

Initial Position, Requirements and Plans of the IIP within the EDUKALIBRE Project

The **Institute for Industrial Production (IIP)** (founded 1982) is responsible for the teaching of business engineers with courses on Production Management with an focus on Environmental issues at the **University of Karlsruhe** and belongs to the **Faculty of Science of Economics**. Today, this faculty is the largest school for business engineers in Germany. The 11 faculties of the University of Karlsruhe offer about 40 study courses for its 17,000 students. About 3500 professors, research assistants and technical staff work at the University.

The **Institute for Industrial Production (IIP)** works in close cooperation with the **French-German Institute for Environmental Research (DFIU)**. The French-German Institute for Environmental Research (DFIU/IFARE) is a joint effort of the French government, the Regional Council of Alsace (France) and the State of Baden-Württemberg (Germany) and aims at supporting transboundary cooperation in the field of environmental research. Prof. Dr.rer.nat. Otto Rentz is director of both institutes.

The **interdisciplinary method of solving technical and economic problems** is characteristic of the institute. Research includes primarily the techno-economic analysis and evaluation of emission reduction techniques (especially for dust, SO₂, NO_x and VOC), the development of regional/national emission reduction strategies as well as the techno-economic evaluation of production-integrated waste treatment concepts and their control in all the Member States of the European Union.

Recent research projects of the research team “Technique Assessment” comprise - inter alia - the development of methodologies and data bases for the assessment and optimisation of the economic performance of emission reduction strategies on a regional, national and supranational level. This concerns mainly the assessment and the technical, economic and ecological (eco-balancing) characterisation of emission reduction measures for different emission sources, as well as the investigation of socio-economic influencing factors regarding the diffusion of such technologies. The institute is also involved in the process of determining Best Available Techniques (BAT) for the sectors production and processing of metals, manufacture of ceramic products and installation of surface treatment using organic solvents. The determination of BAT plays an essential role in the realisation of the IPPC-Directive 96/61/EC (concerning integrated pollution prevention and control) in all Member States of the European Union.

Therefore, the development, implementation, training and use of multi-criteria decision support tools is a crucial part of the institute’s work, as the following **projects** demonstrate:

- Elaboration of cost functions for the control of VOC emissions for France (on behalf of ADEME)
- Development of a Multiple Criteria Based Decision Support System for Integrated Technique Assessment in the Iron and Steel Industry (on behalf of the Volkswagen Foundation, Hannover)
- Development of an efficient system for multi criteria decision support (on behalf of the German Ministry of Trade and Commerce)
- Network on Integrated Scenario Analysis of Metal COATING (ISACOAT) funded by the 5th framework programme of the EU.
- Information Requirements and Countermeasure Evaluation Techniques in Nuclear Emergency Management (EVATECH)
- Integrated Process Design for Inter-Enterprise Plant Layout Planning of Dynamic Mass Flow Networks

The **course program** of the Institute covers two major lectures fields accompanied by a series of mandatory *Seminars*, which are elaborated in groups of around four teams of three to four students. Each Seminar consists of a written paper of about 20 pages, an oral presentation of 20 min. and a discussion of 15 min.

The whole course program focuses on applying Operations Research Methods in the field of Industrial Production. The major blocks cover the following issues:

- **Industrial Production** covers issues from long-term, strategic Planning to tactical and operational Planning and app. 150 students attend each year this program. This block consists of the following lectures:
 - Industrial Production / Material and Energy Flows in the Economy I (IP1): 6 credits (ECTS)
 - Planning of Plants and Equipment (IP2): 6 credits (ECTS)
 - Production Planning and Control (IP3): 6 credits (ECTS)
 - Computer aided PPC and Process Simulation: 2 credits (ECTS)
 - Recycling-orientated Production: 2 credits (ECTS)
- **Material and Energy Flows in the Economy** covers issues about mass and energy flow management within and inter enterprises and about 20 students attend each year this program. This block consists of the following lectures:
 - Industrial Production / Material and Energy Flows in the Economy I (IP1): 6 credits (ECTS)
 - Material and Energy Flows in the Economy II: 5 credits (ECTS)
 - Material and Energy Flows in the Economy III: 5 credits (ECTS)
 - Emissions into the Environment: 5 credits (ECTS)

Due to the very diverse requirements of the lectures (given by the difference in the number of students), very different demands exist for the support of the development of course material and the use of software within the course:

- Software Support for the field of courses compiled within the *Industrial Production* field is needed for the supply of course material and
- the possibility to post questions,
- multiple choice questions for practicing the course material,
- course evaluation sheets,
- feedback systems etc.

All tools needed for this field according to the current teaching practice concentrate on the individual student and the support of his learning.

The demands in the field of *Material and Energy Flows in the Economy* and the *Seminars* is quite different.

- In this area tools are needed supporting the discussion between the students and especially between groups of students.
- In a first step electronic teaching material has to be developed to provide the students with the material over the web. Only with electronic material an efficient realisation of these Seminars on an European level at different universities is possible.

A lot of the exercises have a focus on environmental issues by incorporating optimization algorithms of Operations Research and adjusting these methods to the given context. Herein the focus is not on complex algorithms, but on the appropriate mapping of the given context. This mapping involves the discussion about the input parameters for the computer model. For example the *Learning Curve* in industrial applications. Aim of the exercise is not the calculation of a certain result given one certain input parameter, but to explore the different perspectives of all stakeholders (Controlling, Production, Environmentalist, Politician etc.). By defining different limits of growth different results can be evaluated according to an sensitivity analysis approach.

Further examples are the evaluation of the *Economies of Scale* in the context of plant layout planning and the multi-criteria decision support in the context of the defining “best available techniques”. Especially in the field of mass and energy flow analysis conflicting objectives characterise the plant layout planning. The minimisation of energy demand, the minimisation of water demand or waste water generation or the minimisation of certain input mass flows arises different options, which may contradict each other. Furthermore different scales have to be compared with each other, for example costs, energy demand and solvent emissions, which are all measured in different units.

In situations like these different multi-criteria methods can be used to rank the different alternatives by their environmental impact. In the framework of this project a spreadsheet based tool will be developed incorporating different multi-criteria decision support methods. These tools can be used by different groups to discuss certain emission reduction techniques. Providing these tools in OpenSource software it is possible to use these tools in different Universities and further hereby the discussion between the students. The same scenario could be used in different European universities to find compromises about technical issues, like the initiative of the European Commission tries to foster with the generation of reference notes about Best Available Techniques (BAT) in Seville.

Since the already available tools are only in German and based on commercial software, further development has to be done to transfer them to spreadsheet based OpenSource software. In this case most of the implementation has to be redone, this the object hierarchy and the syntax between the commercial software and the OpenSource software is quite different.

For commenting these issues not only multiple choice sheets are necessary, but furthermore sheets allowing to type in the results and comment on these results in text boxes.

Annex 1:

This Annex contains a small, explanatory bit of source code to illustrate the structure and the complexity of the coding.

```

Sub PROMETHEEMitNormierung()
    Einlesen
    MatrizenAufbauen
    DifferenzundPraeferenz
    GesamtPhiMitNormierung
    Sensitivitaetsanalyse
    Sensitivitaetsintervall
End Sub
...
...
...

Sub GesamtPhiMitNormierung()
'Nachdem in der Prozedur differenzundpraeferenz die gewichteten Präferenzen
'für die einzelnen Kriterien berechnet wurden,
'werden diese nun in der Gesamtauswertungstabelle zusammengefaßt
'sowie PhiPlus, PhiMinus und PhiNetto berechnet.

'Gesamtmatrix mit phi netto etc. vorbereiten

ET.Cells(AnzahlKriterien + 6, 1).Activate
MsgBox ("Nun werden die Präferenzwerte aggregiert." & Chr(10) & Chr(10) _
& "Now the aggregation of the preference values starts." _
& Chr(10) & Chr(10) & "L'aggregation de valeurs de préférences commence.")
    For j = 0 To AnzahlAlternativen - 1
        PhiPlus = 0
        For spalte = 3 To AnzahlAlternativen + 2
            x = 0
            z = Abstand + 1

            For i = 1 To AnzahlKriterien
                x = ET.Cells(z + j, spalte).Value + x
                z = z + VorschubProm
            Next
            With ET.Cells(AnzahlKriterien + 6 + j, spalte)
                .Value = x / (AnzahlAlternativen - 1) 'NORMIERUNG
                .NumberFormat = "0.000"
            End With

            PhiPlus = PhiPlus + (x / (AnzahlAlternativen - 1))
            With ET.Cells(AnzahlKriterien + 6 + j, AnzahlAlternativen + 3)
                .Value = PhiPlus
                .NumberFormat = "0.000"
                .Font.ColorIndex = 41
            End With

        Next
    Next

'PhiMinus berechnen
z = AnzahlAlternativen + 6 + AnzahlKriterien
For spalte = 3 To AnzahlAlternativen + 2

```

```

PhiMinus = 0
For j = 1 To AnzahlAlternativen
    PhiMinus = PhiMinus + ET.Cells(z - j, spalte).Value
Next

With ET.Cells(z, spalte)
    .Value = PhiMinus
    .NumberFormat = "0.000"
    .Font.ColorIndex = 41
End With

Next

'PhiNetto berechnen
z = AnzahlKriterien + 5
s = AnzahlAlternativen + 4
For j = 1 To AnzahlAlternativen
    PhiNetto =
    ET.Cells(z + j, s - 1).Value - ET.Cells(z + 1 + AnzahlAlternativen, j
+ 2).Value
    With ET.Cells(z + j, s)
        .Value = PhiNetto
        .NumberFormat = "0.000"
        .Font.ColorIndex = 41
        .Font.Bold = True
    End With

    'graphische Auswertung vorbereiten
    With ET.Cells(z + j, breite - 1)
        .Value = ET.Cells(z + j, 2).Value
        .Font.ColorIndex = 41
    End With
    With ET.Cells(z + j, breite)
        .Value = ET.Cells(z + j, s - 1).Value
        .NumberFormat = "0.000"
        .Font.ColorIndex = 41
    End With
    With ET.Cells(z + j, breite + 1)
        .Value = -ET.Cells(z + 1 + AnzahlAlternativen, j + 2).Value
        .NumberFormat = "0.000"
        .Font.ColorIndex = 41
    End With
    With ET.Cells(z + j, breite + 2)
        .Value = PhiNetto
        .NumberFormat = "0.000"
        .Font.ColorIndex = 41
    End With

Next

'Beschriftung für graphische Auswertung
ET.Cells(z, breite).Value = "Phi Plus"
ET.Cells(z, breite + 1).Value = "Phi Minus"
ET.Cells(z, breite + 2).Value = "Phi Netto"

End Sub

```

Annex 2:

This Annex contains a rough overview of the lecture times at the Institute for Industrial Production.

			Lecture Mass- and Energy Flows in the Economy	Seminar	
Project Duration	2003	Oct	1st of Oct: winter term starts 13th of Oct: lectures start	start of seminar work winter term	
		Nov			
		Dec			
	2004	Jan			seminar presentations and handover of the paper application for the seminar in the summer term
		Feb	14th of Feb: lectures end		
		Mar	26th of Mar: exam 31st of Mar: winter term ends		
		Apr	1st of Apr: summer term starts 19th of Apr: lectures start		start of seminar work summer term
		May			
		Jun			
		Jul	24th of Jul: lectures end		seminar presentations and handover of the paper application seminar winter term
		Aug			
		Sep	23rd of Sep: exam 30th of Sep: summer term ends		
		Oct	1st of Oct: winter term starts 18th of Oct: lectures start		start of Seminar work winter term
		Nov			
		Dec			
	2005	Jan			seminar presentations and handover of the paper application for the seminar in the summer term
		Feb	mid Feb: lecture ends		
		Mar	31st of Mar: winter term ends		
		Apr	1st of Apr: summer term starts		start of seminar work summer term
		May			
		Jun			
		Jul	mid Jul: lectures end		seminar presentations and handover of the paper
		Sep	30th of Sep: summer term ends		