

The Exergy of Materials With Application to Societal Exergy Analysis

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Abstract: A single paragraph of about 200 words maximum. For research articles, abstracts should give a pertinent overview of the work. We strongly encourage authors to use the following style of structured abstracts, but without headings: (1) Background: place the question addressed in a broad context and highlight the purpose of the study; (2) Methods: describe briefly the main methods or treatments applied; (3) Results: summarize the article's main findings; (4) Conclusions: indicate the main conclusions or interpretations. The abstract should be an objective representation of the article, it must not contain results which are not presented and substantiated in the main text and should not exaggerate the main conclusions.

Keywords: keyword 1; keyword 2; keyword 3 (List three to ten pertinent keywords specific to the article; yet reasonably common within the subject discipline.)

1. Introduction

Our research question:

How should integrated energy and material conversion chains be represented for societal exergy analysis?

Contributions of this paper:

1. Demonstrate a consistent exergy analysis approach for ECCs and MCCs, including physical, chemical, and concentration exergies.
2. Apply the exergy analysis approach to a MCC from extraction (iron ore, coking coal, limestone) to pig iron.
3. Demonstrate the interaction between energy and material conversion chains using PSUT matrices amenable to existing energy conversion chain datasets.

2. Methods and data

2.1. Material Exergy Calculation

The exergy of a system (B) is the maximum amount of work that can be extracted by processes that take the system to equilibrium with the reference environment, defined by T_0 , P_0 , and a certain chemical composition.

Thus, the total exergy of a system (B) is the sum of the work of two reversible processes that bring the system (a) from T and P to T_0 and P_0 (without changes in the chemical

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composition) and (b) from its chemical composition to to the reference chemical composition (while the system remains at T_0 and P_0).

Reference environments can include the atmosphere, the ocean, or the Earth's crust. For our purposes, the reference environments are at T_0 and P_0 , and are characterized by a mixture of reference species.

Reference species are characterized by partial pressure ($P_i = P_0 y_i$) in the atmosphere, by concentrations (C_i) in the ocean and by mole fraction (y_i) in the Earth's crust.

3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

3.1. Subsection

3.1.1. Subsubsection

Bulleted lists look like this:

- First bullet;
- Second bullet;
- Third bullet.

Numbered lists can be added as follows:

1. First item;
2. Second item;
3. Third item.

The text continues here.

3.2. Figures, Tables and Schemes

All figures and tables should be cited in the main text as Figure 1, Table 1, etc.



Figure 1. This is a figure. Schemes follow the same formatting.

Table 1. This is a table caption. Tables should be placed in the main text near to the first time they are cited.

Title 1	Title 2	Title 3
Entry 1	Data	Data
Entry 2	Data	Data ¹

¹ Tables may have a footer.

The text continues here (Figure 2 and Table 2).

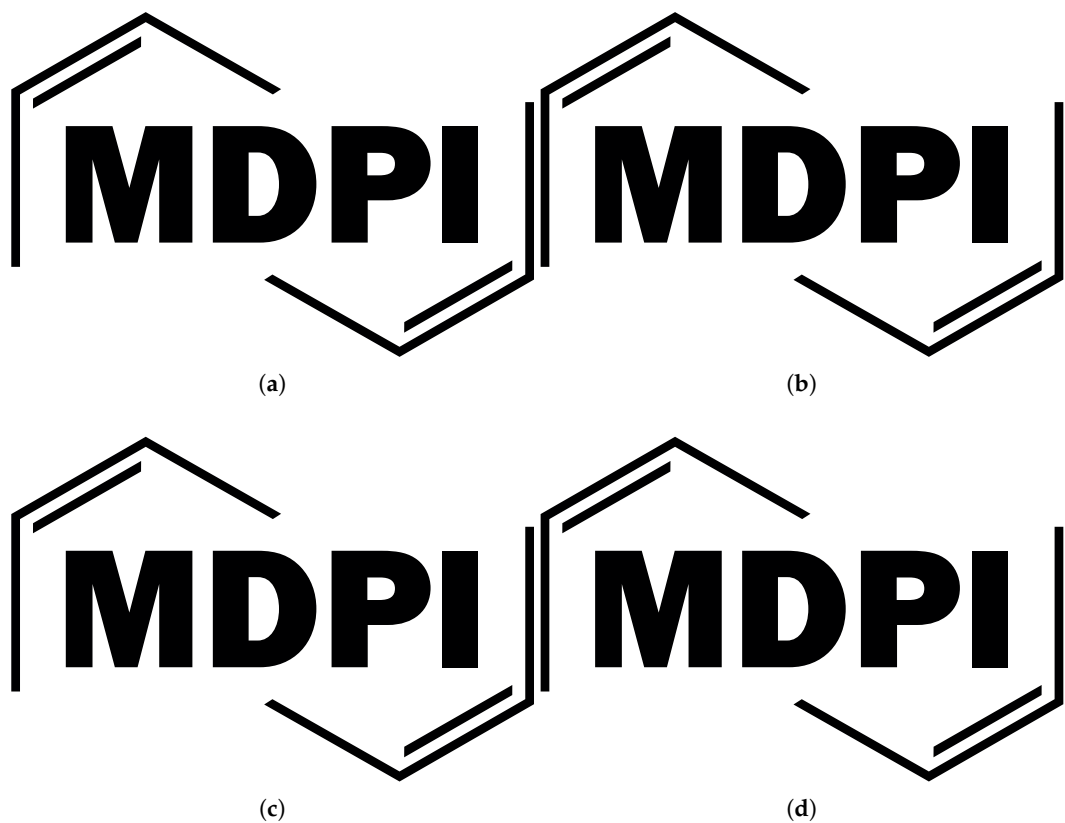


Figure 2. This is a wide figure. Schemes follow the same formatting. If there are multiple panels, they should be listed as: (a) Description of what is contained in the first panel. (b) Description of what is contained in the second panel. (c) Description of what is contained in the third panel. (d) Description of what is contained in the fourth panel. Figures should be placed in the main text near to the first time they are cited. A caption on a single line should be centered.

Table 2. This is a wide table.

Title 1	Title 2	Title 3	Title 4
Entry 1 *	Data	Data	Data
	Data	Data	Data
	Data	Data	Data
Entry 2	Data	Data	Data
	Data	Data	Data
	Data	Data	Data

* Tables may have a footer.

Text.

Text.

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56

3.3. *Formatting of Mathematical Components*

57

This is the example 1 of equation:

58

$$a = 1,$$

(1)

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

59

60

This is the example 2 of equation:

61

$$a = b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t + u + v + w + x + y + z$$

(2)

Please punctuate equations as regular text. Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

Theorem 1. *Example text of a theorem.*

The text continues here. Proofs must be formatted as follows:

Proof of Theorem 1. Text of the proof. Note that the phrase “of Theorem 1” is optional if it is clear which theorem is being referred to. □

The text continues here.

4. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

5. Conclusions

This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

6. Patents

This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

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Abbreviations

The following abbreviations are used in this manuscript:

- MDPI Multidisciplinary Digital Publishing Institute
- DOAJ Directory of open access journals
- TLA Three letter acronym
- LD Linear dichroism

Appendix A

Appendix A.1

The appendix is an optional section that can contain details and data supplemental to the main text—for example, explanations of experimental details that would disrupt the flow of the main text but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data are shown in the main text can be added here if brief, or as Supplementary Data. Mathematical proofs of results not central to the paper can be added as an appendix.

Table A1. This is a table caption.

Title 1	Title 2	Title 3
Entry 1	Data	Data
Entry 2	Data	Data

Appendix B

All appendix sections must be cited in the main text. In the appendices, Figures, Tables, etc. should be labeled, starting with “A”—e.g., Figure A1, Figure A2, etc.

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Author 1, A.B.; Author 2, C.D.; Author 3, E.F. Title of presentation. In Proceedings of the Name of the Conference, Location of Conference, Country, Date of Conference (Day Month Year); Abstract Number (optional), Pagination (optional).

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