The Happiness-Energy Paradox: Energy Use is Unrelated to Subjective Well-Being

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Abstract
Earth’s per capita energy use continues to grow, despite technological advances and widespread calls for reduction in energy consumption. The negative environmental consequences are well known: resource depletion, pollution, and global warming. However many remain reluctant to cut energy consumption because of the widespread, although, implicit, belief that a nation’s well being depends on its energy consumption. This article systematically examines the evidential support for the relationship between energy use and subjective well-being at the societal level, by integrating data from multiple sources, collected at multiple levels of government, and spanning four decades. This analysis reveals, surprisingly, that the most common measure of subjective well-being, life satisfaction, is unrelated to energy use – whether measured at the national, state or county level. The nil relationship between happiness and energy use is reminiscent of the well-known Easterlin Paradox, however the causal mechanisms responsible to each remain in question. We discuss the possible causes for the Happiness-Energy paradox and potential policy implications.

Keywords Energy use · Energy consumption · Energy intensity of economy · Sustainability · Happiness · Life satisfaction · Subjective well-being (SWB)

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The environmental consequences of human energy consumption are one of the world’s biggest problems. In particular, energy consumption is a key driver of climate change (MacKay 2008; Pachauri et al. 2014). For instance, 98% of US carbon dioxide emissions are due to energy consumption (Energy Information Administration 2008). Despite technological advances, Earth’s per-capita energy use has increased about 40% over the past four decades, and continues to grow. An essential policy and ethical challenge is to find ways to be environmentally efficient at production of human well-being, to achieve good life for all within planetary boundaries (Dietz et al. 2009; O’Neill et al. 2018).

Energy is a strategic resource. Countries wage wars over energy sources, and much of politics is driven by energy. Many countries rely heavily on energy production and many use it as a political tool. Virtually all countries seek to obtain more energy sources. A recent example is fracking (Inman 2014). Yet, we need to consume less—for at least two obvious reasons: First, worldwide, most of the energy consumed is non-renewable, and this pattern of use will persist for some time (MacKay 2008). Second, energy consumption causes pollution, and pollution harms the environment, other species, and ourselves (MacKerron and Mourato 2009; Gandelman et al. 2012; Ferreira et al. 2013). Thus, natural resource depletion and pollution potentially cancel out the benefits of energy consumption.

Many argue that consumption must be reduced dramatically. A recent report by an Intergovernmental Panel on Climate Change is alarming (Pachauri et al. 2014 and http://www.ipcc.ch).

A major review estimated that global climate change could reduce global GDP by 20%. (Stern et al. 2006) Indeed, the threat is serious enough that claims for not growing the economy anymore or even “degrowing” are being strongly argued (Kallis 2011; Kallis et al. 2012). Some argue that reduction as high as a factor of ten is needed in affluent societies (Pretty 2013).

Moreover, it is generally believed that there is a fundamental tradeoff between societal energy consumption and self-interest at the individual and national level. It is believed that substantially reducing energy consumption requires individual sacrifices: It is widely (although not universally) believed that increased energy consumption is necessary both for overall national economic growth and to increase the directly consumed amenities (such as cooling, travel, lighting) that increase well-being (Jorgenson et al. 2014; Stern and Kander 2012; Dietz 2015; Carter 1977; Smil 2005). However recent research in the field of subjective well-being (SWB) offers theoretical reason for hope – the key point from SWB literature relevant here is that there is a consumption threshold beyond which SWB become satiated (Lamb and Steinberger 2017). In what follows we bridge the study of energy consumption and SWB and examine the empirical relationship between these at a global scale.

While energy consumption is useful, most energy consumption both pollutes and depletes natural resources (Arrow et al. 2004; Soytas et al. 2007). How energy use affects human well-being on the whole remains an open question, which we examine in this research. Traditional approaches to examining the effects of development have measured societal benefits using the Gross Domestic Product (GDP) and its adjustments – per capita and purchasing power parity (Jorgenson 2014). Relying solely on
GDP as a measure of societal benefit has a broad range of shortcomings which are now becoming broadly recognized – and does not generally capture individual’s evaluation of their quality of life (Giannetti et al. 2015). We evaluate the benefits and problems of energy use using both GDP and gold-standard measures of subjective well-being (SWB), life satisfaction. Combining these measures reveals surprising relationships among energy consumption and societal benefit.

By combining data on energy consumption and SWB we find that the people in economically developed areas consuming more energy are not happier. This finding is consistent across time and multiple levels of spatial aggregation—it applies to patterns of energy consumption at the local, national, and global scale. Further, across both developed and developing countries with normal economies we observe a strong inverse relationship between SWB and the energy-intensiveness (the amount of energy per unit of GDP). This suggests that a national increase in energy consumption does not contribute to SWB (likely the opposite) except where such consumption leads to unusually great increases in GDP. By combining data on energy consumption and SWB we find that the people in economically developed areas that consume more energy are not happier. This finding is consistent across time and multiple levels of spatial aggregation—it applies to patterns of energy consumption at the local, national, and global scale.

Analysis and Results

Selection of Measures and Data

There is a consensus that the survey items that we use are good measures of subjective well-being (Diener 2009; Oswald and Wu 2009; Stiglitz et al. 2009). All SWB measures come from surveys representative of given areas. Such measures are reasonably valid and reliable (Diener et al. 2013). One caveat is limited cross-cultural comparability (Diener and Suh 2003). Our cross-country results showed strong relationships and it is unlikely that the whole effect is due to measurement error, and we mostly used data within the US.

Unlike SWB, energy consumption measures used here are not very similar or directly comparable and differ across studies due to availability of measures. For the purposes of determining broad and durable patterns, we identified the existing data sources that have been systematically and continuously measured over periods of at least five years; have coverage of units within the target population (states, counties, nations) that is as complete as possible; and are of high quality.

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1 The concept of subjective well-being (SWB) has been well-studied, for recent reviews see Diener (2009) and Diener et al. (2013). It is now widely recognized in this field of study that SWB is a broad multidimensional concept that unifies such popular concepts as (affective) happiness, and life satisfaction. Because it is a multidimensional concept, a complete measurement of all aspects of SWB requires collecting a large set of measures from each subject. Most broad-scale research in this field aims to measure the cognitive dimension of SWB, i.e., life satisfaction, because of its general domain (necessary for cross-comparisons), and established validity and reliability (see, Diener et al. 2013). We follow the standard practice in this area, and make use only empirical data and use life-satisfaction as our measure of SWB.

2 As argued later, only developing nations could improve SWB through greater energy consumption, but across the developed world, the relationship between energy consumption and SWB is nil.
Global Patterns

We started by examining the relationship between energy use and SWB across the world, by country. We used data from the World Database of Happiness (http://www1.eur.nl/fsw/happiness/hap_nat/nat_fp.php?mode=8). The SWB scale is based on multiple data sources and is for the most part based on responses to questions of the form: “All things considered, how satisfied are you with your life as a whole these days?” on a scale from 0 = “dissatisfied” to 10 = “satisfied.” The measure of total per capita energy consumption (kg of oil equivalent per capita) comes from the World Bank (http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE). All data were averaged over the years 2000–2009.

Data are plotted in Fig. 1. The basis for the received wisdom that increasing well-being requires increased energy consumption is illustrated by the figure on the left. Across countries there is a clear positive association between energy use and SWB. SWB generally increases alongside energy consumption, but the variance across countries is large and there are many outliers. For example, some countries that have high energy use, such as Russia (RU), are unhappy. In contrast, many countries such as Costa Rica (CR) or Mexico (MX) are able to reach the highest level of SWB while maintaining very low energy use. As energy use rises, its relationship with SWB flattens out, especially after the threshold of 5000 kg of oil equivalent per capita. In general, developed countries have a greater SWB (Mazur 2011; Jorgenson 2014).

How does the relationship between energy use and SWB change if we take economic development into account? It is well known that the relationship between energy use and SWB is affected by level of development (e.g., Jorgenson and Givens 2015; Knight and Rosa 2011). As recently highlighted by Dietz et al. (2009), it is important to examine how efficient a nation is in producing human well-being. Surprisingly, we find that when we measure energy as a function of economic efficiency, the relationship reverses. This is shown in the second panel of Fig. 1, which displays on the x axis the energy intensity of gross domestic product (energy/GDP). Countries that consume less energy per unit of wealth are happier. Some of the happiest countries are the highly-developed Nordic countries (DK, FI, NO, SE). Their energy consumption is high (Fig. 1, panel 1), but relative to income, their energy consumption is among the lowest in the world (Fig. 1, panel 2). In a descriptive sense, high energy intensity means that a country requires a high cost to convert energy into GDP. Another way to put this is that some countries are more efficient (in the economic, not technical sense) at converting energy into wealth.

There are a number of plausible causal explanations for this observed pattern. One hypothesis consistent with the data is that energy-use is largely unrelated to SWB once basic needs are met, but is driven up by other factors (some of which are explored below). A second plausible hypothesis is that countries with lower energy-intensity of GDP employ more energy-efficient technologies: These technologies reduce energy input for the same output of goods or services, so that consumption can remain high at low levels of pollution. A third plausible hypothesis is that countries with lower energy-intensity of GDP have economies that are rely less on inherently energy-intensive industries. A fourth plausible hypothesis is that country-specific characteristics (e.g. as industrial development, financial development, air temperature, and population) simultaneously drive energy use up and well-being down.

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3 This is known as saturation, first mentioned with respect to human development by Martinez and Ebenhack (2008).
These hypotheses cannot be definitely tested with the available data, however examining individual countries favors the first hypothesis: The Netherlands (NL) is rich, energy efficient, and happy. But there are also outliers. For instance, Colombia (CO) is happy and energy efficient, but poor. In general, Latin America poses a puzzle for SWB researchers. Latin Americans are relatively poor but happy. They also use very little energy and have similar energy intensity to that of the US. Notably, all Latin American countries cluster at the top left in the first panel. Great SWB is possible using little energy. East European post-Soviet countries, on the other hand, cluster at the bottom and some at the left. Some countries are relatively unhappy despite low energy intensity of GDP such as Congo (CG). Some countries, on the other hand, are relatively happy despite high energy intensity such as Trinidad and Tobago (TT) and Kazakhstan (KZ).

**US States and Counties** To further probe the hypotheses discussed above, and to answer old question of whether more energy is needed to increase well-being if there is already a great deal of energy being consumed (Mazur and Rosa 1974), we turned to the US, since it is among the countries that use the most energy per capita. State and
county level SWB data come from the Behavioral Risk Factor Surveillance System (http://www.cdc.gov/brfss) using a similar measure of SWB: “In general, how satisfied are you with your life?” on a scale from 1 = “very dissatisfied” to 4 = “very satisfied.” State energy data came from the US Energy Information Administration (http://www.eia.gov/state) and is measured as total energy consumption per capita in the residential sector. California’s residential electricity consumption per capita came from the Energy Consumption Data Management System (http://www.ecdms.energy.ca.gov/elecbycounty.aspx). State level data were averaged over 2005–2010; and California data were averaged over 2006–2010. Results are shown in Fig. 2.

Energy-hungry states are not happier. There are two outliers, Hawaii and California, consuming much less energy in the residential sector than others. We zoom in on California counties in the second panel of the same figure. There is also a great deal of variation in energy use across California counties, and the relationship with SWB is also nil. We have experimented with energy intensity of GDP as we did earlier across countries, but in the case of the US subregions the results are not different.

**Over Time Movement** It is well-known that SWB is related to income in a cross-section, but not over time (Easterlin 1974; Easterlin et al. 2012). To account for this we supplemented our cross-sectional results with an exploration of SWB and energy consumption over time. We used the General Social Survey (http://gss.norc.org), which measures SWB as follows: “Taken all together, how would you say things are these days—would you say that you are very happy, pretty happy, or not too happy?” 1 = “not too happy”, 2 = “pretty happy”, 3 = “very happy”. Energy consumption is measured as total energy use per capita in the residential sector, the same measure as used for states. Figure 3 shows SWB and energy use over time by census division. There is not much co-movement: the two series correlate at .2 only. Energy consumption is only weakly related to SWB.

High residential energy use in the US is often linked to energy inefficient suburbanization: sprawling car-dependent large housing (so called McMansions) (Duany et al. 2001). Energy use and pollution per capita are higher in sprawling suburbs than in compact cities (Meyer 2013). Such suburbs typically crop up in affordable and spacious South and indeed much of the country, and least in increasingly compact and expensive North East and West Coast—Figure 3 agrees: New England and Pacific have their energy use per capita declining. Another problem for climate change is that the rest of the World may want to mimic this unsustainable lifestyle.

Americans continue to consume large amounts of energy as compared to other countries. With the notable exceptions of New England and the Pacific region, energy

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4 The series code is TERPB, and further information is available at https://www.eia.gov/state/seds/sep_use/notes/use_technotes.pdf

5 Total residential electricity consumption has two components: (A) validated Quarterly Fuel and Energy Report (QFER) retail sales/delivery data and (B) self-generation. Electricity Consumption = retail sales + self-generation. Retail sales: electricity amounts delivered from the grid and consumed by the customer. Self-generation: electricity produced and consumed on-site by the customer (for example, parking lot roofs covered with PV panels). Self-generation only contributes to total consumption and not to total sales.

6 Parts of California, notably Los Angeles, are often argued as examples of wasteful suburbanization, yet Los Angeles new homes are much smaller than average (https://www.laweekly.com/news/how-the-size-of-the-typical-la-home-has-grown-over-the-years-7364336).

7 Notably, Central and Eastern Europe have been suburbanizing recently (Stanilov and Sýkora 2014).
Fig. 2 SWB and total residential energy use across US states and residential electricity use across California counties. The relationship was also quite flat in terms of total energy consumption and its GDP intensity. State level data were averaged over 2005–2010, and California data were averaged over 2006–2010.

Fig. 3 SWB (6-yr moving average) and total energy consumption in residential sector per capita. Correlation is .2 only (for unsmoothened series).
use is not decreasing, and sometimes it is increasing. Americans do not spend any less on energy either: 5–10% of personal expenditure over past 50 years were on energy (BEA 2014).

Discussion

The analysis above shows that energy use is apparently unrelated to SWB, especially in developed nations such as the US. Why? There are a number of potential causal explanations rooted in on existing theories of individual behavior, social behavior, and economics. Existing observed information does not allow us to definitively test each of these causal theories here. The discussion below aims to suggest productive areas for future by outlining four possible behavioral explanations, and several additional economic/industrial explanations.

One possibility is that bounded rationality plays a strong role: Decisions on how much to produce and consume based on expected SWB are tricky, humans are often predictably wrong and experience much less SWB than expected (Kahneman et al. 1997), and are wrong in their perceptions of energy consumption and savings (Attari et al. 2010; Dietz 2014). Thus it is perhaps not surprising that there is a discrepancy between expectation (more energy use, more SWB) and experience (more energy use, no more SWB) is not surprising.8

Second explanation is that energy consumption is a positional good: Consumption buys position, but because everyone is in competition with everyone else, the race cannot be won (Frank 2012; Kasser 2003). A related explanation is a “hedonic treadmill” (Brickman et al. 1978): It is possible that consumption does not increase well-being because of hedonic adaptation. More consumption would not make people happy if their basic needs are already satisfied.

A third potential explanation builds on Veblen’s concept of conspicuous or wasteful consumption (Veblen 2005a, b). Such consumption does not satisfy needs but simply aims to demonstrate that one is better than others. Much of such consumption wastes energy without satisfying human needs, and does not make us any happier (Csikszentmihalyi 1999; Frank 2004, 2005, 2012).

A fourth potential explanation based on the livability theory (Veenhoven 2014), is that consumption result in more well-being only up to the point that is used to satisfy basic human needs. Hence, energy used to alleviate extreme temperatures, provide food, shelter, basic transportation, etc, will increase human SWB (if it out-weighs the costs such as pollution). But energy consumed on non-essential human needs (arguably most energy consumed in developed nations) will result in little SWB, if any, and our findings are consistent with such an explanation.

In parallel with these potential behavioral explanations, industrial and economic factors could contribute to the relationship between energy use and SWB. One possibility that any direct positive effect of energy use on SWB is offset by an increase in pollution. (See, for example, Li et al. 2018 for a review of the effects of air pollution on

8 While we believe the the behavioral explanations are pivotal, there are other potential explanations. For instance, access to technology may affect the threshold energy level needed to meet core human needs.
SWB). If such an indirect effect exists, the relative dependence of a nation’s economy on industries that are energy intensive and/or highly polluting, and the availability and deployment of energy efficient technologies in these industries, would be likely to mediate together the relationship between SWB and energy consumption (Stern 2011). These mediators in turn may be causally affected by country-specific characteristics such as economic history, population, and climate. Future research can focus on testing specific explanations—here we have focused on documenting the overall relationship.

Conclusions

Again, while for simplicity we use term “energy”, it is important to keep in mind that we have used different measures of energy. At the country level, among developed countries, there is no relationship between energy use and development. Further, for all countries with normal economies, the less energy-intensive is a country’s economy, the happier are its people. (Fig. 1, Panel 2). Across US states and California counties, energy consumption and SWB have no apparent relationship. Likewise, the changes over time in energy use are almost unrelated to changes in SWB across US Census regions. With this correlational study we aim to bring the relationship between energy use and well-being to wider audiences, and encourage more research in this area.

While correlation is not sufficient for causality, it is typically necessary – especially across relatively homogeneous units of observation (Mazur 2011). Although this is an observational study and does not demonstrate causality, the patterns observed suggest that in the US, and across the developed World, change in energy use will not cause significant change in SWB. Further it suggests that, even in developing countries, increases in energy consumption do not contribute to SWB except where such consumption leads to unusually great increases in GDP. These patterns contrasts with widely held assumption about the relationship between SWB and energy consumption. There are many possible explanations—and while the available data does not support a causal analysis, we offer some conjectures for future research.

We found that energy consumption is neither necessary for SWB, nor linked directly to it, and we speculate the relation between energy use and SWB is very similar to the relation between economic growth and SWB, i.e., the Easterlin Paradox (Easterlin et al. 2010): common wisdom has it that over time income should increase SWB, and so common wisdom has it that energy use should increase SWB, but neither does. Specifically, Easterlin Paradox states that at a point in time SWB varies directly with income, but over the long run (10 years or more) SWB does not increase when a country’s income increases. Two countries that dramatically increased both GDP and energy use are Japan and more recently China. From 1960 till 1990 Japanese energy use per capita increased more than three fold; from 1990 to 2007 Chinese energy use per capita more than doubled, but SWB remained flat in both China and Japan.⁹

¹⁹ Primary energy use (before transformation to other end-use fuels) in kilograms of oil equivalent, per capita from World Development Indicators accessed through https://www.google.com/publicdata. SWB data come from Frey and Stutzer (2002) and Easterlin et al. (2012)—note that Chinese SWB slightly increased in last several years. Also note that in the US both energy use per capita and SWB remain flat over past four decades (using GSS data and above measure of energy use). We provide additional analyses in supplementary material.
It is striking that there were only several attempts to relate energy consumption to SWB. In a small sample of 55 countries, one early study used a set of 27 indicators to measure quality of life (Mazur and Rosa 1974), which was later extended over time (Mazur 2011). Mazur (2013) confirmed his earlier findings: among industrial nations, already high in their energy and electricity consumption, further increases in per capita energy or electricity consumption are unrelated to changes in SWB. Another study is a recent article that analyzes cross national data (Winfrey 2013). But neither study explores energy intensity of GDP, nor variation at finer geographic representation than a country. This is an important contribution of this study: there is more heterogeneity across units at more aggregated levels (e.g., countries are less comparable than US states), and there is less precision (e.g., state level SWB and energy averages are less precise descriptions of individuals than county level averages). And it is well known that there may be different relationships at different levels of aggregation (e.g., Ashkanasy 2011), i.e. earlier cross-national findings may not hold at state or county levels. Furthermore, cross-sectional relationships often differ from time-series relationships (Easterlin et al. 2012), i.e. earlier cross-sectional findings needed confirmation in time-series analysis in present study.

We do not claim causality in this correlational study. Yet, as persuasively pointed out by labor economist Andrew Oswald (e.g., Blanchflower and Oswald 2011; Oswald 2014), correlational studies are not without merit despite what many economists think—many scientific breakthroughs were first discovered in observational studies, for instance, that smoking is related to cancer. It is often overlooked that experiments tend to suffer from many problems that are not inherent in observational studies such as lack of external validity, small sample size, artificial laboratory setting, and so forth, for discussion see Pawson and Tilley (1997). At the same time, we encourage research into the causal relationships between energy use and SWB.

There is a need for future research in this important area. There have been many calls to systematically collect SWB data, and we should collect energy use data for the same subjects. Such data would allow the exploration of the relationship at the individual level.

We conjecture that in the developed world, we can decrease energy consumption without much loss in SWB, if any. While people from India and China may need to consume more energy, it is possible that Americans could consume consume considerably less without reducing SWB. For example, Texans might reduce energy consumption by half, following the example of California, and remain content. We agree with Dietz et al. (2009) that we should strive for environmentally efficient well-being: achievement of human well-being at low level of environmental stress; and we agree with Steinberger and Roberts (2010) that high human development can be achieved at moderate energy and carbon levels.

Based on our analysis, we suggest an interventions to decrease energy consumption. First, we may simply need to increase awareness of the empirical relationship between SWB and energy consumption: there is no evidence that increasing already substantial consumption does buy substantial SWB. Just as increasing income beyond a point does not result in much SWB (Kahneman and Deaton 2010), increasing energy consumption beyond a point does not result in much SWB either. In short, SWB can be achieved at low levels of energy consumption—human flourishing requires energy to satisfy basic needs only. We are hopeful that awareness and education can change behavior. Many other ways to curb consumption have been suggested (Dietz 2014, 2015; Asensio and Delmas 2015; Dumas 1987; Attari et al. 2010). Proposals to
consume less energy are urgently needed as market economy is often incentivizing people to consume more energy, for instance when new sources are discovered as with current natural gas bonanza in the US (Hopkins 2017).

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