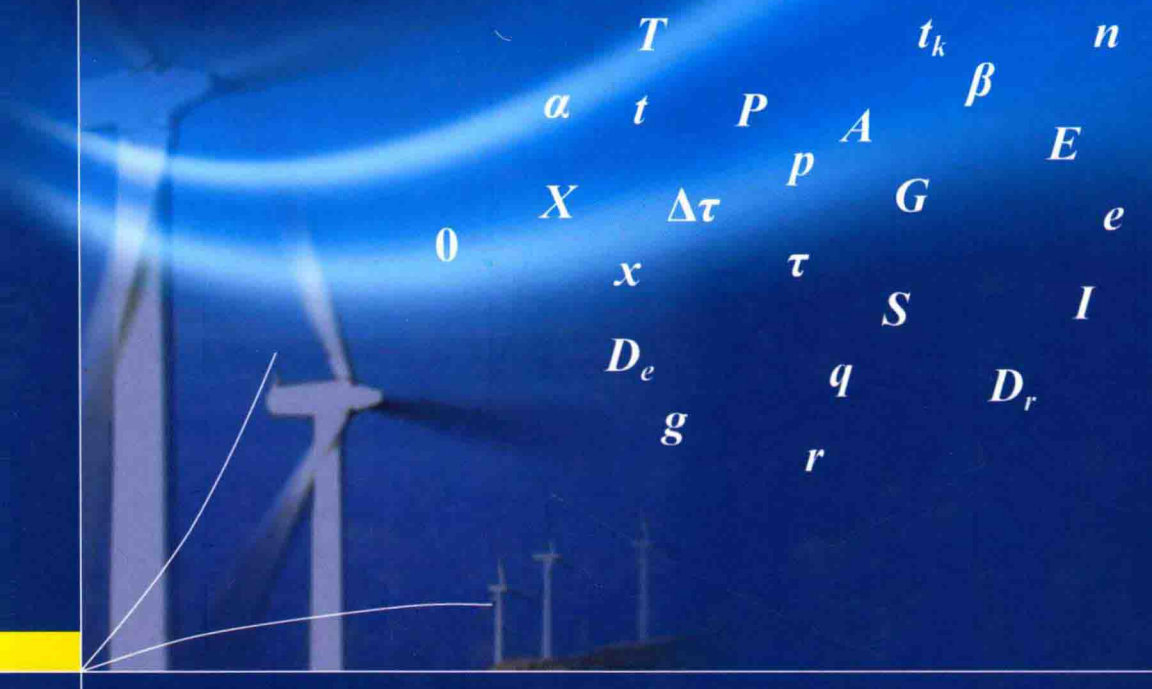
THE STUDIES OF INDUSTRIAL ECOLOGY

（工业生态学研究）

SELECTIONS 2000-2013

INSTITUTE OF INDUSTRIAL ECOLOGY, NORTHEASTERN UNIVERSITY, P. R. CHINA

LU ZHONGWU, YUE QIANG AND SHI HAN, EDITORS



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Preface

Two decades and several years ago, a few pioneer scientists brought forth in the West a new discipline — Industrial Ecology (IE), conceived in sustainable development, and dedicated to the proposition that the human social economic system is a subsystem of the natural ecological system; that mankind should deal with nature in a friendly manner and learn from it. The thinking mode of industrial ecologists should be the combination of reductionism and holism.

In a word, IE is really a distinguished, outstanding discipline.

Since the appearance of IE, developed countries have paid close attention to it, and have applied it widely.

Fifteen years ago, we recognized and believed that introducing the new discipline to China should be beneficial to its sound development. However, China is a rapidly developing country, of which the national condition is quite different from that of developed countries. Therefore, introducing the discipline of IE to China should not be the indiscriminate copy of the existing texts. Instead, it should be done by integrating the fundamental principles of IE with the national condition of China.

In the eyes of industrial ecologists, some specific features of China's national condition over the past 30 years are as follows:

(1) the continuous rapid growth of gross domestic product (GDP);

(2) the continuous rapid growth of resource use and the output of industrial product;

(3) the continuous rapid growth of industrial waste and pollutant generation;

(4) the huge amount of household waste and pollutant emission;

(5) the deficiency of water resource;

(6) the relatively backward technology.

With the above understanding in mind, we began to proceed with a disciplinary introduction, during which the revision on the existing IE has been carried out.

The objective of the revision of this discipline consists in its "Chinalization", i.e., to reform it in order to make it in accordance with China's contemporary national condition.

The main job of the revision consists in the fundamental study on some research projects we selected, i.e., to carry out the theoretical analysis and mostly the mathematical treatment on them.

In the whole process, the maxim we observe is to "get to the bottom of the matter"; the academic characteristics we appreciate are curiosity, free thinking and no-hurry.

This book is a selection of the published papers written by the members of IE research group at Northeastern University (NEU) of China in the period of 2000–2013. Some of them were originally written in English, and the rest were translated from Chinese.

The papers in this book represent the findings of our research projects with different orientations. The brief introduction of a few of them will be given in the following paragraphs, and the rest will be omitted for the sake of space.

1. *On the relationship between gross domestic product* (GDP) *growth and resource use, waste emission*

1) The background

The quantitative relationship between GDP growth and resource use and waste emission is of most importance for a rapidly industrializing country, like China, in order to implement the policy of sustainable development.

However, the unique equation in this regard was the IPAT equation, the master equation in IE, and it "should be viewed as conceptual rather than mathematically rigorous". Therefore, it was unable to be applied to identify quantitatively the relationship between GDP and resource use, waste emission.

2) The progress

The IPAT equation was split into two mathematically rigorous equations: one of them for resource use, and the other for waste emission (Eq.(2.2) and Eq.(2.9)).

Equations for calculating resource use and waste emission during GDP growth were derived, respectively (Eq.(2.5b) and Eq.(2.12b)).

The critical value of the "decreasing rate of resource use and waste emission per unit of GDP" was defined and formulated (Eq.(2.8) and Eq.(2.16)).

The variations of resource use and waste emission under different conditions were calculated and discussed in detail (Section 2.2.2 and Section 2.3.2).

2. *On the decoupling indicator and decoupling chart*

1) The background

Resource use and waste emission are usually "coupled" with GDP. It is agreed that resource and waste emission should be "decoupled" from GDP, at least relatively decoupled. It is the prerequisite for sustainable development.

The "decoupling" has been a hot topic of scientific research in recent years. And, the existing decoupling indicators have not been widely accepted.

2) The progress

The decoupling indicators for resource use and waste emission were derived

respectively based on the findings of the research project mentioned above (Eq.(4.4) and Eq.(4.6)).

A unified decoupling chart was designed. It can be used both for resource use and waste emission (Fig.4.1).

Several groups of case studies were completed for developed and developing countries (Fig.4.2, Fig.4.3 and Fig.5.1–Fig.5.3).

3. *On the steel scrap resource for steel industry*

1) The background

For steel manufacturing, there are two processes, one is iron-ore based, and the other is steel-scrap based. The former has been the dominating process in China for many years.

Several years ago, there was a strategic debate on the question whether it is correct or not to accelerate the development of EAF (electric arc furnace) process of steel production in China. As it is a steel-scrap based process, therefore the debate focused on the availability of steel scrap resource. However, there were no scientific methods as yet, for predicting the quantity of steel scrap generation. The debate was continuing.

2) The progress

The "steel scrap index (S)" was proposed and formulated (Eq.(8.1)).

The relationship between the value of S and the variation of steel output was clarified as shown in the table:

Tab.0.1 The relationship between steel scrap index (S) and steel output

variation of steel output	value of S	sufficiency or deficiency of steel scrap resource
increasing	small	deficient
keep constant	medium	relatively sufficient
decreasing	large	sufficient

(Section 8.2 ~ Section 8.3)

It was concluded that the reason of severe deficiency of steel scrap resource for steel industry in China is its continuous rapid growth of steel output. In this case, the opinion of accelerating the development of EAF process was incorrect. Thus, the debate was ended, and large amount of investment loss was avoided.

4. *On the substance flow analysis* (SFA) *on society level*

1) The background

The existing method of SFA, which is widely used in developed countries, is the method for analyzing substance flow in steady state. It is not fit for China, because the quantities of substances flowing in China are rapidly increasing. A new method should be conceived for analyzing substance flow in unsteady state.

2) The progress

A new method, which is called the "following observing method of SFA", was proposed. A series of equations for the model of this method were derived and discussed (Eq.(7.3)–Eq.(7.9)).

The case studies of SFA for Fe, Al, Cu, Pb, Zn in China were carried out.

We hope that from the above mentioned brief introduction on four projects, one can see, in general, our approach of the revision of the existing IE.

All in all, the Chinalization of the discipline is still in the process of being developed.

In the days to come, China will place a greater emphasis on the quality of development. Resource conservation and environmental protection will become more and more important. The discipline of IE will play a greater and greater role. Thus, it seems to us that the pace of Chinalization of IE should be accelerated. Meanwhile, we will work even harder than ever before.

For the rise and advance of such an IE, the efforts of all industrial ecologists, both domestic and from abroad, are needed.

We, the members of IE research group at Northeastern University, will take part actively in the research contingent on the subject.

The publication and distribution of this book provide a good chance for the academic exchange between us and readers from all over the world.

In this regard, we appreciate the policy for promoting the progress of the arts and the sciences in China. It says "let a hundred flowers blossom and a hundred schools of thought contend", of which the core is equality, mutual respect and mutual understanding among all participants in the academic exchange.

We hope, on one hand, this book will find use as a reference for our colleagues and students of various related majors, both in developing and developed countries.

On the other hand, shortcomings and deficiencies in this book are inevitable. We hope the readers of this book will not restrict their criticism.

Looking back on the course of our study on IE, we would like to express sincere thanks to all persons and organizations for their help, especially to Xie Zhenhua (Vice director of Committee of Population, Resources and Environment of CPPCC) for his deep trust and encouragement; to T.E.Graedel (Professor at Yale University, Member of the Academy of Engineering, USA), Y.Moriguchi (Professor at the University of Tokyo, Japan) and S. Hashimoto (Professor at Ritsumeikan University, Japan) for the intimate academic exchanges between us; to He Jicheng, Ding Lieyun (Former president of NEU) and Zhao Ji (President of NEU) for their concern and support for our study of IE.

Regarding the preparation and publication of this book, we are indebted to the authors for their excellent papers, to Yue Qiang, Shi Han for their great efforts in editorial work. We appreciate our interaction with the staff at China Science Press. Finally, we express sincere our thanks to the Graduate School of NEU, Subject Construction and Development Department of NEU, International Cooperation and Exchange Department of NEU for their generous support on the preparation and publication of this book.

Lu Zhongwu
May. 2015

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