste minimization and resources use optimization, are researched in several laboratories and departments of the university.

3 Key concepts

3.1 Waste minimization, resources use optimization

Waste minimization and waste prevention are on the top of waste management hierarchy, and a priority in any nation's or organization's waste management strategy. Waste minimization has been defined by the OECD as (Riemer & Kristoffersen 1999):

> *"Preventing and/or reducing the generation of waste at the source; improving the quality of waste generated, such as reducing the hazard, and encouraging re-use, recycling, and recovery"*

Waste prevention differs from this in a way that it only includes strict avoidance, reduction at sources and re-use, and does not include recycling and recovery operations (Vancini 2000).

Minimizing the amount of waste in an organization or in individual process goes hand-in-hand with optimizing their use of resources. Strictly speaking, resources use optimization is not a waste management concept. It refers to use of natural resources in general, and points out their limited nature which is necessitating their sparing use. It can be defined as follows (Dillon and Anderson 1990):

> *"The objective of resource use optimization is to maximize the level of net benefit generated by applying a resource to produce an output."*

Resources use optimization is a key element of integrated resources management, which has been defined by the R'99 conference on recovery, recycling and re-integration as:

> *"the recovery of economic value from any resource produced naturally or by society while considering ecological, economic, technological and social implications of recovery, recycling and re-integration technologies."*

Integrated resources management is an extended view from waste management, one that also wishes to avoid the negative connotations associated with the word 'waste.' For the same reason, waste minimization is also extended to the wider concept of resources use optimization.

3.2 The definition of waste

Waste is defined by the European Council Directive on waste (91/271/EEC) as:

> *"any substance or object (in the categories set out in Annex I) which the holder discards or intends or is required to discard.*

Effective cycling of materials is presently hindered by this definition of waste, and the legal consequences associated with the label of waste. Under present environmental regulation, waste

is viewed more as a potential pollutant and not as a useful resource. Industry has voiced serious concerns that definitions may become a barrier to an efficient and sustainable European waste management. (Pongrácz 2002.) The Community Directive on Waste introduces a distinction and provides for different permits between disposal operations and recovery operations. This legal situation has created a number of disputes that had to be resolved at the European Court of Justice. Among others, it was referred to the ECJ for ruling whether waste may be classified as re-usable residue and thus fall outside the scope of the legislation on waste. The Court held that "a substance of which its holder disposes may constitute waste within the meaning of Directives even when it is capable of economic re-utilization" (Purdue 1998). The problem arises because there is no explicit link between the term 'waste,' and 'disposal' and 'recovery operations.' As well, the distinction between the recovery of waste and the further use of residues left over from a particular process is somewhat fragile. (Ibid.) The Waste Directive recognizes the need to ensure a "common terminology and definition of waste" in order to improve the efficiency of waste management, and work is presently on-going under the thematic strategy on the prevention and recycling of waste (COM(2003)301final). There is a need to focus upon the development of more appropriate, sustainable definitions so that what is now commonly perceived as being waste will in fact be increasingly seen as resource-rich, 'non-waste' (Pongrácz 2002).

3.3 Industrial Ecology

Industrial Ecology is aiming at developing closed industrial ecosystems, which does not necessarily mean closed systems within industry, or closed loop recycling. The idea of Industrial Ecology is to mimic natural ecosystems in their efficiency of recycling materials (Graedel and Allenby 1995). A significant difference between natural ecosystems and industrial systems is that in the nature "recycling organisms" have been evolved which close the natural cycles of major elements. Evidently, biological evolution responded to inherently unstable open systems by inventing new processes to stabilize the system by closing the cycles. This was a result of a several billion years' long evolutionary process. (Ayres 1988.) To complete the industrial metabolism, we also need to develop recycling technologies that enable us to cycle material within industrial ecosystems efficiently. By-product utilization is an essential 'ingredient' in both resources use optimization and in realizing Industrial Ecology in practice.

4 Objectives and research steps

4.1 Waste Definition in Legislation and its Environmental Impact: Toward an Integrated Material Policy.

In the first instance, this consortium aspired to provide a co-ordinated approach to addressing the issue of finding a proper definition for waste. The question of whether industrial by-products are wastes or non-wastes has been the concern of recycling industry Europe-wide, including Finland. There has been a great interest by the members of this consortium to offer contribution into addressing the question of waste definitions. Conceptual analysis of waste definitions and their legislative impact had been thoroughly investigated and several publications were published by RESOPT members on this subject during the duration of the project (Pongrácz and Pohjola 2004, Pongrácz et al 2004a&d). It is maintained that wastes have to be analyzed by the reason of their generation, as prevention requires knowledge of the cause. It has been demonstrated that wastes can be separated into four classes: things produced with no purpose, things that have fulfilled their purpose, things with unsatisfactory performance, and things that their owner failed to use for their purpose (Pongrácz 2002). As it is argued that every waste can be put into one of these classes, it follows that everything outside of these classes is a non-waste. Based on this consideration, it can be argued that *non-waste* is a thing, which has been assigned a purpose by the (potential) owner, and this owner will either use it for that purpose, or by adjustment of state

or structure, ensures that the thing will be able to perform with respect to the assigned purpose (Ibid.).

Researchers involved in industrial by-product utilization, as well as their industrial parties processing by-products, provided a base of analyzing the issue of waste definition. Several industrial by-products such as metallurgical rejects (Makkonen 2004), CO_2 (Turunen et al. 2004a & b), waste potatoes (Liimatainen 2003, Liimatainen et al. 2004), oils used in forestry industry (Juntunen 2003), and the constraints of by-product utilization (Poikela 2005a, Poikela et al 2005) were analyzed as case studies.

4.2 Methodology development for waste management: Focus on the waste management hierarchy

World-wide, waste minimization is on the top of the hierarchy of waste management options. To facilitate waste minimization and thereby resources use conservation, the main roles of waste management are waste avoidance, and turning wastes to non-wastes. Waste prevention, however, starts at the design table: products have to be planned considering re-use, recycling, and refurbishment; processes need to be designed in view of waste minimization. Waste Management Theory (WMT) evolving has continued under the RESOPT project and several presentations have been made, and scientific articles published in this subject (Pongrácz et al. 2004a & b, Pongrácz 2005a).

These developments were utilized in doctoral researches regarding *waste minimization in the chemical industry* (García et al 2004a & 2005a) as well as *the use of environmental best practice technologies in food industry for waste minimization and utilization* (Pap et al. 2004 a,b,c & 2005). The Building Performance and Construction Laboratory, involved in a research and education of *environmentally conscious renovation and refurbishment*, had also contributed to this part (Tikka 2003).

Envirowise tools were also investigated and successfully tested in industry case studies in Northern Ostrobothnia (Kvist et al. 2004, Päivärinta et al. 2004). The Envirowise Best Practice Programme is a government funded programme in the UK that helps companies to become more competitive through improving their environmental performance by reducing waste at source. Environmental Performance Guides provide companies with the tools that allow them to measure and improve their performance. Good Practice Guides describe how practical, cost-saving measures to reduce waste can be put into action. (Envirowise 2005.)

In addition, a conceptual model of environmental management systems (EMS) of reverse information streams has been studied (Nurminen and Pongrácz 2004), the role of EMS in waste minimization in metallurgy industry has been investigated (Kvist et al. 2004 & 2005 a,b), several surveys regarding attitudes and activites in waste minimization have been performed (García et al. 2005b, Mikkola 2004, Olgyaiová 2005) the role of motivation in waste minimization behaviour investigated (Olgyaiová 2005, Olgyaiová et al. 2005), ways of employee motivation suggested (Olgyaiová 2005) and a strategic waste minimization programme was proposed (Mikkola 2004).

The ultimate aim of this research step was further the development of WMT. In particular, WMT's connection to Industrial Ecology Theory had been analyzed (Pongrácz 2005a).

4.3 Establishing a local 'Waste Intelligence Network'

The main purpose of this initiative was mapping of material flows, and locating waste sinks, and loose ends. This process is on-going, it has not been expected that it could have been finished within the duration of this project. However, parts have already been executed, available

information has been collected (Ylä-Mella et al. 2005), with help received from the FINWASTE project. This step was initiated in order to locate sources of non-utilized wastes, those that were to be addressed in the next step.

In addition, the RESOPT homepage has been established (2003) as a forum of presenting and sharing our work, where all the presentations and articles published under RESOPT are collected and are freely available.

4.4 Secondary material utilization through waste exchanges and new product development

The ultimate aim of secondary material utilization is to close material flows through by-product synergies under the paradigm of Industrial Ecology. The possibility of waste exchanges between industrial firms and Oulu municipality shall further be studied, to close material loops locally, and thus avoid transportation of recyclables on large distances. Information has been gathered from researches previously conducted on waste utilization (Heino and Koskenkari 2003 & 2004, Pekkola 2004). Cases of industrial waste utilization in Oulu region, and the Oulu environmental cluster have been analyzed (Poikela 2005, Poikela et al 2005, Nurmesniemi 2005). Building on these experiences and through co-operation within the researchers of the consortium, it is hoped that further creative ideas for closing material flows within the region will surface.

A wide range of industrial products and wastes have been studied: solvents (García 2004b), food products (Pap et al. 2004c & 2005, Mikkonen et al. 2004), oils (Junttunen 2003, Vähäoja 2003, Vähäoja et al. 2005), hazardous waste (Kuokkanen 2003, Saarela 2004, Saarela et al. 2004), electronic scrap (Saukkoriipi 2003, Saukkoriipi et al. 2004, Ylä-Mella et al. 2004, Pongrácz et al. 2004c), CO_2 (Turunen 2004 a & b), ashes, dusts and sludges (Nurmesniemi et al. 2004 and 2005, Pyökiö et al. 2004, Makkonen 2004) and volatile emissions (Ojala et al. 2005).

Several diploma works (Mikkola 2004, Olgyaiová 2005, Poikela 2005) and pro-graduation works (Junttunen 2003, Saarela 2004, Liimatainen 2004) have been completed under this heading.

For an effective information flow, numerous smaller discussion events took place, as well as some larger seminars (on October 20th, 2003 and June 17th, 2005) for a wider audience were arranged, as well as a conference on waste minimization and resources use optimization organized on June 10th, 2004. All of the graduate and post-graduate researchers were also encouraged to participate the intensive post-graduate course on waste minimization and resources use optimization (March 29th – April 2nd 2004), which has been organized in collaboration with the Graduate School in Chemical Engineering and the SITA Centre for Sustainable Wastes Management at the University College of Northampton, U.K.

5 Dissemination of information within the consortium

Openness and sharing is one of the most significant principles of the RESOPT consortium (Pongrácz 2004b). The RESOPT's Internet homepage (RESOPT 2003) has been the foremost important forum that presents the members and their work with links to their recent publications produced under RESOPT.

These publications have been presented on various international and national scientific conferences and stakeholder meetings. RESOPT has also published two proceeding books (Pongrácz 2004a & 2005b), which have been distributed on RESOPT-organized events, as well as placed in Oulu University's library. The full proceedings are also available to download from RESOPT's homepage. In addition to this, RESOPT has significantly contributed to extending Oulu University library's waste management related publications. 12 proceeding books, 4

reports, 3 textbooks and additional 2 scientific books have been donated to the library. Some of these have been acquired from RESOPT's resources; however, most of them have previously been owned by RESOPT members and acquired while visiting conferences. In addition, 2 scientific journals and one waste management professional magazine has been subscribed from RESOPT's resources and also placed in Oulu University Library.

A discussion forum has also been established, to which members and other interested parties could have had subscribed and discussed various waste management issues. Unfortunately, this forum has not managed to fulfill its potential and has not been in regular use. In contrast, personal meetings have been frequent; RESOPT meetings have been arranged on a regular basis. On average there were about 2 RESOPT meetings monthly, where research progress has been reported, lively discussions on waste management and resources use optimization were kept and further strategies were discussed.

6 Connection to other projects

Of the other projects financed by the Eco-efficient society programme, collaboration was closest with the *FINWASTE* project lead by Ilmo Mäenpää of the Thule Institute of Oulu University. The FINWASTE project maps waste flows as part of material flows in Finland. Docent Mäenpää's expertise, and the waste data collected and organized by FINWASTE immensely increased the knowledge-base of this consortium and aided our analyses of waste utilization potential.

Students participating the waste minimization and resources use optimization post-graduate course also benefited from the knowledge of Michael Lettenmeier, one of the leaders of the *FIN-MIPS in transport* a project. Michael Lettenmeier delivered a lecture on the concept and measures of eco-efficiency.

RESOPT has also benefited from the experiences of the *OPTIDUST* project co-ordinated at the Process Metallurgy Laboratory, the *regional network of recycling* initiated by the Employment office of the City of Oulu and the "Otetaan uusiksi" project of Kotka-Hamina region. Hannu Makkonen of OPTIDUST, Virpi Knuutinen of the regional recycling network and Vesa Pekkola of Otetaan uusiksi have delivered presentations on RESOPT-organized events (Makkonen 2004, Knuutinen 2003, Pekkola 2004). In addition, informal exchange of information has been established with the New Design Culture (NDC) project, involving the Chemical Process Engineering Laboratory, University of Jyväskylä, and VTT.

7 International collaboration with the consortium

Our international activity has been dynamic and fruitful. Our long-term collaboration with the SITA Centre for Sustainable Wastes Management at the University College in Northampton in U.K. has been strengthened and widened to include joint publications (García et al. 2005a & b, Pongrácz et al 2004a, b & c), researcher exchange and guest lecturing. This collaboration is especially important, as the Northamptonshire Resource Efficiency project, which was co-ordinated by Prof. Phillips of SITA, has been a model to building the RESOPT consortium. This project is based on a partnership between companies and higher education institutes. It is a highly cost effective method intended to develop a culture of waste minimization in the country. This partnership stands as a model for waste minimization developments world-wide.

A bilateral agreement under the Socrates program had already existed between our Department of Process and Environmental Engineering and The Department of Food Engineering of Szent István University in Budapest, Hungary. RESOPT had its share of activity under this agreement, as a joint publication has been done with Szent István (Pap et al. 2004c). In addition, bilateral

agreement had been made with the Faculty of Economics and Administration of Masaryk University in Brno, Czech Republic. Under this latter agreement, a joint diploma project had been conducted to analyze the roles of motivation in waste minimization and compare the levels of environmental awareness in Czech Republic and Finland (Olgyaiová 2005, Olgyaiová et al. 2005).

8 Results

One of the main values of this consortium was its unique line-up, bringing together researchers and senior academics from several departments of the University of Oulu with waste management companies and organizations in and near Oulu, as well as with environmental regulatory bodies. This research consortium offered multidisciplinarity and variety in different strategic and conceptual levels. Resource management issues have been dealt with on conceptual, organizational and technical levels. On the other horizon, the environmental, legal and social impacts, as well as the economics and logistics of resources use have also been analyzed. The consortium also addresses the gap between global goals and local practices. It is hoped that this project contributed to promoting waste minimization and resources use optimization in Oulu region. The significant academic and educational impact is undisputable, as 11 post-graduate students have been working in, or collaborating with the project, 3 diploma and 3 pro-gradu works have been finalized, aided by 6 doctors and senior academic members. A new post-graduate course was developed and lectured, and knowledge gained during the project has been used in other undergraduate courses as well. Several academic papers have been published, and 6 journal papers have been compiled by RESOPT, and submitted to a refereed academic journal of Solid Waste Technology and Management. In addition, a scientific conference was organized and 2 proceeding books have been published. All of the results have been disseminated widely and efficiently. Countless new contacts have been made, and a lively, dynamic scientific group open to communicate and share has been established.

9 Conclusions

Sustainable waste management is about achieving an effective flow of materials, energy and information. Universities have a substantial role in waste management research, as well as in educating engineers to meet the needs of industry. Collaboration between industry and universities has the dual benefit of speeding up response time and amplifying knowledge dissemination. Ultimately, waste avoidance should become the ‘open source’ of waste management – one that everybody can use freely and be encouraged to explore further, develop and put forward (Pongrácz 2004b).

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