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Energy Consumption, Energy Distribution, and Clean Energy Use Together Affect Life Expectancy

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Abstract: Background: Energy use per capita is a measure of the wealth of a population. A minimum of wealth or energy is certainly needed to achieve good living standards and a healthy life. Life expectancy at birth might be used as an indicator of overall health and well-being. We hypothesized that the effect of energy use on life expectancy does reach a limit, above which further energy use does not further increase life expectancy. Methods: We used global World Bank data for the years between 1972 and 2014 on national energy use and life expectancy and applied non-linear models searching for a threshold. We also controlled for distribution inequalities. Results: There is a clear upper threshold for the effects of energy use, but this threshold did not remain completely constant over the years. Conclusions: While a certain level of wealth and energy use is necessary for health and well-being, there is a certain threshold beyond which additional energy consumption has no beneficial effects. A more even distribution of wealth and energy within a population and the use of cleaner energy sources might, above a certain level, be more important than the average use of energy.

Keywords: global world bank data; energy use; life expectancy; non-linear models; distribution of wealth; GINI coefficient

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Citation: Weitensfelder, L.; Moshammer, H.; Ataniyazova, O. Energy Consumption, Energy Distribution, and Clean Energy Use Together Affect Life Expectancy. *Sustainability* **2024**, *16*, 678. https://doi.org/10.3390/su16020678

Academic Editor: Pow Seng Yap

Received: 23 November 2023
Revised: 9 January 2024
Accepted: 10 January 2024
Published: 12 January 2024

1. Introduction

Societies generally strive to reach a (non-disabled) high life expectancy, most preferably with high living standards. However, economic growth usually requires energy consumption, and while economic growth is connected to a higher life expectancy, energy consumption plays a contradictory role due to the environmental degradation that goes along with it [1]. Hence, the connection between energy consumption and life expectancy is not very clear. Additionally, climate change concerns require a decrease in our environmental impact, and technical solutions have already helped to decrease energy intensity as has been shown for the example of China [2]. Relationships between energy consumption and financial development might also vary depending on the developing stage of the market [3]. Additionally, the renewability of energy also seems to be connected to life expectancy, as very recent results show [4], with correlations between renewable energy and life expectancy being higher in high-income groups. Especially when energy comes from burning fossil fuels, consequences are not only problematic regarding climate change, but also regarding acute and subacute health effects from air pollutants: The impact of atmospheric pollution on human health is very high. Each person uses about 10–12 m^3 of air per day. Even slight concentrations of toxins can cause serious illness. As it is mentioned by WHO “half the world has no access to clean fuels or technologies (e.g., stoves, lamps), the very air we breathe is growing dangerously polluted: nine out of ten people now breathe polluted air, which kills 7 million people every year” [5]. Air pollution leads to an acute form of cardiovascular, reproductive, and nervous system pathologies, increasing the risk of diabetes, cancer, and lung diseases. Hence, connections between energy consumption and life expectancy might be slightly different for low-income or emerging countries than for high-income countries.

Our present research focuses on the latter and was inspired by a previous work: One of us (HM) has been invited to contribute a chapter [6] to a booklet edited by the Austrian Academy of Sciences. The booklet consists of different aspects and approaches towards the "Energy Transition for a sustainable society" and HM was asked to present the public health point of view. His primary approach to the topic considered the need of energy consumption for sustaining (human) life, but also human civilization. Moreover, is it possible from a public health point of view to define a level of energy consumption that is sufficient and beneficial for health and well-being, and above which, further increases in energy consumption would not lead to additional benefits? Put bluntly: What is enough and what is too much? The chapter reminded the reader that societal development from Paleolithic hunter–gatherer societies to Neolithic agricultural communities and further on until the industrial revolution and beyond, went hand-in-hand with an increase in energy capture and use [7,8]. However, there are clear signs that the levels of energy capture that are nowadays exceeded in many societies not only lead to an unsustainable exploitation of our planet, but are also detrimental to individual health, for example, due to high caloric food intake [9,10] or insufficient physical activity [11] because of a reliance on machines for mobility and physical tasks.

A brief literature search delivered several studies linking levels of energy consumption to indicators of population health like life expectancy [12–17]. In summary, these studies indicated that a higher energy consumption is beneficial for society up to a certain point by providing safe food and shelter, but also access to education and healthcare. With closer scrutiny, the type of energy source (clean and sustainable versus fossil and dirty) might matter more than the amount of energy; an assumption that has recently been confirmed based on the data from 131 different countries [4]. Furthermore, the distribution of energy within a society might be of greater importance than the average energy consumption per society [16]. Moreover, what was most surprising in this literature search was a blog by Roger Pielke [18] in which he presented a scatter plot depicting single countries in the year 2010 (according to World Bank statistics) with Energy use (kg of oil equivalent per capita) on the x-axis, and life expectancy at birth (in years) on the y-axis. Each country is represented by a dot of the same size and a regression line is drawn through the cloud of dots hinting at a quasi-linear increase in life expectancy with increasing per capita energy consumption.

A closer inspection of that scatter plot revealed that (a) energy use was depicted on a logarithmic scale, and (b) even on this logarithmic scale it was evident that the increase in life expectancy was stronger on the left side of the picture where the energy consumption was still very low.

Therefore, we decided to examine if (a) there is an upper threshold to this energy consumption/life expectancy association in the World Bank data, and (b) if this threshold can be demonstrated, remains constant over time. To put it bluntly again, we wanted to see whether the goal of a higher life expectancy goes along with a steadily increasing need for energy (and hence, the need for additional sustainable energy), or whether above a certain threshold any additional energy consumption is no longer connected to an increasing life expectancy. In that case, it would allow for a rough estimate of a level of sufficient, but not too much, energy capture from a public health point of view. Because of restraints in time and article length HM was not able to dive deeply into this project within the previously mentioned chapter [6]. Therefore, we want to present these findings here.

2. Materials and Methods

From the World Bank Development indicators database [19] the following data were extracted for all available countries between the years 1971 and 2014: total population, life expectancy at birth, energy capture, and gross domestic product (GDP) per capita. While for the other variables more recent data would have been available, energy capture was only provided for that limited time span (with data for only very few countries for 2015 as well). From ourworldindata.org [20], we extracted data on economic inequality and used the GINI coefficient for additional analyses: The GINI coefficient indicates the degree of inequality in the distribution of wealth, ranging between 0 and 1, with 0 representing perfect equality. In the first step, for selected countries, generalized or proportional hazards additive models (GAM) for life expectancy as a function of energy capture weighted by population assuming a Gaussian distribution and the association modelled as a natural cubic spline with 3 degrees of freedom were calculated. The GDP per capita or GINI index were added as possibly confounding variables. The plot of the association allowed for an initial visual assessment of the shape of the association and confirmed our expectation of a saturation level. To provide a more intuitive picture of global and temporal variation, the data set was also uploaded onto an offline version of Gapminder [21]. This is a free online tool offered by "an independent educational non-profit fighting global misconceptions". Using this online resource, an online presentation of the results was created [22].

Next, for every year separately, a regression model assuming a linear association up to a certain threshold and a constant life expectancy above that threshold was calculated, weighted by population number (Formula (1)).

$$\text{life\_exp} = \{a\} + \{b\} \times \text{Energy} \times (\text{Energy} < \{c = 5000\}) + \{b\} \times \{c\} \times (\text{Energy} > \{c\}), \quad (1)$$

where {a} represents the constant, {b} the coefficient of the linear association, and {c} the threshold that was initiated with 5000.

Finally, for each year, the population weighted life expectancy was calculated. Time trends for life expectancy, as well as {a}, {b}, and {c} were depicted and analyzed in linear regression over time.

All calculations were performed in STATA BE Vers. 17 [23].

3. Results

3.1. Visualisation of the Association between Energy Capture and Life Expectancy

General additive models for selected years clearly indicated an increase in life expectancy up to a certain threshold (Figure 1). What is already clear for single years can also be observed online for single countries, or groups of countries, or all countries with available data over time in the export from Gapminder Offline [22]: For some countries over prolonged periods of time the life expectancy is increasing, for other countries the energy capture increases, but only rarely do both variables increase in parallel.

In the Gapminder application [22], it is possible to either follow the general worldwide trends or to focus on selected countries. Those countries with the highest energy consumption per capita in 2014, according to World Bank data, are on the one hand Iceland and on the other hand countries around the Persian Gulf. While Iceland has access to cheap and clean geothermal and hydro-power energy and might be in need for higher energy use due to climatic conditions, the latter might be also true for the countries around the Persian Gulf that still rely heavily on fossil fuels. Unsurprisingly, among these high energy use countries, Iceland has the highest life expectancy. Many countries, above all Western Countries from Europe, but also Japan and the United States, display a steady increase in life expectancy without any clear trend in energy use. The countries of the former Soviet Union display a much more complicated picture with a steep decline in life expectancy after the fall of the Soviet Union and a recovery thereafter, while energy use is shifting back and forth.

In the 1970s, most countries still had an energy use per capita below 2000 kg of oil equivalent, while in the final years of the observation period, many countries exceeded this threshold. Indeed, the population weighted average of the energy use per capita lies around 2000 kg of oil equivalent (Figure A3), although with a broad confidence interval.

Energy use and GDP per capita were strongly correlated with each other, with the R^2 in linear regression weighted by population size ranging with a few exceptions (1978–1980) between 0.85 and 0.97 in the earlier years (1971–1986) and between 0.60 and 0.78 in the later years (1990 onwards) of the observation period. Because of this strong cross-correlation, combining both variables in the same model was not possible. The shape of the association between GDP per capita and life expectancy was very similar to that between energy use and life expectancy.

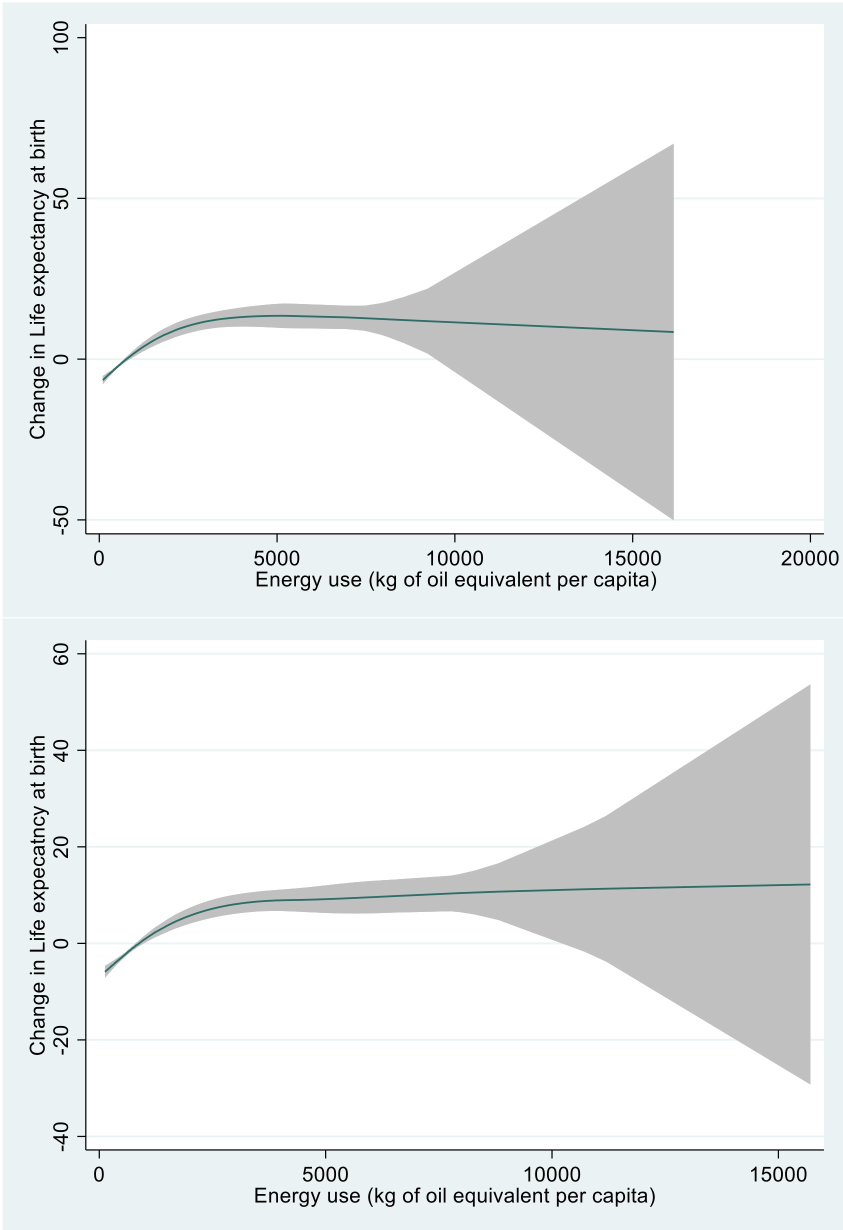

Figure 1. Non-linear association (natural cubic spline with 3 degrees of freedom) between energy use and life expectancy, countries weighted by population number, 1984 (**upper**) and 1994 data (**lower** graph). 2014 data available at [6].

Considering the possibility of a lagged effect of energy use (or GDP per capita) on life expectancy, the life expectancy 20 years later (i.e., the life expectancy of the next generation) was also examined. There was a strong correlation between life expectancy in year y and in year y + 20. The effects of energy use, or of the GINI index, on life expectancy now or 20 years later were very similar.

The GINI index, with higher values indicating higher inequality, was in all years inversely correlated with life expectancy. Sufficient country data on the GINI index were only available from 1992 onwards. Even afterwards, data were still missing from many countries. In 1992, only 46 countries had information on life expectancy, energy use, and GINI index. The association between energy use and life expectancy was not substantially influenced by the introduction of the GINI index into the model. The effect of the GINI index deviated significantly from linearity with the steepest decline around a GINI coefficient of about 0.5 (Figure A1 in Appendix A).

In the World Inequality Database [20], not only the GINI index was reported per country and year, but also other measures of inequality, most notably the income share of the richest 10%, 1%, and 0.1%, as well as of the poorest 50%. As a kind of sensitivity analysis, for some selected years we replaced the GINI coefficient by one of the other inequality indictors. But, based on the Akaike Information Criterion, none of the inequality indictors was consistently better than the others. Furthermore, multiplying the income share of the poorest 50% with the average GDP per capita, thus providing an estimate of the income for the majority of people, did not give a clearly better fit than the average GDP per capita alone.

3.2. Non-Linear Regression Models

For all years there was a clear and significant indication of a threshold. Below that point, there was also always a significantly positive association with energy capture. Figure 2 presents the results of that threshold model for the year 1994 as an example. For more example years (1972–2012, every 10th year) but without displaying the confidence intervals, the same results are presented in Figure A4.

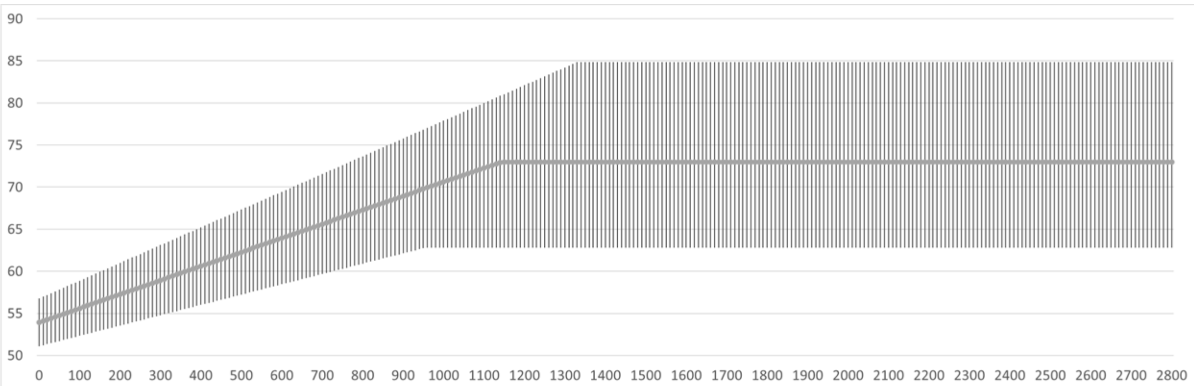

Figure 2. Linear association with an upper threshold between energy use (x-axis: in kg of oil equivalent) and life expectancy (y-axis: in years), countries weighted by population number, 1994 data, point estimates and 95% confidence intervals. The figure is based on the following coefficients: {a} (hypothetical life expectancy with zero energy use): 53.93 years; {b} (slope in years per kg of oil equivalent): 0.017; {c} (upper threshold of energy use): 1142.38.

3.3. Time Trends

Results from the first year (1971) deviated strongly from the following years, which could be due to data from Asia, where life expectancy in Bangladesh dropped from 42.6 years to 26.0 years in the year of the Bangladesh war [24]. Hence, this year was excluded from further trend analysis. Over the years, both life expectancy (population weighted global average) and energy use per capita increased by about 0.3 years per year ($p < 0.001$) and about 12.6 kg of oil equivalent per year ($p < 0.001$), respectively. This is graphically demonstrated in Appendix A (Figures A2 and A3).

Furthermore, the constant that is the hypothetical life expectancy at zero energy use and the upper threshold increased over time (Figures 3 and 4), but the increase in the latter was far from linear. Between around 1990 and 2000, the threshold was even slightly lower than in the years before. Only after the year 2000, an increase in the threshold was observed, possibly indicating a more energy-intensive lifestyle. However, at the same time, since the year 2000, the slope of the association below the threshold declined, indicating a weakening effect of the energy use per capita on life expectancy (Figure 5). Indeed, the time course in Figure 5 mirrors that in Figure 4 closely: an increasing threshold goes in parallel with a reduced slope.

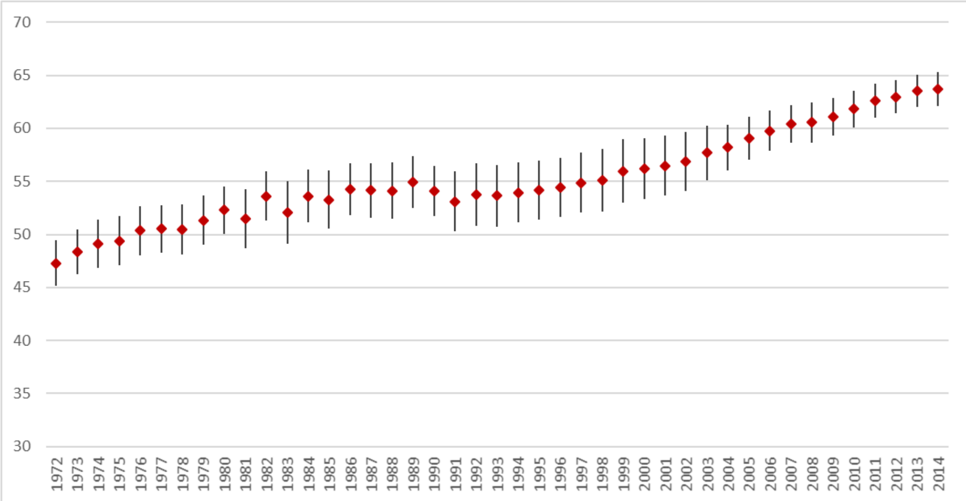

Figure 3. Temporal change of the hypothetical life expectancy at birth (in years, y-axis) under the assumption of zero energy use from 1972–2014 (x-axis).

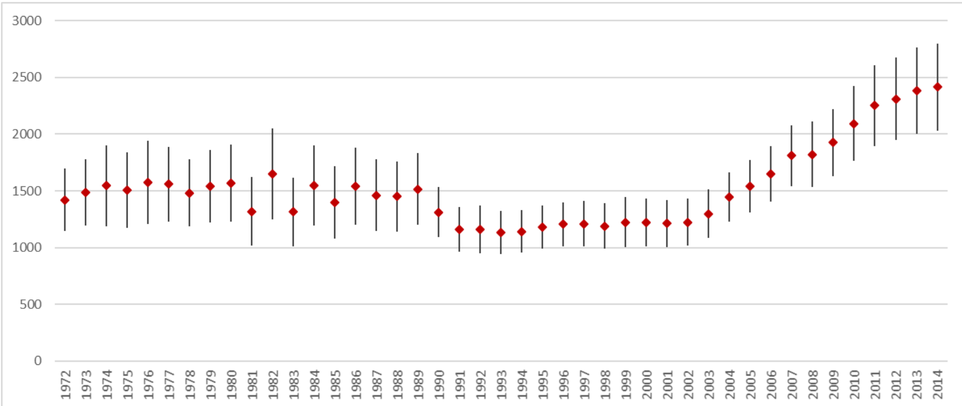

Figure 4. Temporal change of the upper threshold of energy use in kg of oil equivalent per capita (y-axis) from 1972–2014 (x-axis).

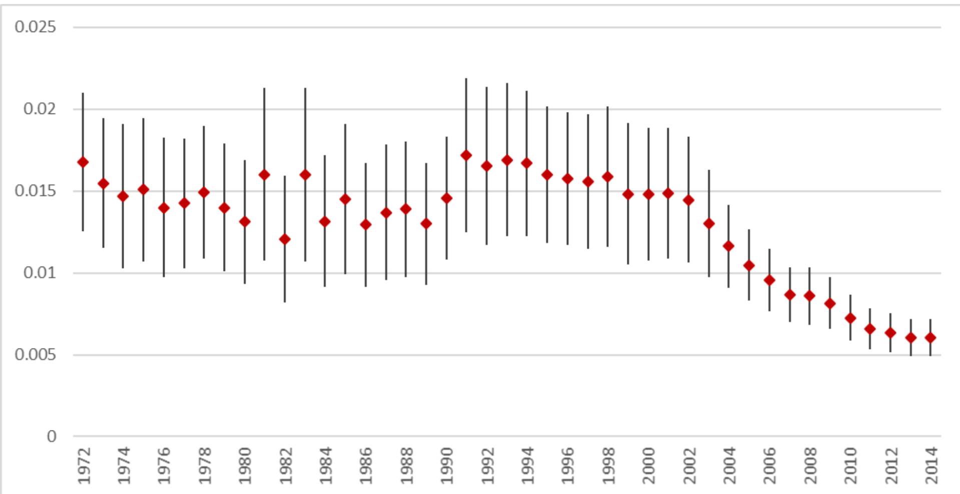

Figure 5. Temporal change of the slope (in years per kg of oil equivalent, y-axis) of the association between life expectancy and energy use in kg of oil equivalent per capita from 1972–2014 (x-axis).

4. Discussion

Overall, our results show that both life expectancy and energy consumption per capita increased over time, but the increase was much more pronounced for life expectancy. The overall increase in energy use per capita was mainly driven by the catch-up of less developed countries, while most countries that already had a high energy use in 1972 did not display a further increase, but still displayed an additional increase in life expectancy. Energy use is strongly connected to economic growth, so the higher energy demand of economic growth must urgently be mitigated and hence questions of energy efficiency and renewability become important topics in rising economies [25]. Overall, however, the correlation between energy use and economic growth seemed to be less strong in the later years of our observation period, and the strength of the connection might also differ in more and less developed countries [26]. This could also be exemplified by the Chinese experience. China's development is bound to be constrained by high energy consumption, in order to coordinate and balance energy consumption with economic growth. However, as Dai et al. suggest [27] (although retracted), "*As an important material basis for the development of human society, energy is also the main driving force of economic growth. However, while energy promotes the economic growth, it also brings pollution problems to the world environment and gradually becomes the bottleneck, hindering the sustainable development of the economy*". Therefore, from our available data it cannot be decided which of the two (energy consumption or growth) is directly linked to life expectancy causally, and the results talking about energy use would be more or less equivalent to the results with GDP instead. Besides, aspects like health spending should also be accounted for [28].

Additionally, the World Bank data shows how the effect of per capita energy use on life expectancy (below a threshold) slowly decreases. However, as shown in Figure 5, the coefficient is still above zero with an increasingly smaller confidence interval resp. variance. This is likely due to the fact that an increasing number of countries have crossed the threshold, and thus, only fewer countries contribute to the association below that threshold. It seems that for this smaller group of countries the distribution of wealth or energy access within each country might be more relevant for health as captured by life expectancy, than the average wealth or energy use. Indeed, using the GINI index as one measure of inequality, displays a strong association with life expectancy that is independent from the average wealth. Unfortunately, data on wealth distribution within countries were available only for rather few countries. This hindered a more in-depth analysis. It may be that the average life expectancy of a country is mostly driven by the wealth or energy use of a poorer part of the country's population. It would be interesting to assess the energy use of which part of the population (e.g., the poorer half) would provide the best model fit. Regarding this, future investigations should be encouraged.

While the data clearly show a threshold beyond which a further increase in energy use does not translate into an additional increase in life expectancy, this threshold changed over the years and especially increased after the year 2000 (Figure 4), and around the year 1990 there was even a slight reduction in the threshold. However, such a step-wise change could easily be due to changes in reporting and data collection. Nevertheless, at the same time as when the threshold increased, the slope of the association below that threshold also decreased and remained at a still positive, yet much smaller value. Therefore, an overall (substantial) benefit of an increase in energy use cannot be assumed. Hence, there is no need for higher energy consumption in order to maintain a higher life expectancy. Additionally, life expectancy hypothetically even increased without any energy use (Figure 3) indicating that the average energy use became less and less important for population health.

Energy consumption can root from a variety of different sources, and even energy consumption that derives from industry might in fact root in different sectors. Some countries might furthermore rely more on high energy-intense industry than others. A comparison of 7 OECD countries in 2003, for example, showed that production in the US was generally more energy-intense than in other countries with the exception of Canada [28]. However, such results do not apply to all sectors equally: In the case of the US, for example, the energy intensity did not apply to the iron and steel sector [29]. The example shows that the production of different goods varies in energy-intensity, and this could also be connected to the increasing energy threshold we found after the year 2000 (Figure 4). As countries are very diverse in their productive sectors and inter-sectoral connections, there are more country than sector differences which need to be considered for political decisions [30].

Furthermore, products themselves seem to be of importance for energy consumption: A big variety of products, especially electronic devices such as smartphones and tablets, have now become widespread globally. Nevertheless, the information and communication industry is not so much in focus yet when it comes to greenhouse gas emissions, though the sector's environmental impact is growing rapidly, especially for smartphones: In 2018 it was estimated that the greenhouse gas emissions of smartphones might have risen from 17 Mt CO_2 in 2010 to 125 Mt in 2020, mostly driven by production energy and a short average life of the device [31].

Our research did not differentiate between which area the energy is consumed in which can be seen as a limitation, and further research regarding sector-specific energy consumption should still be encouraged.

As a further limitation, it has to be mentioned that our data is a very rough overall estimate, where several factors that might be of importance for life expectancy could not be considered (e.g., political situations, access to healthcare). We also could and did not differentiate between renewable and non-renewable energy. Technical development has made renewable energy much more available than it was in the 1970s, and several production areas nowadays pay attention to energy efficiency. Hence, an even more detailed investigation regarding the types of energy should be further encouraged.

An ecological study approach will never support causal interpretation. However, an association between wealth and/or energy capture and health both on the individual [32] and the societal level is well established. Furthermore, there must be an upper threshold to this association. With the need for energy transition in mind, we set out to estimate that threshold using real world data, not to prove an already established association. Our endeavor was burdened by data limitations especially regarding temporal coverage and sector specificity. In the later years covered by our analysis, many countries might already have transgressed the threshold we sought. This would have reduced our ability to estimate this threshold with sufficient accuracy.

5. Conclusions

The hope to find a precise threshold above which energy use per capita would no longer increase life expectancy was not fully satisfied. This threshold seemed to increase in the years after 2000. This might partly be an artefact due to the reduction in countries still contributing to the part of the association left to the threshold though. Until the year 2000, that threshold appeared pretty stable at around or below 1500 kg of oil equivalent per capita. In 2014, many countries representing about 50% of the world population have already exceeded that old threshold with the population weighted mean even approaching 2000 kg of oil equivalent per capita.

This would indicate that for most of the world additional energy use would not contribute to additional population health and well-being. While for the less developed countries, a further increase in wealth or energy use might still be beneficial, providing the means for improved housing, food security, mobility, education, or cultural amenities. For the most developed part of the world, a reduced energy use would not endanger the health and well-being of its citizens. Indeed, the use of cleaner energy and the fairer distribution of energy and material resources within each country would likely have a more beneficial impact on well-being than the generation of more resources.

Author Contributions: Conceptualization, H.M. and L.W.; methodology, H.M.; validation, L.W. and O.A.; formal analysis, H.M.; writing—original draft preparation, H.M.; writing—review and editing, L.W. and O.A.; visualization, H.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

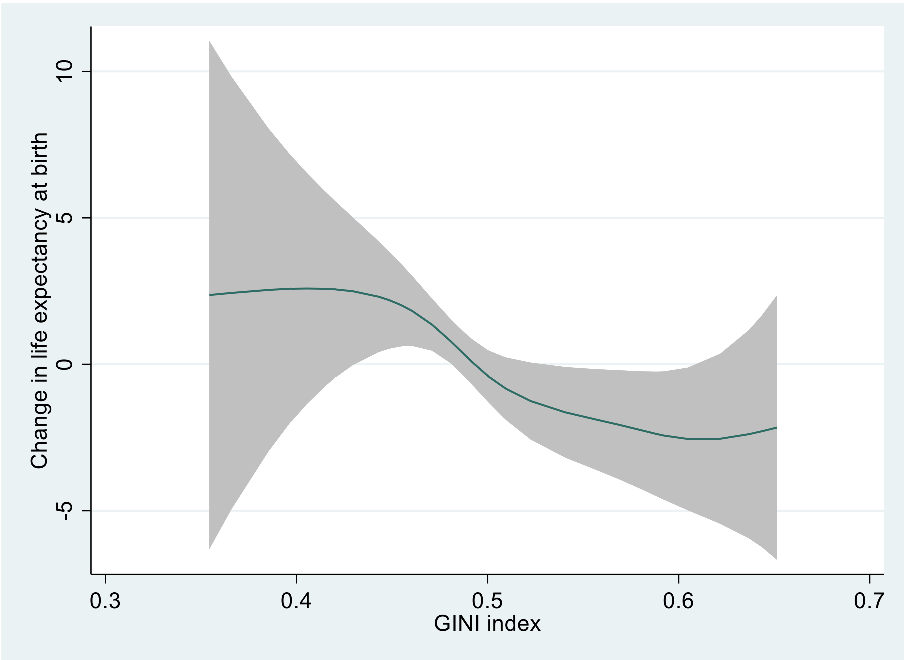

Figure A1. Non-linear association (natural cubic spline with 3 degrees of freedom) between GINI index and life expectancy, countries weighted by population number, 1997 data as an example.

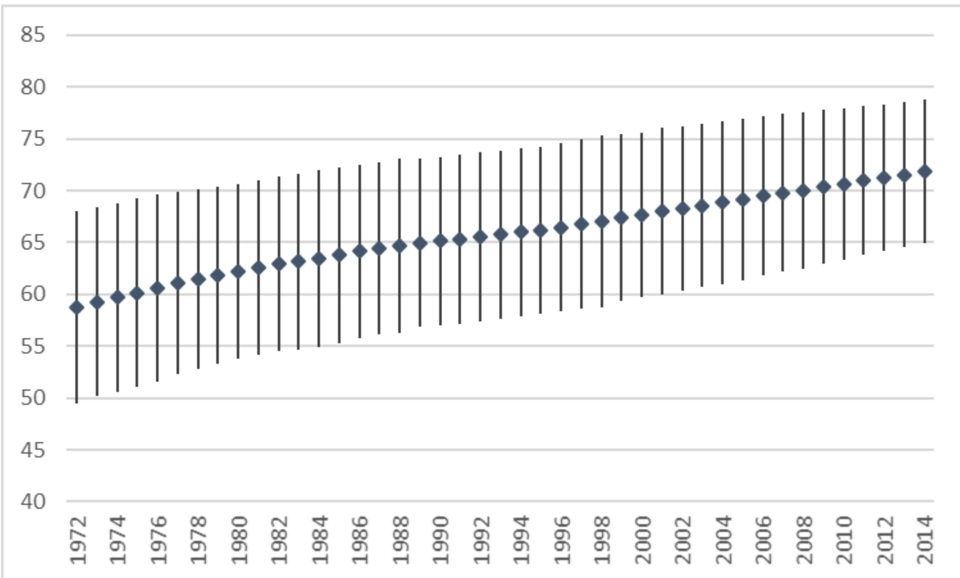

Figure A2. Temporal change of life expectancy at birth (y-axis) from 1972–2014 (x-axis).

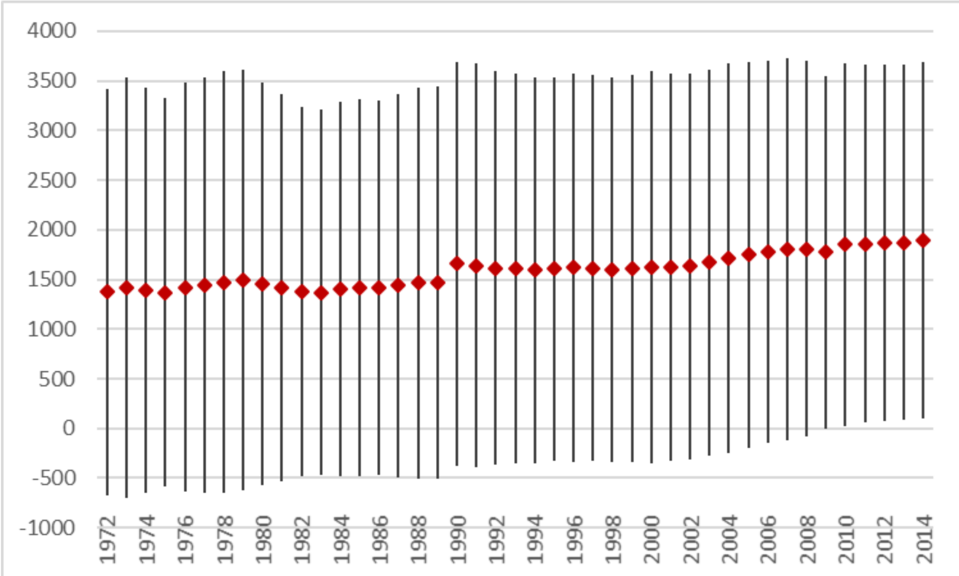

Figure A3. Temporal change of energy use per capita in kg of oil equivalent (y-axis) from 1972–2014 (x-axis).

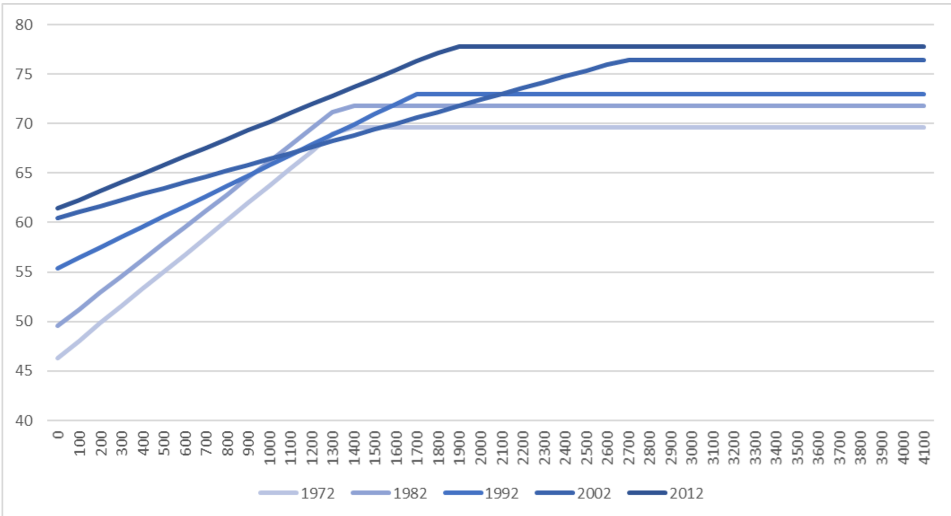

Figure A4. Point estimate of the association between energy use (in kg of oil equivalent per capita) on the x-axis and life expectancy at birth (in years) on the y-axis for 5 example years 10 years apart each.

References

1. Wang, Z.; Mansoor, M.; Haider, A.; Nawaz, K.; Wang, B.; Zhao, W.; Xu, F. The Dynamic Relationship between Economic Growth and Life Expectancy: Contradictory Role of Energy Consumption and Financial Development in Pakistan. *Struct. Change Econ. Dyn.* **2020**, *53*, 257–266. [CrossRef]
2. Li, M.; Gao, Y.; Liu, S. China's Energy Intensity Change in 1997–2015: Non-vertical adjusted Structural Decomposition Analysis Based on Input-Output Tables. *Struct. Change Econ. Dyn.* **2020**, *53*, 222–236. [CrossRef]
3. Durusu-Ciftci, D.; Soytas, U.; Nazlioglu, S. Financial development and energy consumption in emerging markets: Smooth structural shifts and causal linkages. *Energy Econ.* **2020**, *87*, 104729. [CrossRef]
4. Wang, Q.; Wang, L.; Li, R. Does renewable energy help increase life expectancy? Insight from the linking renewable energy, economic growth, and life expectancy in 121 countries? *Energy Strategy Rev.* **2023**, *50*, 101185. [CrossRef]
5. How Air Pollution Is Destroying Our Health. Available online: https://www.who.int/news-room/spotlight/how-air-pollution-is-destroying-our-health (accessed on 20 November 2023).
6. Moshammer, H. Energy needs, social potentials and barriers to change—With a focus also on possible input from health-related civil society initiatives. In *Energy Transition for a Sustainable Society*; KIÖS Opinions, 13; Winiwarter, W., Bruckman, V.J., Eds.; Austrian Academy of Sciences: Vienna, Austria, 2023; pp. 21–24.

7. Morris, I. *Why the West rules—For Now: The Patterns of History, and What They Reveal About the Future*; Farrar, Straus and Giroux: New York, NY, USA, 2010.
8. Social Development. Supplemental Material by Ian Morris. Available online: http://www.ianmorris.org/docs/social-development.pdf (accessed on 7 June 2022).
9. Healthy Diet. WHO Fact Sheet. 29 April 2020. Available online: https://www.who.int/news-room/fact-sheets/detail/healthy-diet (accessed on 19 September 2023).
10. Ekmekcioglu, C.; Wallner, P.; Kundi, M.; Weisz, U.; Haas, W.; Hutter, H.-P. Red meat, diseases, and healthy alternatives: A critical review. *Crit. Rev. Food Sci. Nutr.* **2018**, *58*, 247–261. [CrossRef] [PubMed]
11. Bonilla, D.A.; Peralta-Alzate, J.O.; Bonilla-Henao, J.A.; Cannataro, R.; Cardozo, L.A.; Vargas-Molina, S.; Stout, J.R.; Kreider, R.B.; Petro, J.L. Insights into Non-Exercise Physical Activity on Control of Body Mass: A Review with Practical Recommendations. *J. Funct. Morphol. Kinesiol.* **2023**, *8*, 44. [CrossRef] [PubMed]
12. Lloyd, P.J. The Role of Energy in Development. *J. Energy South. Afr.* **2017**, *28*, 54–62. [CrossRef]
13. Njiru, C.W.; Letema, S.C. Energy Poverty and Its Implication on Standard of Living in Kirinyaga, Kenya. *J. Energy* **2018**, *2018*, 3196567. [CrossRef]
14. Nkalu, C.N.; Edeme, R.K. Environmental Hazards and Life Expectancy in Africa: Evidence from GARCH Model. *SAGE Open* **2019**, *9*. [CrossRef]
15. Salehnia, N.; Karimi Alavijeh, N.; Hamidi, M. Analyzing the impact of energy consumption, the democratic process, and government service delivery on life expectancy: Evidence from a global sample. *Environ. Sci. Pollut. Res.* **2022**, *29*, 36967–36984. [CrossRef] [PubMed]
16. Wang, S.; Luo, K. Life expectancy impacts due to heating energy utilization in China: Distribution, relations, and policy implications. *Sci. Total Environ.* **2018**, *610–611*, 1047–1056. [CrossRef] [PubMed]
17. Wang, S.; Liu, Y.; Zhao, C.; Pu, H. Residential energy consumption and its linkages with life expectancy in mainland China: A geographically weighted regression approach and energy-ladder-based perspective. *Energy* **2019**, *177*, 347–357. [CrossRef]
18. Graph of the Day: Life Expectancy vs. Energy Use. Blog by Roger Pielke. 14 February 2013. Available online: https://rogerpielkejr.blogspot.com/2013/02/graph-of-day-life-expectancy-vs-energy.html (accessed on 14 September 2023).
19. World Bank Development Indicators Database. Available online: http://data.worldbank.org/?display=default (accessed on 14 September 2023).
20. Our World in Data. Economic Inequality. Available online: https://ourworldindata.org/economic-inequality (accessed on 6 October 2023).
21. Gapminder. Available online: https://www.gapminder.org/ (accessed on 14 September 2023).
22. Vizabi Export. Available online: https://www.isde.org/bubble/ (accessed on 14 September 2023).
23. *STATA*; Version 17.0; Stata Corp.: College Station, TX, USA, 2021.
24. Our World in Data. Life Expectancy. Available online: https://ourworldindata.org/life-expectancy (accessed on 18 October 2023).
25. Khan, S.; Murshed, M.; Ozturk, I.; Khudoykulov, K. The roles of energy efficiency improvement, renewable electricity production, and financial inclusion in stimulating environmental sustainability in the Next Eleven countries. *Renew. Energy* **2022**, *193*, 1164–1176. [CrossRef]
26. Kulionis, V.; Wood, R. Explaining decoupling in high income countries: A structural decomposition analysis of the change in energy footprint from 1970 to 2009. *Energy* **2020**, *194*, 116909. [CrossRef]
27. Dai, L.; Jia, R.; Wang, X. Relationship between Economic Growth and Energy Consumption from the Perspective of Sustainable Development. *J. Environ. Public Health* **2022**, *2022*, 6884273. [CrossRef] [PubMed]
28. Liu, H.; Zhong, K. Relationship between health spending, life expectancy and renewable energy in China: A new evidence from the VECM approach. *Front. Public Health* **2022**, *10*, 993546. [CrossRef] [PubMed]
29. De Nooij, M.; van der Kruk, R.; van Soest, D.P. International comparisons of domestic energy consumption. *Energy Econ.* **2003**, *25*, 359–373. [CrossRef]
30. Álvarez-Martínez, M.T.; Mainar-Causapé, A.J. The GHG Emissions Generating Capacity by Productive Sectors in the EU: A SAM Analysis. *Sustainability* **2021**, *13*, 2363. [CrossRef]
31. Belkhir, L.; Elmeligi, A. Assessing ICT global emissions footprint: Trends to 2040 & recommendations. *J. Clean. Prod.* **2018**, *177*, 448–463. [CrossRef]
32. Renahy, E.; Mitchell, C.; Molnar, A.; Muntaner, C.; Ng, E.; Ali, F.; O'Campo, P. Connections between unemployment insurance, poverty and health: A systematic review. *Eur. J. Public Health* **2018**, *28*, 269–275. [CrossRef] [PubMed]