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A guide to writing articles in energy science

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ABSTRACT

Energy science addresses key questions of sustainable development. This suggests that energy scientists should communicate their research effectively with readers both from within and outside of the scientific community. In the communication of energy science, however, scientific writing potentially presents a weak link. Here, we address this problem by clarifying the principle conventions for writing articles in energy science. We propose a top-down approach to writing that begins with structuring the article into sections. Each section should, in turn, be structured in and of itself so that readers can: (i) comprehend the scientific context; (ii) grasp the research questions addressed; (iii) verify methods and results; and (iv) understand the significance of the results. Subsequently, authors should ensure clarity of their scientific arguments by: (i) presenting existing information at the beginning of a sentence and new information at the sentence's end; (ii) articulating action with appropriate verbs, preferably in active voice; (iii) placing statements in positive form; and (iv) using consistent technical terminology. Substantial text revisions constitute an indispensable part of scientific writing and enable authors to make their exposition concise. Following the conventions outlined in this article can make writing easier, more efficient, and enables energy scientists to communicate their research effectively with a wide audience.

1. Introduction

Energy science comprises fundamental and applied research on modern energy systems. Energy science intersects with multiple disciplines and addresses key questions of sustainable development [1]. The importance of the field is reflected by an increasing number of refereed scientific articles published each year. *Web of Science* lists under the key words '*energy efficiency*,' '*energy policy*,' and '*renewable energy*,' a total of 372 articles that were published in 1990, but a staggering 14,200 articles published in 2010. This development has been paralleled by more intensive cooperation between energy scientists, policy makers, and industry experts [2–4]. As a result, energy scientists face the need to communicate their research effectively to readers both from within and outside of the scientific community.

In the process of research communication, however, writing often presents a challenge to energy scientists. This challenge arises for a variety of reasons, including insufficient training at universities. We elicit persisting problems by reviewing the abstracts of 100 refereed articles published in 2009 and 2010 by four leading journals in the field of energy science. We find that only half of all abstracts begin by providing scientific context. Moreover, about four fifths of the abstracts fail to explicitly define a research question, and one third of the abstracts lacks an interpretation of results. We also identify recurring structural defects in scientific arguments, often associated with ambiguous wording. These findings may not be representative of the entire field. Anecdotal evidence, however, suggests that similar problems are widespread in energy science and also persist in other fields of science. Thus, writing likely presents a weak link in the communication of energy science, in particular, and science in general.

Guidance on scientific writing is abundant but often scattered and unavailable in a concise single document. Authors focus either on: (i) the structure and content of articles and their individual sections (e.g., [5–8]), (ii) text composition, syntax, and wording (e.g., [9,10]), or (iii) practical approaches to scientific writing (e.g., [11–13]). Guidance also appears in excellent but often voluminous books (e.g., [14–16]), which makes it time consuming to obtain the relevant information. We thus see a need for a comprehensive, yet brief, article that clarifies the conventions of writing in energy science. The purpose of this article is to provide such clarification, thereby making the fundamental conventions for writing articles more accessible to energy scientists.

Although there is no strict algorithm for writing articles, we argue that applying a set of conventions can make writing easier and more efficient for scientists in their role as authors as well as more transparent and less ambiguous for the readers. Concise writing originates from a well-defined structure and careful wording. Both can be achieved by adopting a top-down approach to writing that

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contains the following steps: (i) defining the macro-structure of an article (that is, the order of sections), (ii) defining the meso-structure of an article (that is, the order of information within each section), (iii) structuring arguments within individual paragraphs and sentences, (iv) using concise expressions and wording, and (v) adhering to additional conventions for presenting research. The sections below describe the individual steps of the top-down approach in consecutive order. We illustrate our reasoning with examples from refereed articles published in energy science. Even though our examples focus on this particular field, most of the presented conventions are equally relevant for writing articles in other fields of science.

2. Defining the macro- and meso-structure of the article

The top-down approach to writing begins by defining the macro-structure of the article, i.e., by dividing the article into appropriate sections. The macro-structure is the skeleton of the article and typically contains the following sections: (i) abstract, (ii) introduction, (iii) methodology, (iv) results, (v) discussion, and (vi) conclusions. After clarifying the macro-structure, each section should contain a structure in and of itself. We refer to this intra-sectional structure as the meso-structure of the article. Transparent meso-structure can compensate for poor writing, while no amount of clever writing can compensate for poor meso-structure [6]. We now explain the key elements in the meso-structure of articles in energy science.

2.1. Abstract

An article should start with an *abstract* that provides the readers with a concise summary of the research. Authors often decide to write the abstract last after completing their manuscript [8,22]. However, drafting a preliminary abstract first can be useful because it establishes a contextual focus for writing the subsequent sections of the article [11,18]. Authors can ensure that the abstract presents all necessary information in the correct order by adhering to the following structure, which provides the readers with [13,17–19]:

- one sentence of introduction comprehensible to a wide audience,
- one sentence of more detailed background information comprehensible to scientists within energy science,
- one sentence clearly defining the research question addressed by the article,
- one sentence indicating the main approach chosen and, if applicable, the research hypothesis tested,
- one sentence summarizing the main results,
- one or two sentences presenting detailed quantitative results relevant for addressing the research question and explaining the meaning of the results compared to previous findings and established knowledge,
- one or two sentences discussing the results from a more general perspective by presenting, e.g., conclusions or recommendations comprehensible to peers and non-peers alike.

The abstract is arguably the most important part of the article [20] and often the first and only section actually read by a wide audience. Thus, the abstract should be a dedicated piece of work [21] that captures the interest of the readers. The abstract itself should be self explanatory. In any case, the abstract should not contain an outline of the research; instead, it must precisely summarize the essential elements of the article [8,20]. Any abstract must be free of equations and references and, to the extent possible, abbreviations [8,22]. The maximum length of an abstract is typically specified by the journal but at any rate should not exceed 300 words.

2.2. Introduction

The *introduction* needs to familiarize readers with the research by explaining the content of the first three sentences of the abstract in greater detail. The first part of the introduction must engage readers by establishing the scientific context of the research [22,23]. This requires making reference, in chronological order, to seminal work in the field. Authors should guide the readers from general to more specific aspects of their research by explaining knowledge gaps and linking these to a clear definition of their research question. The introduction might subsequently mention and justify the methods as well as the scope and assumptions of the research, and might end with a brief outline of all subsequent sections. At any rate, the introduction should be limited to a maximum of 600–700 words.

2.3. Methodology

The *methodology* section should explain in logical order the approaches used to address the research question. This requires providing [12,24]:

- detailed definitions of technical terms that enable readers to understand all subsequent concepts and methods,
- an explanation of methods, starting with the general and ending with the specific, thereby following the chronological order in which the analysis was conducted,
- examples to illustrate complex approaches.

Authors should focus on novel methodologies and new data; standard approaches should only be briefly mentioned, preferably by making reference to the scientific literature. The methodology section should: (i) justify the chosen method, if multiple approaches are possible, and (ii) clarify all calculations to allow peers to verify the research results [8]. An extensive explanation of calculation procedures should only be presented if this is essential for understanding the research. Otherwise, authors may present this information together with, e.g., extensive input data used for modeling in an appendix. Authors must provide references to all data sources. Raw data often contain invaluable information for other scientists [25]. We encourage authors to publish their raw data as supplemental information on the journal's web page.

2.4. Results

The *results* section qualitatively and quantitatively presents all findings relevant for answering the research question. Authors should present results by starting with the general and ending with the specific. The bulk of empirical findings should be presented in diagrams; tables should only be used if the precise quantity of a parameter is critical. Any results must be accompanied by quantitative information about their uncertainty, if applicable; authors should, however, explain this uncertainty in greater detail in the discussion section. Extensive amounts of data must be presented in an appendix. The results section may contain comparisons with findings from other studies. In this case, authors should refer to the outcome of such comparisons briefly in the discussion section. When writing the results section, authors should avoid presenting:

- results redundantly in tables, figures, and text,
- methodology (that belongs to the methodology section),

– extensive discussion and interpretation of results (that belongs to the discussion section).

2.5. Discussion and conclusions

The *discussion* section interprets the results [7]. Typically, it is this section with which both authors and readers struggle the most due to lack of clear meso-structure. We propose to order the elements of the discussion section as follows [6,7]:

– one or two sentences repeating the principal results,
– several sentences explaining the strengths and weaknesses of the methodology, input data and results, in particular detailing potential sources of uncertainty,
– several sentences discussing the results in relation to other studies,
– several sentences describing the significance of the research in relation to established knowledge,
– a sentence or two outlining unanswered research questions and future research requirements.

The discussion section must provide an unbiased account of the research without unnecessary speculation [6,7]. Authors should pay attention to the discussion of uncertainties and demonstrate that these are justifiable and limited. Furthermore, if results refer to a specific system, e.g., a product, economic sector, country, or time period, authors should indicate to what extent their findings have broader validity. The article should not be sold by the discussion, i.e., the importance of its results should not be inflated, nor should conclusions be drawn or speculation be made beyond what the empirical evidence supports [7].

Authors may, at this point, conclude with several sentences or include a separate *conclusions* section. Conclusions should not simply repeat the abstract but:

– answer the research question and/or specify to what extent knowledge gaps could be addressed,
– provide readers with a central message,
– make recommendations and outline future research based on the results and discussions presented earlier.

The conclusions section should be limited to fewer than 250 words. After drawing conclusions, an article typically ends with:

– *acknowledgements* given to, e.g., those who provided information, funding, or review,
– a list of *references*, which must be formatted consistently according to the journal's style guide,
– if applicable, *appendices* that provide detailed information regarding methodology and/or results.

2.6. General remarks

Defining the macro- and meso-structure of the article already requires including key diagrams as well as core findings and conclusions in the respective sections of the article. Authors can use this information as contextual guidance when starting to write the introduction and, subsequently, the remaining sections of the article. Each section following the introduction (i.e., methodology, results, discussion, and conclusion) should begin with a topic sentence. Such a sentence identifies the section's relation to the preceding information and provides the readers with a direction [7].

Authors should compile the list of references while writing the article. Furthermore, we propose writing down ideas immediately upon occurrence, even if only in rough form. Postponing this task may result in losing valuable information. The next section demonstrates how authors should structure their scientific arguments to communicate their research effectively.

3. Structuring scientific arguments

Difficulties in both writing and reading articles in energy science often arise from challenges in communicating complex matters. We find in our review of 100 refereed articles that poor composition of arguments is a major problem, in addition to deficient meso-structure. This section provides the basic conventions for structuring scientific arguments.

Authors must be aware when structuring scientific arguments that readers perceive information based on the order in which it is presented to them. Readers typically have an expectation about where in the line of reasoning they might encounter existing or new information [9]. To understand the readers' perception, we revert for a moment to the macro-structure of an article as explained in Section 2. Articles commonly start with an introduction that first presents common knowledge. This familiarizes the readers with the topic and provides context for the new material presented later. Thus, a well structured article starts with existing information and ends with new information. The design of simple tables often follows an analogous structure: typically, the independent variable is presented in the first column as a contextual anchor; the dependent variables, containing new information, are presented in the columns to the right. Sentence structure should adhere to a similar pattern.

Gopen and Swan [9] refer to the location of existing information as the *topic position* and to the location of new information as the *stress position* in a sentence. The topic position provides the readers with perspective: it links information to material presented in earlier sentences or it establishes the scientific context. Thus, authors should present existing information in the topic position at the beginning of a sentence [9,14]. New information should appear in the stress position at the end of a sentence for emphasis. By using a semicolon, authors can create a second stress position within a sentence [9].

The topic position and the stress position are typically linked by a verb that indicates the action of a sentence. Verbs must be carefully chosen and placed to ensure that readers can understand the scientific argument as well as the contextual focus of the sentence. We now suggest several conventions for structuring scientific arguments. We demonstrate their effectiveness by using examples from refereed articles. We emphasize the important elements of each example by placing these in *italics*. The examples given below often suffer from multiple defects. We primarily correct the defect emphasized in the respective example. We correct remaining defects only if required for clarity. In this case, we explain all additional changes in the text. Many examples contain abbreviations; if these are not explained in the original text, we provide a table explaining them in Appendix A.

3.1. Place existing information at the beginning of a sentence; place new information at the end of a sentence

> Example: "*Renewable energy* can become the major energy supply option in low-carbon energy economies. *Disruptive transformations* in all energy systems are necessary for tapping widely available renewable energy resources. Organizing *the energy transition* from non-sustainable to renewable energy is often described as the major challenge of the first half of the 21st century. *Technological innovation*, *the economy (costs and prices) and policies* have to be aligned to achieve full renewable energy potentials, and barriers impeding that growth need to be removed."

The individual sentences of this passage use appropriate vocabulary; yet, the passage might leave readers without a sense of direction. We can address the problem by looking at the topic position of each sentence: '*Renewable energy*,' '*Disruptive transformations*,' '*the energy transition*,' and '*Technological innovation, the economy (costs and prices) and policies*' contain new information in a place where readers expect backward references and existing information. Thus, the focus of the paragraph shifts. We revise the passage by: (i) reiterating existing information in the topic position to allow for backward referencing and (ii) relocating the new, emphasis-worthy information to the stress position at the end of the sentence.

> Suggestion: *Renewable energy* can become the major energy supply option in low-carbon energy economies. Tapping widely available renewable energy resources requires, however, *disruptive transformations* in all energy systems. Organizing *the energy transition* from non-sustainable to renewable energy is often described as the major challenge of the first half of the 21st century. Meeting this challenge necessitates the alignment of *technological innovation, the economy (costs and prices), and policies* as well as the removal of barriers impeding the growth of renewable energy.

After our revision, each sentence follows logically from its predecessor. Our example also demonstrates that paying attention to the placement of existing and new information can reveal additional weaknesses. Readers might still ask themselves whether '*disruptive transformations*' are synonymous with '*the energy transition*.' Placing the existing and new information correctly, in particular, allows for the detection of missing phrases that precisely link the subject, verb, and object of a sentence.

> Example: "Meanwhile, *wind turbines* depend on *wind*, and CHP depends on heat demand. Consequently, *the production in some areas sometimes exceeds the demand*."

The first sentence fails to appropriately define the topic. Specifically, it is not the *'wind turbines*' themselves that depend on the *'wind,'* but rather some characteristic of them. Therefore, it is not clear what exactly the subject of the second sentence, '*the production,*' refers to, and why it '*sometimes exceeds the demand.*' By introducing '*electricity production*' as the topic of the first sentence, we can clarify the argument.

> Suggestion: Meanwhile, *electricity production* from *wind turbines* and CHP depend on wind availability and heat demand, respectively. Consequently, the *electricity production* in some areas *sometimes exceeds the demand*.

The argument is now clearer although it still remains vague what '*some areas*' precisely means. Gopen and Swan [9] find misplaced existing and new information to be the primary problem in American professional writing. Our literature review indicates that misplaced and missing information also presents a major problem in communicating energy science. Addressing this shortcoming alone may, thus, greatly improve the clarity of scientific writing in general.

3.2. Articulate the action of a sentence by using appropriate verbs

The verb must define the action of a sentence and ensure contextual focus. Without choosing an appropriate verb, information often remains ambiguous.

> Example: "Metrics related to defining capacity *are* not always clear either. Solar PV capacity *is* generally clear by its established standard of 'peak-capacity,' [...]."

This passage lacks specificity because appropriate verbs, as well as other words specific to the definition of '*peak capacity*', are missing. We can clarify the action by replacing '*are*' and '*is*' with the more specific verbs '*differ*' and '*define*.'

> Suggestion: Metrics related to defining capacity often *differ* from each other. Solar PV capacity is generally *defined* as an established standard through its 'peak-capacity,' [...].

On a related note, authors should differentiate *associated* statements such as '*we analyze*,' '*we conclude*' from *dissociated* statements such as '*we perform an analysis,*' '*we derive the conclusion.*' Both possess equivalent definitions, although readers might perceive the former as more concrete.

3.3. Begin a sentence with the primary clause

Readers expect the principle agent to be the grammatical subject at the beginning of a sentence. Sentences that start with a secondary clause violate this expectation, leaving readers in doubt about the relevance of particular pieces of information.

> Example: "*In economic-energy-environmental modeling approaches*, the representation of technological changes is one of the most important sources of uncertainty in determining the economic costs of climate policy strategies."

We can improve this sentence by: (i) putting the subject first, (ii) specifying the action by an appropriate verb, and (iii) eliminating wordiness.

> Suggestion: The representation of technological changes *in economic-energy-environmental models introduces* uncertainty into estimates of the economic costs of climate policy strategies.

3.4. Follow the subject as closely as possible by its verb

Readers expect the grammatical subject to be followed immediately by a verb. Sentences containing lengthy subject–verb separation suffer from a similar defect as those beginning with a secondary clause: In both cases, readers are likely to perceive passages that interrupt the subject and the verb as unimportant.

> Example: "*Biofuel production*, especially in countries endowed with land and other natural resources, favourable weather conditions and abundant labour, *can* be a means of promoting agriculture and rural development."

The grammatical subject '*biofuel production*' is separated from its verb '*can*' by 16 words. Authors should determine how important the text that separates subject and verb is; if it is important, then it should be placed at the end of the sentence; if it is unimportant, it should be removed.

> Suggestion: *Biofuel production can* be a means of promoting agriculture and rural development, especially in countries endowed with land, other natural resources, favorable weather conditions, and abundant labor.

3.5. Ensure unambiguous connection of subjects and of objects

Authors should ensure, if applicable, that subjects and objects refer to each other unambiguously. Verbose sentences often violate this convention.

> Example: "What is common for the above two approaches is their focus on analysing *the impact of several policies on technology choice*, such as CO_2 *constraints* and *energy taxation*."

Readers may ask whether '*CO_2 constraints*' and '*energy taxation*' are a '*technology choice*,' an '*impact of several policies*,' or '*policies*' themselves. We clarify the sentence by rearranging the grammatical objects:

Suggestion: What is common for the above two approaches is their focus on analysing the *impact of several policies*, such as *CO_2 constraints and energy taxation*, on *technology choice*.

Authors should exercise caution when using the pronoun '*this*' to make reference to a subject or object in the same sentence or in a previous one.

Example: "*We assume* here that *the carbon content of all reducing agents* is equal. *This* is, however, not entirely true."

'This' may refer to making the assumption or to the content of the assumption itself. By introducing essential words, we can clarify the statement.

Suggestion: *We assume* that *the carbon content of all reducing agents* is equal. *This assumption*, however, might be not entirely true.

Clarity of expression can often be improved by replacing the words '*it*' or *'this'* with the respective noun '*it*' or *'this'* actually refers to. By paying attention to the use of singular and plural, authors can distinguish one-to-one relationships from n-to-m relationships [26].

3.6. Connect related pieces of information

Authors can improve the clarity of their arguments by expressing related pieces of information together. This convention is particularly relevant for sentences consisting of two clauses, where the second one is introduced by a conjunction such as '*and*,' '*while*,' or '*but*' [10].

Example: "A zone model of a building with natural ventilation is considered *and* heat is being supplied by condensing boiler."

The sentence improves if we use active voice and a more precise phrase than *'and'* to capture the relationship between the two clauses.

Suggestion: We consider a zone model of a naturally ventilated building *for which* heat is supplied by a condensing boiler.

3.7. Articulate similar ideas using parallel structure

Similarity of form enables the readers to recognize similarity of content [10]. This suggests that authors should articulate similar ideas by using parallel structure, which is more easily understood and retains the readers' focus.

Example: "At present wind power *supplies* 15% of the Danish electricity demand and ca. *50% is produced* in CHP (combined heat and power production)."
Suggestion: At present, wind power *supplies* 15% and CHP *supplies* 50% of the Danish electricity demand.

3.8. Complete compound constructions

Authors should complete compound constructions by including all appropriate words. In particular, prepositions can only be omitted if they are identical for all compounds. A preposition must be added in the following example to ensure grammatical correctness.

Example: "All experiments were carried out *in a* thermostatic room (22 °C) and atmospheric pressure."
Suggestion: All experiments were carried out *in a* thermostatic room (22 °C) and *at* atmospheric pressure.

A preposition can be added in the following example to improve readability.

Example: "A continued accumulation of anthropogenic greenhouse gases (GHGs) will ultimately have severe consequences *for* the climate as well as ecological and social systems."
Suggestion: A continued accumulation of anthropogenic greenhouse gases (GHGs) will ultimately have severe consequences *for* the climate as well as *for* ecological and social systems.

Authors should ensure that no essential words are missing in comparisons containing '*than*.'

Example: "The REC prices affect *more* the variability of the forecasts *than* the CER prices."

This statement is ambiguous and can be clarified in two ways:

Suggestion: The REC prices affect the variability of the forecasts *more than* the CER prices *do*.
Suggestion: The REC prices affect the variability of the forecasts *more than they affect* the CER prices.

By appropriately structuring their arguments, authors may identify persisting weaknesses in their expressions and wording. The next section explains how to address these.

3.9. Enclose parenthetical expressions in commas

Parenthetical expressions interrupt the flow of reasoning and should be avoided to the extent possible. If authors regard it necessary to clarify statements, parenthetical expressions must be enclosed by commas or parentheses. This allows the readers to identify parenthetical material as such.

Example: "Model results show that ITCs due to increased investment in R&D reduce compliance costs."
Suggestion: Model results show that ITCs, due to increased investment in R&D, reduce compliance costs.

4. Clarifying expressions and wording

This section provides conventions on how to clarify expressions and wording. Again, we use examples obtained from refereed scientific articles to illustrate our reasoning.

4.1. Be consistent with tenses

Scientific writing necessitates the consistent use of tenses. One convention suggests: (i) stating established knowledge and making reference to tables and figures in present tense and (ii) describing methods and results of one's own research as well as the recent findings of others in past tense [27]. Here, we suggest the use of present tense throughout the entire article. Adhering to this convention limits the ambiguous use of tenses and retains the readers' focus better than the use of multiple tenses. In any case, authors should avoid to use future and present progressive tenses.

4.2. Write in active voice

Active voice is more direct than passive voice and allows readers to differentiate precisely between the authors' work and research performed by others. A mix of active and passive voice almost inevitably creates ambiguity as to whose methodology or results the authors are referring to. The convention regarding active voice does not, however, preclude any use of the passive voice

[10]. If a sentence primarily focuses on the object or if the perpetrator of the action is unimportant or unknown, the use of passive voice might be appropriate.

Example: "Fossil fuels *are used* for energy generation but also for so-called non-energy purposes, [...]."
Suggestion: Both energy generation and non-energy use *consume* fossil fuels.

The example and the suggestion emphasize different aspects. The example informs us about *fossil fuels*; the suggestion informs us about *energy generation* and *non-energy use*.

4.3. Use the editorial 'we'

Using the editorial '*we*' is common practice in scientific literature, even if an article is written by a single author. The use of '*we*,' instead of the singular '*I*' or the words 'the author,' avoids overemphasis of a single person's contribution, creates an atmosphere of familiarity, and precludes the use of passive voice. Both writing in active voice and using the editorial '*we*' can, in particular, improve the clarity of the methodology section.

Example: "Data for the supply chain *has been collected* reaching back three decades, enabling analysis of trends in production and consumption of iron and steel *over the years*."
Suggestion: *We have collected* data for the supply chain reaching back three decades, enabling *us* to analyze trends in *the* production and consumption of iron and steel.

Our suggestion now clarifies that it is indeed the authors who collected the data.

4.4. Put statements in positive form

Authors should avoid using the word '*not,*' which may obfuscate their arguments; readers want to know what is, instead of what is not.

Example: "This situation may *not persist* in the future, [...]"
Suggestion: This situation may change in the future, [...].

Authors can avoid using the word *'not'* by:

- replacing '*not*' with a proper prefix, for example '*un-*,' '*in-*,' or '*im-*' attached to the respective adjective or adverb,
- altering negative statements such as '*not increasing*' or '*not very high*' into positive statements such as '*remaining constant*' or '*low*'; examples are plentiful (Table 1).

4.5. Omit nominalizations

Nominalizations are grammatical constructs that turn a verb or an adjective into a noun. They make sentences less specific, more difficult to read, and promote wordiness. Authors should omit nominalizations to the extent possible by using appropriate verbs or adjectives instead.

Example: "Many *studies have been carried out* on the subject of biological hydrogen production under heterotrophic, photoautotrophic and photo-heterotrophic conditions."
Suggestion: Biological hydrogen production under heterotrophic, photoautotrophic and photo-heterotrophic conditions *has been studied* frequently.

Authors should, in particular, check and potentially revise nominalizations in conjunction with '*there is/are*.'

Example: "Meanwhile, *there is a growing trend towards* distributed electricity production and supply in Europe."

Table 1
Examples of how to avoid the word '*not*' as means of negation.

Example	Preferred usage
Do not account for	Exclude/neglect
Do not allow	Prevent
Do not have much confidence in	Distrust
Do not meet the requirements	Are insufficient
Not always straight forward	Complicated/difficult/problematic
Not constant	Alternating/changing
Not clear	Unclear/unresolved
Not economically viable	Uneconomical/unprofitable
Not explicitly discussed/not taken into account/not used	Excluded
Not feasible/not the case	Infeasible
Not important	Unimportant/negligible
Not included in	Excluded from
Not just/only [...] but also [...]	Both [...] and [...]
Not sufficiently reliable	Unreliable
Not too distant	Close/near

Suggestion: Meanwhile, distributed electricity production and supply in Europe *is growing*.

4.6. Omit wordiness

Clear writing makes every word relevant [10]. Omitting wordiness and inappropriate jargon (Table 2) makes writing concise and reduces the risk of misinterpretation.

Authors should rephrase expressions containing '*the fact that,*' '*one of the most,*' and '*there are [...] which are [...],*' and omit sentences starting with '*needless to say.*' Instead of explaining '*It is interesting that,*' the statement itself should be made interesting.

Example: "An additional complication *is the fact that* the costs of some parts of the fuel cell do not scale linearly with its capacity."

Table 2
Preferred usage of statements to omit wordiness and inappropriate jargon.

Example	Preferred usage
A considerable amount/number of	Much/many
A decreasing amount/number of	Less/fewer
A (great/vast) majority of	Most
A small number of	Few
As a consequence of/as a result of	Because
As to whether	Whether
At a rapid rate	Rapidly
At an earlier date	Previously
During/in the course of	While
First of all	First
For the reason that/the reason why is that	Because
From the point of view	For
In a number of cases	Some
In a small amount of cases	Rarely
In case	If
In order to	To
In the absence of	Without
In the last/past analysis	Previously
It is apparent that	Apparently
It is worth pointing out that	Note that
On the basis of	By
One of the most important	An important
Regardless of the fact that	Even though
The fact that	Because/although
The question as to whether	Whether
This is a subject that	This subject
Through the use of	By/with
Would seem to indicate	Indicates

Suggestion: An additional complication *arises because* the costs of some parts of the fuel cell do not scale linearly with its capacity.

Our suggestion omits three words and specifies the action by an appropriate verb.

4.7. Omit subjective statements

Authors should avoid presenting subjective statements, such as opinions and value judgments, because these introduce ambiguity into an otherwise clear message.

Example: "The *energy efficiency* of an integrated pulp and paper mill is approximately 10-50% *better*, depending on the grade of paper produced, than in a *stand alone mill*."

The word '*better*' should be replaced by '*higher*.' The original sentence also separates the grammatical subject '*energy efficiency*' from the grammatical object '*stand-alone mill*.'

Suggestion: The *energy efficiency* of an integrated pulp and paper mill is approximately 10-50% *higher* than that of a *stand-alone mill*, depending on the grade of paper produced.

4.8. Be specific, definite, and concrete

Brevity suggests that authors refer to figures and tables parenthetically.

Example: "Our model of the UK iron and steel cycle is shown in Fig. 2."
Suggestion: Our model of the UK iron and steel cycle includes [insert important information here] (Fig. 2).

Furthermore, authors should:

- avoid the use of qualifiers like *'rather,' 'very,' 'little'* – these dilute the message,
- make quantitative instead of qualitative statements [22] (Readers lack a proper understanding if they are only told a parameter is '*larger*' or '*higher*' than another one without knowing by how much, precisely.),
- omit interrupting the line of reasoning with footnotes and extensive cross-referencing; state all important information in the main text; additional details can be communicated in supplementary material provided to the publisher,
- ensure consistency of terminology; always use the same technical term throughout the article even at the risk of repetition (For example, authors should refrain from mixing adjectives such as '*entire,*' '*total,*' and '*absolute*' or nouns such as '*use*', '*consumption*', and '*demand*' into established phrases.),
- use '*that*' and '*which*' as follows: choose '*that*' to differentiate an object from other similar objects; choose '*which*' to add a fact about one particular object.

5. Following additional conventions for presenting research

After having clarified expressions and wording, authors should finally follow several additional conventions that ensure comprehensible exposition.

1. Both *title* and *key words* must precisely represent the content of the article to ensure that readers grasp the topic at a glance and that they find the article listed in databases and search engines [28].
2. Authors should use SI units (International System of units) to quantify parameters; authors should spell out unit abbreviations upon first use in lower case, e.g., *kelvin*, even if abbreviated in upper case, e.g., *K*.
3. Authors must explain any abbreviation (including SI units, country codes, and currencies) upon first occurrence. Authors should avoid overusing abbreviations, unless these are common to the general readership.
4. Authors should abbreviate country names in tables and figures by using two-letter ISO codes. Monetary quantities should be denoted by three-letter ISO codes; authors should specify current or constant currency and, if applicable, the base year of deflation.
5. Authors should round numbers to significant digits.
6. Authors should always reference tables and figures in the text before displaying them. Some journals insist that tables and figures must be self-contained, i.e., readers should be able to understand them only by reading the caption.
7. Authors should always reference scientific statements individually and avoid references to secondary literature to allow readers to locate the primary sources of information.
8. Authors should pay attention to: (i) punctuation, e.g., all sentences that end with expressions in parentheses must be punctuated outside of the closing parenthesis; and (ii) spelling, e.g., '*cannot*' is one word, and '*its*' is a possessive pronoun while '*it's*' is a contraction for '*it is*' (see, e.g., [15] for more information).
9. Authors should chose one type of English, e.g., UK (United Kingdom) or US (United States) English, and follow its rules throughout the article.

Following these additional conventions makes writing clear but may not guarantee that a wide audience finds the research interesting. To engage readers, editors, and reviewers, authors should demonstrate relevance [12] by asking themselves: What would trigger the curiosity of a wider audience? How does our research connect to and extend established knowledge? Answering the first question requires creativity; addressing the second question requires providing an appropriate scientific context and presenting a suitable research design.

Next to paying attention to their technical writing, authors should limit the length of articles to between 6000 and 9000 words, including abstract and appendices but excluding references. Exceptions may apply to, e.g., review articles or comparative technology assessments that may require more extensive explanations. Long articles, however, are more likely to suffer from poor structure, wordiness, and unnecessary detail. At any rate, most journals enforce length restrictions.

Authors can make or lose a good article based on sufficient revisions [14]. We suggest inviting colleagues to review article drafts (see also [18]). This enables authors to scrutinize their writing from the perspective of readers and execute necessary revisions prior to submission. Finally, writing, like any other skill, is difficult and requires commitment and consistent practice. The great pianist Franz List once remarked [29]: "If I do not practice for one day, I notice it; if I do not practice for two days, my friends notice it; three days without practice and the audience will notice it."

6. Conclusions

We demonstrate how writing articles in energy science can be made more efficient, clear, and concise by following a stepwise top-down approach. First, authors should define the macro- and meso-structure of the article. Second, they should carefully structure their scientific arguments, e.g., by placing existing information at the beginning of a sentence, locating new information at the end of the sentence, and expressing actions with appropriate verbs. Third, authors need to pay attention to wording, to the use of tense and voice, as well as to additional conventions for presenting research.

Writing articles is crucial for the communication of energy science. The conventions outlined here allow energy scientists as well as scientists from other fields to communicate their research effectively with readers both from within and outside of the scientific community.

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Appendix A. List of abbreviations

CER	Certified emission reduction
CHP	Combined heat and power
ITC	Induced technological changes
PV	Photovoltaic
R&D	Research and development
REC	Renewable energy certificate

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