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The Energy Paradox: Energy Use And Happiness¹

Adam Okulicz-Kozaryn and Micah Altman

Abstract

It is widely claimed that there is a substantial tradeoff between energy preservation and human wellbeing. We are reluctant to cut energy consumption for fear of decline in our happiness. Despite technological advances, Earth's per capita energy use continues to grow. The environmental consequences are well known: resource depletion, pollution, and global warming. Here we studied the relationship between energy consumption and happiness across four decades, and multiple levels of geography. Surprisingly, we found that received wisdom is false—for counties, states and nations, energy consumption is neither necessary for wellbeing, nor linked directly to it. The relation between energy use and happiness is very similar to the relation between economic growth and happiness, i.e., the Easterlin Paradox.

keywords: energy use, energy consumption, energy intensity of economy, sustainability, happiness, life satisfaction, subjective wellbeing (SWB)

Introduction

¹We thank anonymous reviewer for pointing out that the relation between energy use and happiness is very similar to the relation between economic growth and happiness (i.e., the Happiness Paradox).

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7 The environmental consequences of human energy consumption are one of the world's biggest
8 problems. In particular, energy consumption is a key driver of climate change (MacKay 2008). For
9 instance, 98% of US carbon dioxide emissions are due to energy consumption (Energy Information
10 Administration 2008). Despite technological advances, Earth's per-capita energy use has increased
11 about 40% over the past four decades, and continues to grow.
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17 While energy consumption is useful, most energy consumption both pollutes and depletes
18 natural resources (Arrow et al. 2004, Soytas et al. 2007). How energy use affects human wellbeing on
19 the whole remains an open question, which we examine in this research: We evaluate the benefits and
20 problems of energy use using measures of subjective wellbeing (SWB). This is in contrast with
21 traditional approaches to examining the effects of development, which have used Gross Domestic
22 Product, and its adjustments—per capita and purchasing power parity (Jorgenson 2014).
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29 It is generally acknowledged that there is a fundamental tradeoff between societal energy
30 preservation and individual self-interest. Substantially reducing energy consumption requires individual
31 sacrifices: If we reduce consumption, our wellbeing will suffer (Gordon 2014, Dietz 2015, Jorgenson et
32 al. 2014, Carter 1977, Smil 2005). In this paper, we find that this common assumption is wrong. By
33 combining data on energy consumption and happiness we find that the people in economically
34 developed areas consuming more energy are not happier. This finding is consistent across time and
35 multiple levels of spatial aggregation—it applies to patterns of energy consumption at the local, national,
36 and global scale.²
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45 Energy is a strategic resource. Countries wage wars over energy sources, and much of politics
46 is driven by energy. Many countries rely heavily on energy production and many use it as a political tool.
47 Virtually all countries seek to obtain more energy sources. A recent example is fracking (Inman 2014).
48 Yet, we need to consume less—for at least two obvious reasons: Worldwide, most of the energy
49 consumed is non-renewable, and this pattern of use will persist for some time (MacKay 2008). Second,
50 energy consumption causes pollution, and pollution harms the environment, other species, and
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58 ²As argued later, only developing nations could improve happiness through greater energy consumption, but across the developed
59 world, the relationship between energy consumption and happiness is nil.
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4 ourselves (MacKerron and Mourato 2009, Gandelman et al. 2012, Ferreira et al. 2013). Thus, natural
5 resource depletion and pollution potentially cancel out the benefits of energy consumption.
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8 A recent report by an Intergovernmental Panel on Climate Change is alarming
9 (http://www.ipcc.ch). Indeed, the threat is serious enough that claims for not growing the economy
10 anymore or even “degrowing” appear reasonable (Kallis 2011, Kallis et al. 2012). At the very least,
11 curbing consumption is a reasonable course of action. Some argue that reduction as high as a factor of
12 ten in affluent societies is needed (Pretty 2013). This, of course, begs the question, what would happen to
13 our wellbeing if we reduced energy consumption? Again, common wisdom says that there is a link
14 between happiness and energy use—happiness requires energy consumption. Since, arguably, the
15 implicit end goal of energy consumption is wellbeing or happiness, and hence, energy conservation would
16 be counter-productive if it resulted in decreased wellbeing. We argue here that such a decrease, if any,
17 will not be substantial. Our analysis suggests that curbing energy consumption that results in pollution,
18 i.e. most of today’s energy use, will not affect adversely happiness in the developed world.
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33 **Analysis and Results**

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39 We used the most comprehensive data available at multiple levels of aggregation over-time. There is a
40 consensus that the survey items that we use are good measures of subjective wellbeing (Diener 2009,
41 Oswald and Wu 2009, Stiglitz et al. 2009). All SWB measures come from surveys representative of
42 given areas. Such measures are reasonably valid and reliable (Diener et al. 2013). One caveat is limited
43 cross-cultural comparability (Diener and Suh 2003). Our cross-country results showed strong
44 relationships and it is unlikely that the whole effect is due to measurement error, and we mostly used
45 data within the US.
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55 **Global Patterns.** We started by examining the relationship between energy use and wellbeing across
56 the world, by country. We used data from the World Database of Happiness
57 (http://www1.eur.nl/fsw/happiness/hap_nat/nat_fp.php?mode=8). The happiness scale is based on
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4 multiple data sources and is for the most part based on responses to questions of the form: "All things
5 considered, how satisfied are you with your life as a whole these days?" on a scale from 0="dissatisfied"
6 to 10="satisfied." The measure of total per capita energy consumption (kg of oil equivalent per capita)
7 comes from the World Bank (<http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE>). All data were
8 averaged over the years 2000-2009.
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14 Data are plotted in figure 1. The basis for the received wisdom that increasing wellbeing requires
15 increased energy consumption is illustrated by the figure on the left: Across countries, there is a clear
16 positive association between energy use and happiness. Happiness generally increases with energy
17 consumption, but the variance across countries is large and there are many outliers. For example, some
18 countries that have high energy use, such as Russia (RU), are unhappy. In contrast, many countries
19 such as Costa Rica (CR) or Mexico (MX) are able to reach the highest level of happiness while
20 maintaining very low energy use. As energy use rises, its relationship with happiness flattens out,
21 especially after the threshold of 5,000 kg of oil equivalent per capita. In general, developed countries
22 have a greater quality of life and wellbeing (Mazur 2011, Jorgenson 2014).
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33 How does the relationship between energy use and happiness change if we take economic
34 development into account? It is well known that the relationship between energy use and well being
35 differs by level of development (e.g., Jorgenson and Givens 2015, Knight and Rosa 2011). As recently
36 highlighted by Dietz et al. (2009), it is important to examine how efficient a nation is in producing human
37 wellbeing. Surprisingly, we find that when we measure energy as a function of economic efficiency, the
38 relationship reverses. This is shown in the second panel of figure 1, which displays on the x axis the
39 energy intensity of gross domestic product (energy/GDP). Countries that consume less energy per unit of
40 wealth are happier. Some of the happiest countries are the highly-developed Nordic countries (DK, FI,
41 NO, SE). Their energy consumption is high (figure 1, panel 1), but relative to income, their energy
42 consumption is among lowest in the world (figure 1, panel 2). In a descriptive sense, high energy intensity
43 means that a country requires a high cost to convert energy into GDP. Another way to put this is that
44 some countries are more efficient (in the economic, not technical sense) at converting energy into wealth.
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services, so that consumption can remain high at low levels of pollution. For instance, 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 happiness 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 happiness 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).

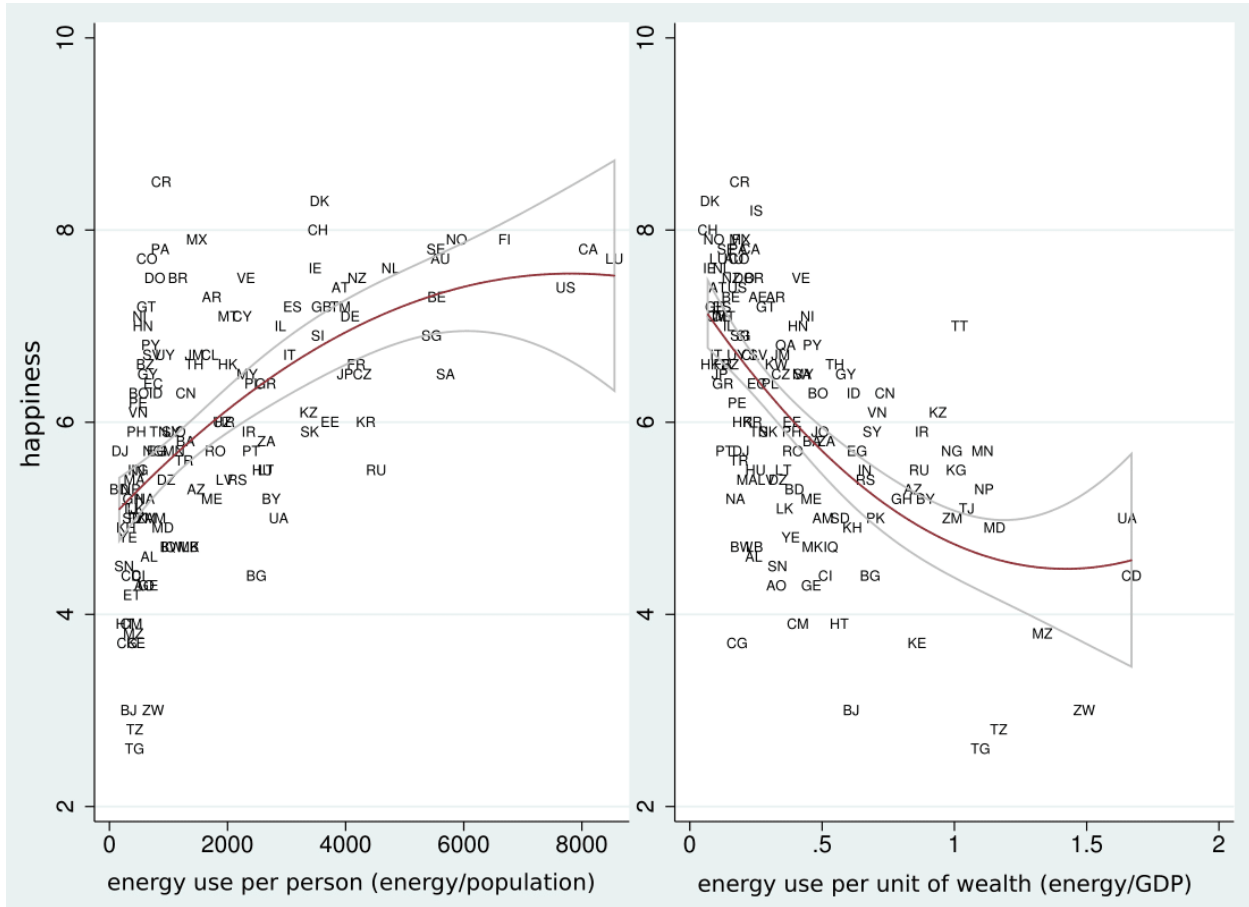


Figure 1: Countries that consume more energy per person are happier (first panel). The positive relationship in first panel is spurious—taking into account the level of development, the relationship reverses—the more energy per unit of wealth, the less happiness (second panel). Quadratic fit shown with 95% confidence intervals. Energy use refers to use of primary energy before transformation to other end-use fuels (kg of oil equivalent per capita). All data were averaged over the 2000–2009 period. Country codes are in table S1 in supplementary material. Several outliers were dropped: countries with energy use above 10,000: United Arab Emirates, Iceland, Kuwait, Qatar, Trinidad and Tobago; and countries with energy intensity higher than 2: Ethiopia, Turkmenistan, Uzbekistan.

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6 **US States and Counties.** To answer the old question of whether more energy is needed to increase
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8 wellbeing if there is already a great deal of energy being consumed (Mazur and Rosa 1974), we turned to
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10 the US, since it is among the countries that use the most energy per capita. State and county level
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12 happiness data come from the Behavioral Risk Factor Surveillance System (<http://www.cdc.gov/brfss>)
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14 using a similar measure of SWB: "In general, how satisfied are you with your life?" on a scale from
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16 1="very dissatisfied" to 4="very satisfied." State energy data came from the US Energy Information
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18 Administration (<http://www.eia.gov/state>) and is measured as total energy consumption per capita in the
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20 residential sector. California's residential electricity consumption per capita came from the Energy
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22 Consumption Data Management System (<http://www.ecdms.energy.ca.gov/elecbycounty.aspx>). State
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24 level data were averaged over 2005-2010; and California data were averaged over 2006-2010. Results
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26 are shown in figure 2.
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29 Energy-hungry states are not happier. There are two outliers, Hawaii and California, consuming
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31 much less energy in the residential sector than others. We zoom in on California counties in the second
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33 panel of the same figure. There is also a great deal of variation in energy use across California counties,
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35 and the relationship with happiness is also nil. We have experimented with energy intensity of GDP as
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37 we did earlier across countries, but in the case of the US subregions the results are not different.
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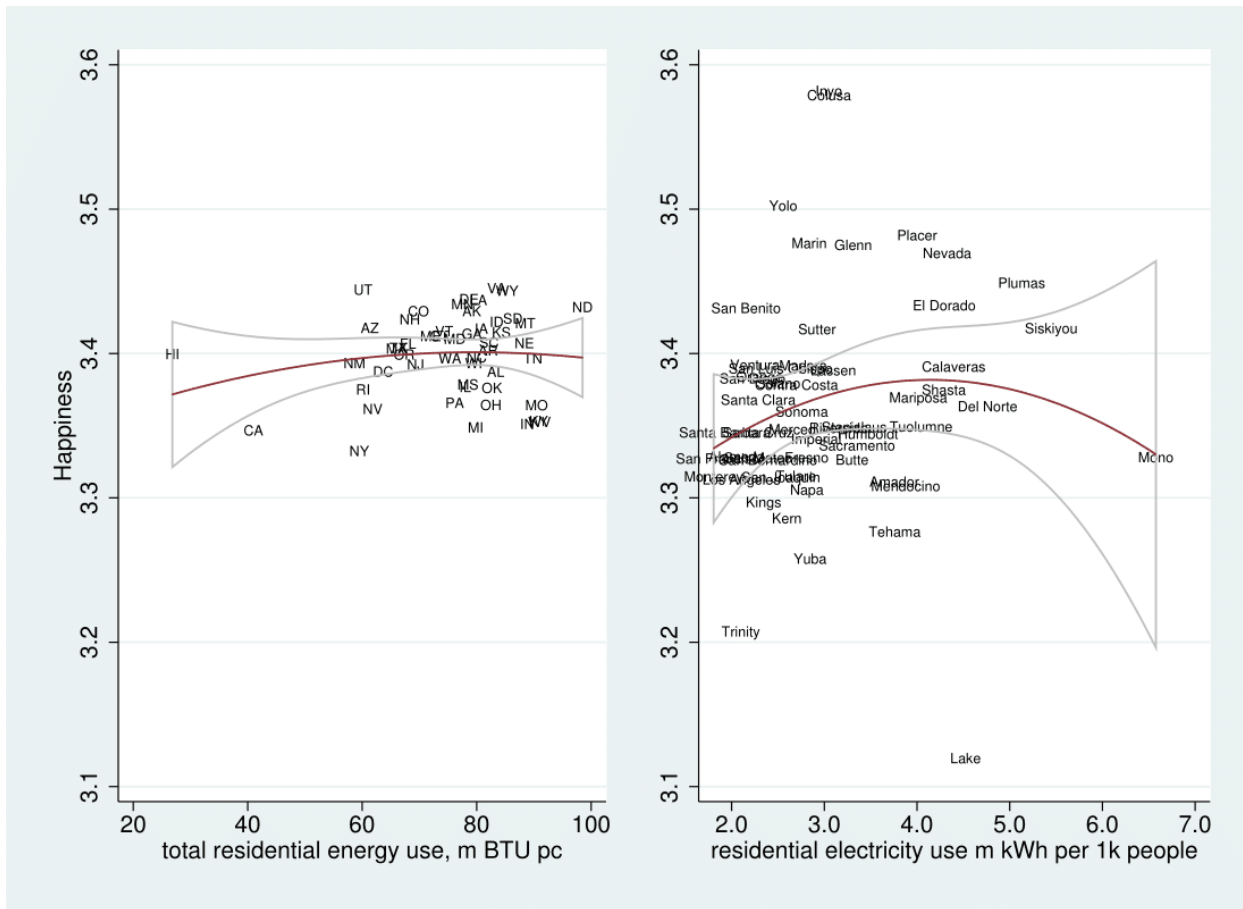


Figure 2: Happiness and total residential energy use across US states and residential electricity use across California counties. The relationship was also quite flat in terms of total energy consumption and its GDP intensity. State level data were averaged over 2005-2010, and California data were averaged over 2006-2010.

Over Time Movement. It is well-known that happiness 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 happiness and energy consumption over time. We used the General Social Survey (<http://gss.norc.org>), which measures happiness 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 happiness 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 happiness.

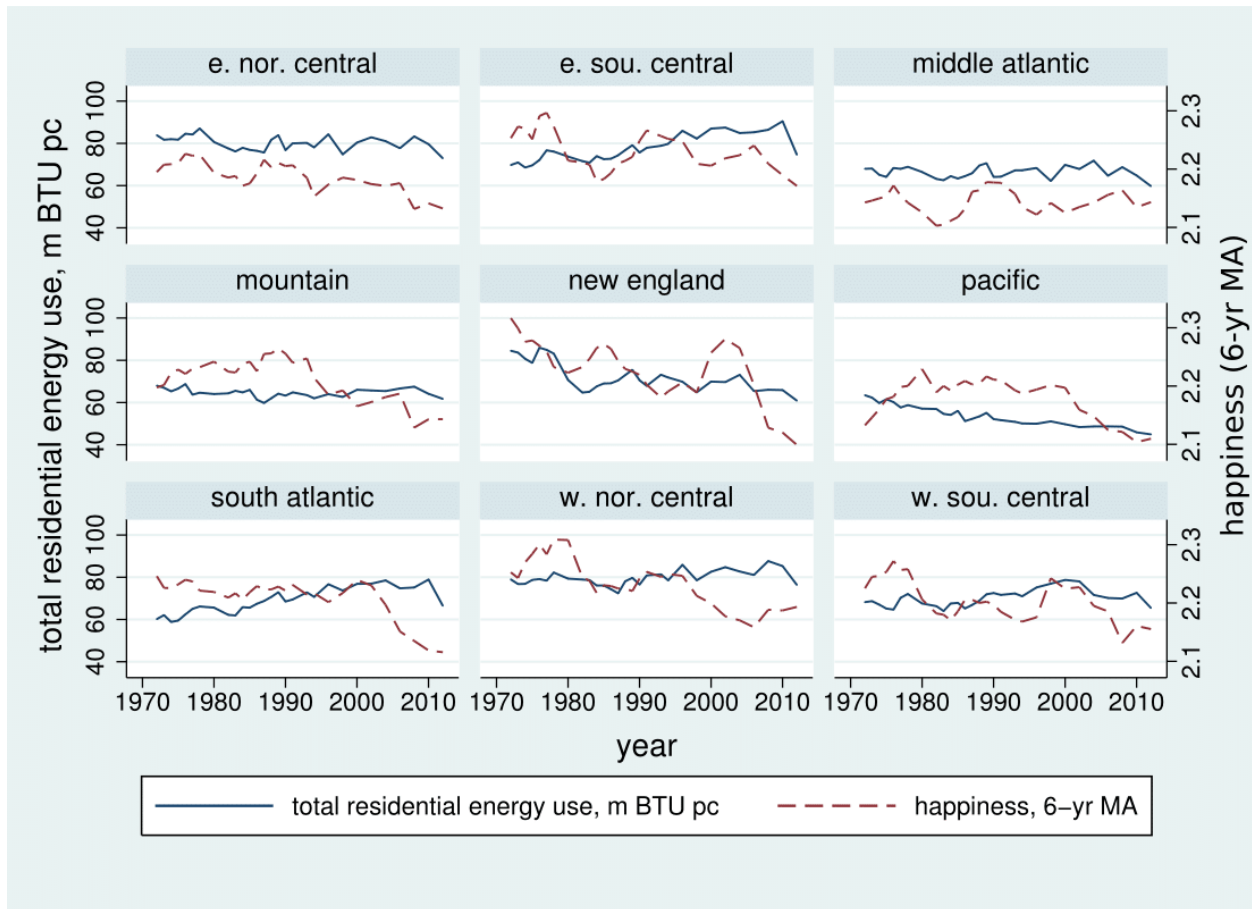


Figure 3: Happiness (6-yr moving average) and total energy consumption in residential sector per capita. Correlation is .2 only (for unsmoothed series).

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 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).

Conclusion and Policy Implications

At the country level, the lower the energy consumption, given development level, the happier the country (figure 1, Panel 2). Across US states and California counties, energy consumption and

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4 happiness have no apparent relationship. Likewise, the changes over time in energy use are almost
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6 unrelated to changes in happiness across US Census regions. With this correlational study we aim to
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8 bring the relationship between energy use and wellbeing to wider audiences, and encourage more
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10 research in this area.

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12 Happiness can be achieved at low levels of energy consumption. At high levels of energy
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14 consumption, such as that found in the US, energy and happiness have no apparent relationship. This
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16 finding contrasts with a widely held assumption that the relationship is positive. There are many
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18 possible explanations—and while the available data does not support a causal analysis, we offer some
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20 conjectures for future research. One possibility is that bounded rationality plays a strong role:
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22 Decisions on how much to produce and consume based on expected happiness are tricky, humans
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24 are often predictably wrong and experience much less happiness than expected (Kahneman et al.
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26 1997), and are wrong in their perceptions of energy consumption and savings (Attari et al. 2010, Dietz
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28 2014). Thus it is perhaps not surprising that there is a discrepancy between expectation (more energy
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30 use, more happiness) and experience (more energy use, no more happiness) is not surprising.³
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33 We found that energy consumption is neither necessary for wellbeing, nor linked directly to it,
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35 and we speculate that in the developed world, we can decrease energy consumption without much
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37 loss in happiness, if any. While people from India and China may need to consume more energy, it is
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39 possible that Americans could consume considerably less without reducing happiness. For
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41 example, Texans might reduce energy consumption by half, following the example of California, and
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43 remain content.

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45 The relation between energy use and happiness is very similar to the relation between economic
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47 growth and happiness, i.e., the Easterlin Paradox: at a point in time happiness varies directly with income,
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49 but over the long run (10 years or more) happiness does not increase when a country's income increases
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51 (Easterlin et al. 2010). It appears that explanations for our energy paradox may be similar to those of the
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53 Easterlin Paradox. We discuss possible explanations below and we provide additional analyses in
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55 supplementary material.
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59 ³While we believe the behavioral explanations are pivotal, there are other potential explanations. For instance, access to
60 technology may affect the threshold energy level needed to meet core human needs.
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4 Why is energy use unrelated to happiness, especially in developed nations such as the US?

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6 This article only documents the relationship, and finding the cause is left for the future research—there
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8 are many potential explanations. Importantly, however, there is substantial theory consistent with our
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10 findings. One potential explanation is that energy consumption is a positional good: Consumption buys
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12 position, but because everyone is in competition with everyone else, the race cannot be won (Frank
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14 2012, Kasser 2003). A related explanation is a “hedonic treadmill” (Brickman et al. 1978): It is possible
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16 that consumption does not increase wellbeing because of hedonic adaptation. More consumption would
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18 not make people happy if their basic needs are already satisfied. A third potential explanation builds on
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20 Veblen’s concept of conspicuous or wasteful consumption (Veblen 2005a,b). Such consumption does
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22 not satisfy needs but simply aims to demonstrate that one is better than others. Much of such
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24 consumption wastes energy without satisfying human needs, and does not make us any happier
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26 (Csikszentmihalyi 1999, Frank 2004, 2005, 2012).
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29 It is important to note that the popular claim that human wellbeing requires substantial energy
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31 use or the claim that there is a tradeoff between conservation and wellbeing are not well grounded in
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33 theory. According to the livability theory (Veenhoven 2014), more consumption does result in more
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35 wellbeing if it helps to satisfy basic human needs. Hence, energy used to alleviate extreme
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37 temperatures, provide food, shelter, basic transportation, etc, will increase human happiness (if it out-
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39 weighs the costs such as pollution). But energy consumed on non-essential human needs (arguably
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41 most energy consumed in developed nations) will result in little happiness, if any, and our findings are
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43 consistent with such an explanation.
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46 It is striking that there were only several attempts to relate energy consumption to happiness. In
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48 a small sample of 55 countries, one early study used a set of 27 indicators to measure quality of life
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50 (Mazur and Rosa 1974), which was later extended over time (Mazur 2011). Mazur (2013) confirmed his
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52 earlier findings: among industrial nations, already high in their energy and electricity consumption,
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54 further increases in per capita energy or electricity consumption are unrelated to changes in happiness.
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56 Another study is a recent article that analyzes cross national data (Winfrey 2013). But neither study
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58 explores energy intensity of GDP, nor variation at finer geographic representation than a country. This is
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60 an important contribution of this study: there is more heterogeneity across units at more aggregated
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4 levels (e.g., countries are less comparable than US states), and there is less precision (e.g., state level
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6 happiness and energy averages are less precise descriptions of individuals than county level averages).
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8 And it is well known that there may be different relationships at different levels of aggregation (e.g.,
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10 Ashkanasy 2011), i.e. earlier cross-national findings may not hold at state or county levels. Furthermore,
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12 cross-sectional relationships often differ from time-series relationships (Easterlin et al. 2012), i.e. earlier
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14 cross-sectional findings needed confirmation in time-series analysis in present study.
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16 We do not claim causality in this correlational study. Yet, as persuasively pointed out by labor
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18 economist Andrew Oswald (e.g., Blanchflower and Oswald 2011, Oswald 2014), correlational studies
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20 are not without merit despite what many economists think—many scientific breakthroughs were first
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22 discovered in observational studies, for instance, that smoking is related to cancer. It is often overlooked
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24 that experiments tend to suffer from many problems that are not inherent in observational studies such
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26 as lack of external validity, small sample size, artificial laboratory setting, and so forth, for discussion see
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28 Pawson and Tilley (1997). At the same time, we encourage research into the causal relationships
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30 between energy use and happiness.
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33 There is a need for future research in this important area. There have been many calls to
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35 systematically collect happiness data, and we should collect energy use data for the same subjects.
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37 Such data would allow the exploration of the relationship at the individual level.
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39 We suggest two interventions to decrease energy consumption. First, we simply need to increase
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41 awareness of what we have just found: increasing already substantial consumption does not buy much, if
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43 any, happiness. Just as increasing income beyond a point does not result in much happiness (Kahneman
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45 and Deaton 2010), increasing energy consumption beyond a point does not result in much happiness
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47 either. In short, happiness can be achieved at low levels of energy consumption—human flourishing
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49 requires energy to satisfy basic needs only. We are hopeful that awareness and education can change
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51 behavior. Secondly, we simply recommend higher taxes on non-renewable energy to discourage its use.
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53 Many other ways to curb consumption have been suggested (Dietz 2014, 2015, Asensio and Delmas
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55 2015, Dumas 1987, Attari et al. 2010).
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References

- Arrow, K., P. Dasgupta, L. Goulder, G. Daily, P. Ehrlich, G. Heal, S. Levin, K.-G. Mañler, S. Schneider, D. Starrett, et al. (2004): "Are we consuming too much?" *Journal of Economic Perspectives*, 147–172.
- Asensio, O. I. and M. A. Delmas (2015): "Nonprice incentives and energy conservation," *Proceedings of the National Academy of Sciences*, 112, E510–E515.
- Ashkanasy, N. M. (2011): "International Happiness: A Multilevel Perspective," *The Academy of Management Perspectives*, 25, 23–29.
- Attari, S. Z., M. L. DeKay, C. I. Davidson, and W. B. De Bruin (2010): "Public perceptions of energy consumption and savings," *Proceedings of the National Academy of sciences*, 107, 16054–16059.
- BEA (2014): "Table 2.8.5. Personal Consumption Expenditures by Major Type of Product, Monthly," *Bureau of Economic Analysis*.
- Blanchflower, D. G. and A. J. Oswald (2011): "International happiness: A new view on the measure of performance," *The Academy of Management Perspectives*, 25, 6–22.
- Brickman, P., D. Coates, and R. Janoff-Buman (1978): "Lottery winners and accident victims: Is happiness relative?" *Journal of Personality and Social Psychology*, 36, 917–927.
- Carter, J. (1977): "Proposed Energy Policy," *Public Broadcasting Service*.
- Csikszentmihalyi, M. (1999): "If we are so rich, why aren't we happy?" *American psychologist*, 54, 821.
- Diener, E. (2009): *Well-being for public policy*, Oxford University Press, New York NY.
- Diener, E., R. Inglehart, and L. Tay (2013): "Theory and validity of life satisfaction scales," *Social Indicators Research*, 112, 497–527.
- Diener, E. and E. M. Suh, eds. (2003): *Culture and Subjective Well-Being*, MIT Press, Cambridge MA.
- Dietz, T. (2014): "Understanding environmentally significant consumption," *Proceedings of the National Academy of Sciences*, 111, 5067–5068.
- (2015): "Altruism, self-interest, and energy consumption," *Proceedings of the National Academy of Sciences*, 112, 1654–1655.

1
2
3
4 Dietz, T., E. A. Rosa, and R. York (2009): "Environmentally efficient well-being: Rethinking sustainability
5 as the relationship between human well-being and environmental impacts," *Human Ecology Review*, 16,
6 114–123.
7
8
9

10 Dumas, L. J. (1987): *The overburdened economy: uncovering the causes of chronic unemployment,*
11 *inflation, and national decline*, Univ of California Press, Berkeley CA.
12
13
14

15 Easterlin, R. A. (1974): "Does Economic Growth Improve the Human Lot?" in *Nations and households in*
16 *economic growth: Essays in honor of Moses Abramovitz*, ed. by P. A. David and M. W. Reder, New
17 York: Academic Press, Inc., vol. 89, 98–125.
18
19
20

21 Easterlin, R. A., L. A. McVey, M. Switek, O. Sawangfa, and J. S. Zweig (2010): "The happiness–income
22 paradox revisited," *Proceedings of the National Academy of Sciences*, 107, 22463–22468.
23
24
25

26 Easterlin, R. A., R. Morgan, M. Switek, and F. Wang (2012): "China's life satisfaction, 1990–2010,"
27 *Proceedings of the National Academy of Sciences*, 109, 9775–9780.
28
29

30 Energy Information Administration (2008): "Emissions of Greenhouse Gases in the United States 2007,"
31 *U.S. Department of Energy, Washington, DC*.
32
33
34

35 Ferreira, S., A. Akay, F. Brereton, J. Cunãdo, P. Martinsson, M. Moro, and T. F. Ningal (2013): "Life
36 satisfaction and air quality in Europe," *Ecological Economics*, 88, 1–10.
37
38

39 Frank, R. (2012): *The Darwin economy: Liberty, competition, and the common good*, Princeton
40 University Press, Princeton NJ.
41
42

43 Frank, R. H. (2004): "How not to buy happiness," *Daedalus*, 133, 69–79.
44

45 ——— (2005): "Does Absolute Income Matter," in *Economics and Happiness*, ed. by L. Bruni and P. L.
46 Porta, Oxford University Press, New York NY.
47
48
49

50 Gandelman, N., G. Piani, and Z. Ferre (2012): "Neighborhood Determinants of Quality of Life," *Journal of*
51 *Happiness Studies*, 13, 547–563.
52
53
54

55 Gordon, K. (2014): "Cutting Energy Without Self Sacrifice," *Wall Street Journal*.
56

57 Inman, M. (2014). The fracking fallacy. *Nature*, 516(7529), 28.
58

59 Jorgenson, A. K. (2014): "Economic development and the carbon intensity of human well-being," *Nature*
60
61
62
63
64
65

1
2
3
4 *Climate Change.*

5
6 Jorgenson, A. K., A. Alekseyko, and V. Giedraitis (2014): "Energy consumption, human well-being and
7 economic development in central and eastern European nations: A cautionary tale of sustainability,"
8 *Energy Policy*, 66, 419–427.
9

10
11
12 Jorgenson, A. K. and J. Givens (2015): "The changing effect of economic development on the
13 consumption-based carbon intensity of well-being, 1990–2008," *PloS one*, 10, e0123920.
14

15
16
17 Kahneman, D. and A. Deaton (2010): "High income improves evaluation of life but not emotional well-
18 being," *Proceedings of the National Academy of Sciences*, 107, 16489–16493.
19

20
21
22 Kahneman, D., P. P. Wakker, and R. Sarin (1997): "Back to Bentham? Explorations of Experienced
23 Utility," *The Quarterly Journal of Economics*, 112, 375–405.
24

25
26
27 Kallis, G. (2011): "In defence of degrowth," *Ecological Economics*, 70, 873–880.
28

29
30
31 Kallis, G., C. Kerschner, and J. Martinez-Alier (2012): "The economics of degrowth," *Ecological
32 Economics*, 84, 172–180.
33

34
35 Kasser, T. (2003): *The high price of materialism*, MIT press.
36

37
38
39 Knight, K. W. and E. A. Rosa (2011): "The environmental efficiency of well-being: A cross-national
40 analysis," *Social Science Research*, 40, 931–949.
41

42
43
44 MacKay, D. (2008): *Sustainable Energy-without the hot air*, UIT Cambridge.
45

46
47
48 MacKerron, G. and S. Mourato (2009): "Life Satisfaction and Air Quality in London," *Ecological
49 Economics*, 68, 1441–1453.
50

51
52
53 Mazur, A. (2011): "Does increasing energy or electricity consumption improve quality of life in industrial
54 nations?" *Energy Policy*, 39, 2568–2572.
55

56
57
58 ——— (2013): *Energy and electricity in industrial nations: the sociology and technology of energy*,
59 Routledge, New York NY.
60

61
62
63 Mazur, A. and E. Rosa (1974): "Energy and life-style." *Science (New York, NY)*, 186, 607.
64

65
66
67 Oswald, A. (2014): "Keynote II," *2014 Wellbeing and Public Policy Conference at Hamilton College*.
68

69
70
71 Oswald, A. J. and S. Wu (2009): "Objective Confirmation of Subjective Measures of Human Well-Being:
72 Evidence from the U.S.A." *Science*, 327, 576–579.
73
74
75

1
2
3
4 Pawson, R. and N. Tilley (1997): *Realistic evaluation*, Sage, Beverly Hills CA.

5
6 Pretty, J. (2013): "The consumption of a finite planet: well-being, convergence, divergence and the
7
8 nascent green economy," *Environmental and Resource Economics*, 55, 475–499.

9
10
11 Smil, V. (2005): "Creating the twentieth century: technical innovations of 1867-1914 and their lasting
12
13 impact," *OUP Catalogue*.

14
15 Soytas, U., R. Sari, and B. T. Ewing (2007): "Energy consumption, income, and carbon emissions in the
16
17 United States," *Ecological Economics*, 62, 482–489.

18
19 Stiglitz, J., A. Sen, and J. Fitoussi (2009): "Report by the Commission on the measurement of economic
20
21 performance and social progress," *Available at www.stiglitz-sen-fitoussi.fr*.

22
23
24 Veblen, T. (2005a): *Conspicuous consumption*, vol. 38, ePenguin, New York NY.

25
26 ——— (2005b): *The theory of the leisure class; an economic study of institutions*, Aakar Books, New York
27
28 NY.

29
30 Veenhoven, R. (2014): "Livability Theory," *Encyclopedia of Quality of Life and Well-Being Research*,
31
32 3645–3647.

33
34 Winfrey, E. M. V. (2013): "Is more always better? The nonlinear relationship between energy
35
36 consumption and wellbeing," Ph.D. thesis, Georgetown University.
37
38
39
40
41
42
43
44
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The Energy Paradox: Energy Use And Happiness*

Draft: Sunday 11th June, 2017

SUPPLEMENTARY ONLINE MATERIAL

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1 Country-level

Table S1: Key variables for each country."

"Country Code (ISO 2 digits)"	"Country Name"	"happiness (WDH)"	"energy use, pc"	"PCGDP"	"co2 emissions, pc"	"female life expectancy"
AD	Andorra	6.8		43,885	7.0	
AE	United Arab Emirates	7.3	9,950	54,559	26.8	77
AF	Afghanistan	4.1		424	0.1	58
AL	Albania	4.6	675	3,044	1.3	79
AM	Armenia	5.0	780	2,427	1.4	76
AO	Angola	4.3	505	2,803	1.0	49
AR	Argentina	7.3	1,720	8,501	4.0	78
AT	Austria	7.4	3,910	44,510	8.4	82
AU	Australia	7.7	5,680	48,066	17.4	83
AZ	Azerbaijan	5.3	1,467	3,251	3.8	72
BA	Bosnia and Herzegovina	5.8	1,307	3,765	4.3	78
BD	Bangladesh	5.3	162	603	0.3	68
BE	Belgium	7.3	5,489	42,572	10.4	82
BF	Burkina Faso	4.4		498	0.1	54
BG	Bulgaria	4.4	2,500	5,530	6.1	76
BI	Burundi	2.9		212	0.0	54
BJ	Benin	3.0	327	715	0.4	58
BO	Bolivia	6.3	566	1,732	1.4	65
BR	Brazil	7.5	1,146	9,472	1.9	76
BW	Botswana	4.7	1,020	5,540	2.2	56
BY	Belarus	5.2	2,727	3,957	5.9	75
BZ	Belize	6.6	579	4,217	1.5	72
CA	Canada	7.8	8,190	46,270	16.7	83
CD	Congo, Dem. Rep.	4.4	296	278	0.0	55
CF	Central African Republic	4.6		427	0.1	47
CG	Congo, Rep.	3.7	309	2,601	0.3	55
CH	Switzerland	8.0	3,528	70,324	5.5	84
CI	Cote d'Ivoire	4.4	469	1,256	0.4	49
CL	Chile	6.7	1,729	11,140	3.9	82
CM	Cameroon	3.9	372	1,121	0.2	53
CN	China	6.3	1,319	2,772	4.2	75
CO	Colombia	7.7	634	5,340	1.4	76
CR	Costa Rica	8.5	888	7,055	1.6	80
CY	Cyprus	7.1	2,250	30,090	7.4	81
CZ	Czech Republic	6.5	4,281	17,574	11.7	79
DE	Germany	7.1	4,072	39,571	9.8	82
DJ	Djibouti	5.7	178	1,161	0.5	60
DK	Denmark	8.3	3,560	58,061	9.4	80
DO	Dominican Republic	7.5	774	4,413	2.2	75
DZ	Algeria	5.4	982	4,068	3.0	74
EC	Ecuador	6.4	705	4,162	2.1	77
EE	Estonia	6.0	3,764	13,790	12.0	78
EG	Egypt, Arab Rep.	5.7	771	2,217	2.2	72

Continued on next page

*We thank anonymous reviewer for pointing that the relation between energy use and happiness is very similar to the relation between economic growth and happiness (i.e., the Happiness Paradox).

Table S1 – continued from previous page

"Country Code (ISO 2 digits)"	"Country Name"	"happiness (WDH)"	"energy use, pc"	"PCGDP"	"co2 emissions, pc"	"female life expectancy"	""
ES	Spain	7.2	3,098	30,650	7.5	84	
ET	Ethiopia	4.2	482	238	0.1	57	
FI	Finland	7.9	6,720	44,691	11.5	82	
FR	France	6.6	4,180	40,050	5.9	84	
GB	United Kingdom	7.2	3,592	38,376	8.8	81	
GE	Georgia	4.3	686	2,119	1.2	77	
GH	Ghana	5.2	295	1,095	0.4	59	
GN	Guinea	4.5		435	0.2	53	
GR	Greece	6.4	2,669	27,165	8.7	82	
GT	Guatemala	7.2	602	2,659	0.9	73	
GY	Guyana	6.5	664	2,567	2.1	68	
HK	Hong Kong SAR, China	6.6	1,993	26,963	6.1	85	
HN	Honduras	7.0	570	1,890	1.0	74	
HR	Croatia	6.0	2,121	12,752	5.0	79	
HT	Haiti	3.9	312	716	0.2	61	
HU	Hungary	5.5	2,586	12,396	5.5	77	
ID	Indonesia	6.3	781	2,513	1.5	69	
IE	Ireland	7.6	3,486	49,200	10.4	81	
IL	Israel	7.0	2,895	27,646	9.0	82	
IN	India	5.5	458	971	1.1	65	
IQ	Iraq	4.7	1,020	3,954	3.5	71	
IR	Iran, Islamic Rep.	5.9	2,351	5,183	6.8	73	
IS	Iceland	8.2	12,501	41,290	7.3	83	
IT	Italy	6.7	3,091	36,994	7.9	84	
JM	Jamaica	6.7	1,398	4,987	3.8	76	
JO	Jordan	5.9	1,138	3,577	3.6	74	
JP	Japan	6.5	3,978	43,598	9.5	86	
KE	Kenya	3.7	453	887	0.3	54	
KG	Kyrgyz Republic	5.5	508	759	1.1	72	
KH	Cambodia	4.9	282	592	0.2	65	
KR	Korea, Rep.	6.0	4,344	18,280	9.9	82	
KW	Kuwait	6.6	10,525	43,489	29.6	75	
KZ	Kazakhstan	6.1	3,371	6,890	10.8	72	
LA	Lao PDR	6.2		844	0.2	63	
LB	Lebanon	4.7	1,374	6,987	4.3	78	
LK	Sri Lanka	5.1	453	2,154	0.6	77	
LR	Liberia	4.3		323	0.2	56	
LT	Lithuania	5.5	2,649	10,090	4.1	78	
LU	Luxembourg	7.7	8,574	99,962	22.2	82	
LV	Latvia	5.4	1,947	10,256	3.3	77	
MA	Morocco	5.4	456	2,370	1.4	72	
MD	Moldova	4.9	906	1,305	1.2	72	
ME	Montenegro	5.2	1,860	5,604	3.7	76	
MG	Madagascar	3.7		421	0.1	62	
MK	Macedonia, FYR	4.7	1,368	3,820	5.3	76	
ML	Mali	4.7		645	0.1	52	
MN	Mongolia	5.7	1,177	2,055	3.8	69	
MR	Mauritania	4.9		1,091	0.5	62	
MT	Malta	7.1	2,005	19,496	6.2	82	
MW	Malawi	6.2		393	0.1	49	
MX	Mexico	7.9	1,549	8,670	3.9	78	
MY	Malaysia	6.5	2,418	7,847	6.4	76	
MZ	Mozambique	3.8	403	331	0.1	52	
NA	Namibia	5.2	627	4,381	1.1	59	
NE	Niger	3.8	130	335	0.1	54	
NG	Nigeria	5.7	734	1,729	0.7	49	
NI	Nicaragua	7.1	516	1,421	0.8	75	
NL	Netherlands	7.6	4,895	48,434	10.5	82	
NO	Norway	7.9	5,972	86,843	9.7	82	
NP	Nepal	5.3	354	505	0.1	66	
NZ	New Zealand	7.5	4,197	32,702	8.3	82	
PA	Panama	7.8	877	6,281	2.1	79	
PE	Peru	6.2	481	3,884	1.3	75	
PH	Philippines	5.9	459	1,807	0.9	70	
PK	Pakistan	5.0	488	949	0.9	65	
PL	Poland	6.4	2,424	10,050	8.0	79	
PS	West Bank and Gaza	4.9		2,262	0.5	73	
PT	Portugal	5.7	2,408	22,063	5.8	81	
PY	Paraguay	6.8	712	2,756	0.7	73	
QA	Qatar	6.8	19,361	64,738	58.0	78	
RO	Romania	5.7	1,791	6,773	4.5	76	
RS	Serbia	5.4	2,166	4,486	6.9	76	
RU	Russian Federation	5.5	4,505	8,714	11.2	73	
RW	Rwanda	4.3		425	0.1	59	
SA	Saudi Arabia	6.5	5,145	16,212	15.3	75	
SD	Sudan	5.0	381	1,181	0.3	62	
SE	Sweden	7.8	5,532	48,956	5.6	83	
SG	Singapore	6.9	5,278	38,239	8.3	82	
SI	Slovenia	6.9	3,532	21,764	7.8	81	
SK	Slovak Republic	5.9	3,392	13,221	7.1	78	
SL	Sierra Leone	3.5		386	0.1	44	
SN	Senegal	4.5	254	937	0.4	62	
SV	El Salvador	6.7	735	3,333	1.1	75	
SY	Syrian Arab Republic	5.9	1,046		3.0	76	
TD	Chad	5.4		687	0.0	49	
TG	Togo	2.6	432	495	0.3	55	
TH	Thailand	6.6	1,432	4,198	3.6	76	
TJ	Tajikistan	5.1	338	578	0.4	70	
TM	Turkmenistan	7.2	3,912	3,010	9.9	69	
TN	Tunisia	5.9	832	3,483	2.2	77	
TR	Turkey	5.6	1,263	8,793	3.6	76	

Continued on next page

Table S1 – continued from previous page

"Country Code (ISO 2 digits)"	"Country Name"	"happiness (WDH)"	"energy use, pc"	"PCGDP"	"co2 emissions, pc"	"female life expectancy"
TT	Trinidad and Tobago	7.0	11,620	13,646	27.0	73
TZ	Tanzania	2.8	430	596	0.1	56
UA	Ukraine	5.0	2,871	2,604	6.8	74
UG	Uganda	4.8		496	0.1	52
US	United States	7.4	7,725	47,470	19.2	80
UY	Uruguay	6.7	939	9,240	1.8	79
UZ	Uzbekistan	6.0	1,901	1,007	4.6	71
VE	Venezuela, RB	7.5	2,177	12,397	6.5	77
VN	Vietnam	6.1	483	1,015	1.1	79
YE	Yemen, Rep.	4.8	308	1,198	0.9	63
ZA	South Africa	5.8	2,652	6,690	9.0	55
ZM	Zambia	5.0	597	1,109	0.2	50
ZW	Zimbabwe	3.0	736	885	0.8	42

Figure S1 shows Gross Domestic Product (GDP) per capita against energy use per capita. It confirms earlier argument that there is some minimum threshold for energy consumption below which, more increase is desirable. That is developing countries should increase their energy consumption. Here, it is clear that at low levels, say below 2,000, no country reaches 20k in gdp, and at higher levels of energy use, there is wide variability in gdp. On the other hand, at low levels of GDP, there is quite a bit of variability in energy use. While moderate or even high happiness is possible at low level of energy consumption (figure ??), moderate wealth is not possible, and moderate wealth in turn is important for happiness.

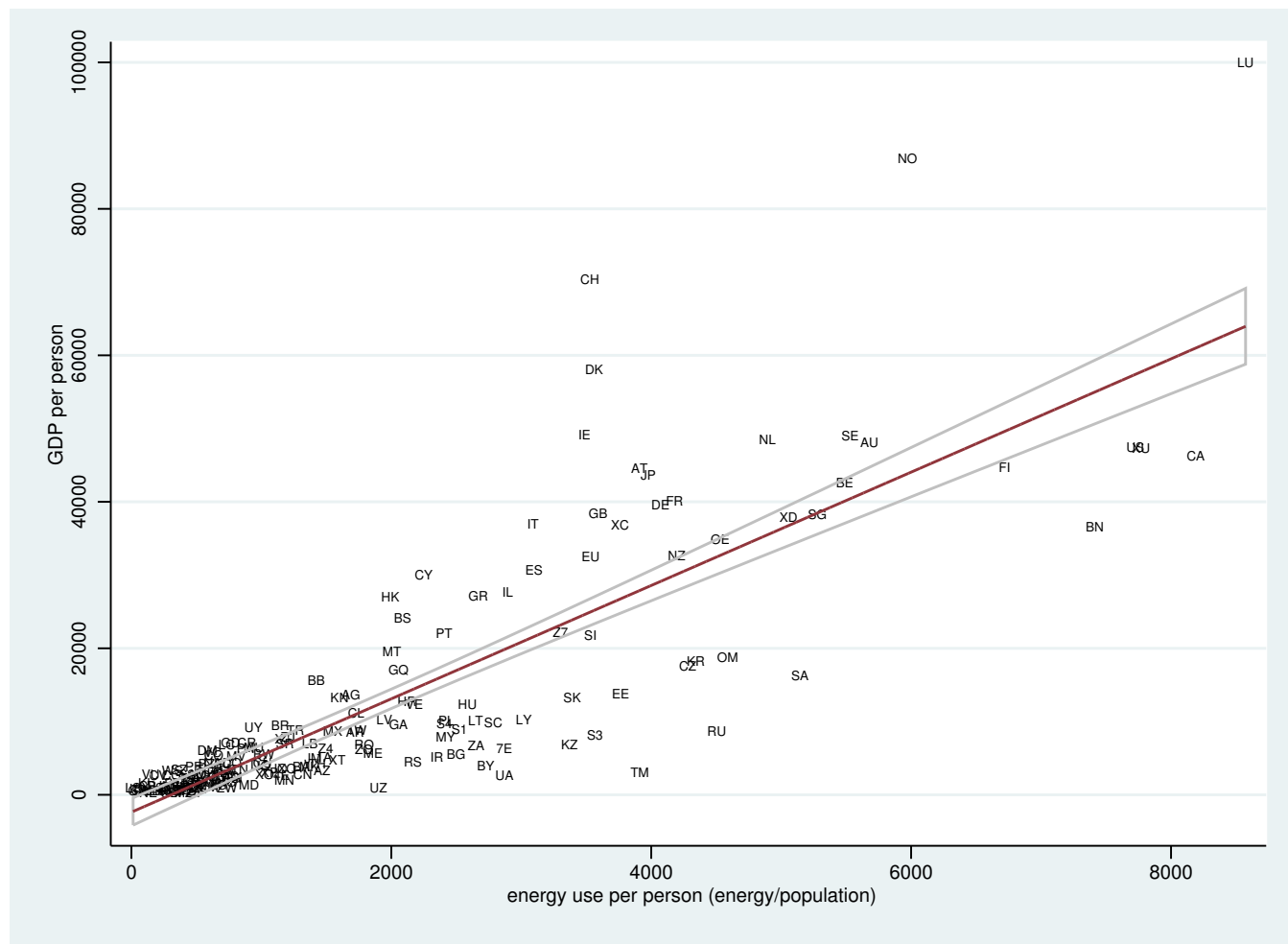


Figure S1: Gross Domestic Product (GDP) per capita against energy use per capita. Linear fit shown with 95% confidence intervals. Energy use refers to use of primary energy before transformation to other end-use fuels. All data were averaged over 2000-2009 period. Several outliers were dropped: countries with energy use above 10,000: United Arab Emirates, Iceland, Kuwait, Qatar, Trinidad and Tobago.

2 Census division-level

Figure S2 shows relationship between GDP and residential energy use across US census divisions. There is not much relationship: some census divisions display positive correlations and some negative. Weak relationship is not due to use of residential energy (total energy use is similarly related to GDP). It is rather, that in developed countries, energy has lower relationship with GDP. While there is clear positive relationship across countries as shown in previous section, there is not much relationship over time in the US.

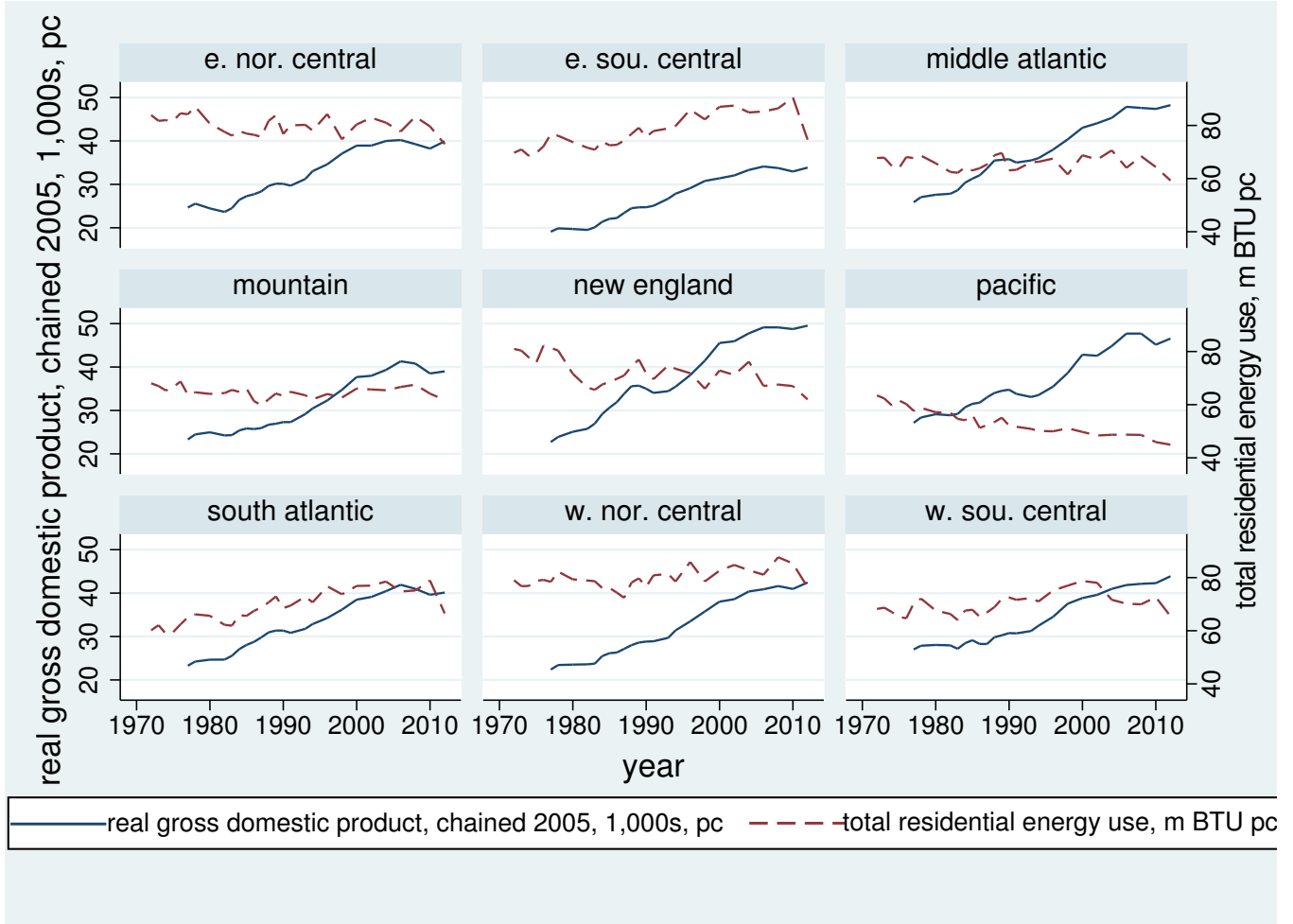


Figure S2: Real Gross Domestic Product (GDP) per capita and residential energy use per capita across census regions.

Figure S3 shows relationship between GDP and happiness across US census divisions. Here, unexpectedly, the relationship is moderately negative, or even strongly negative in Pacific and Mountain. It is only weakly positive in Middle Atlantic.

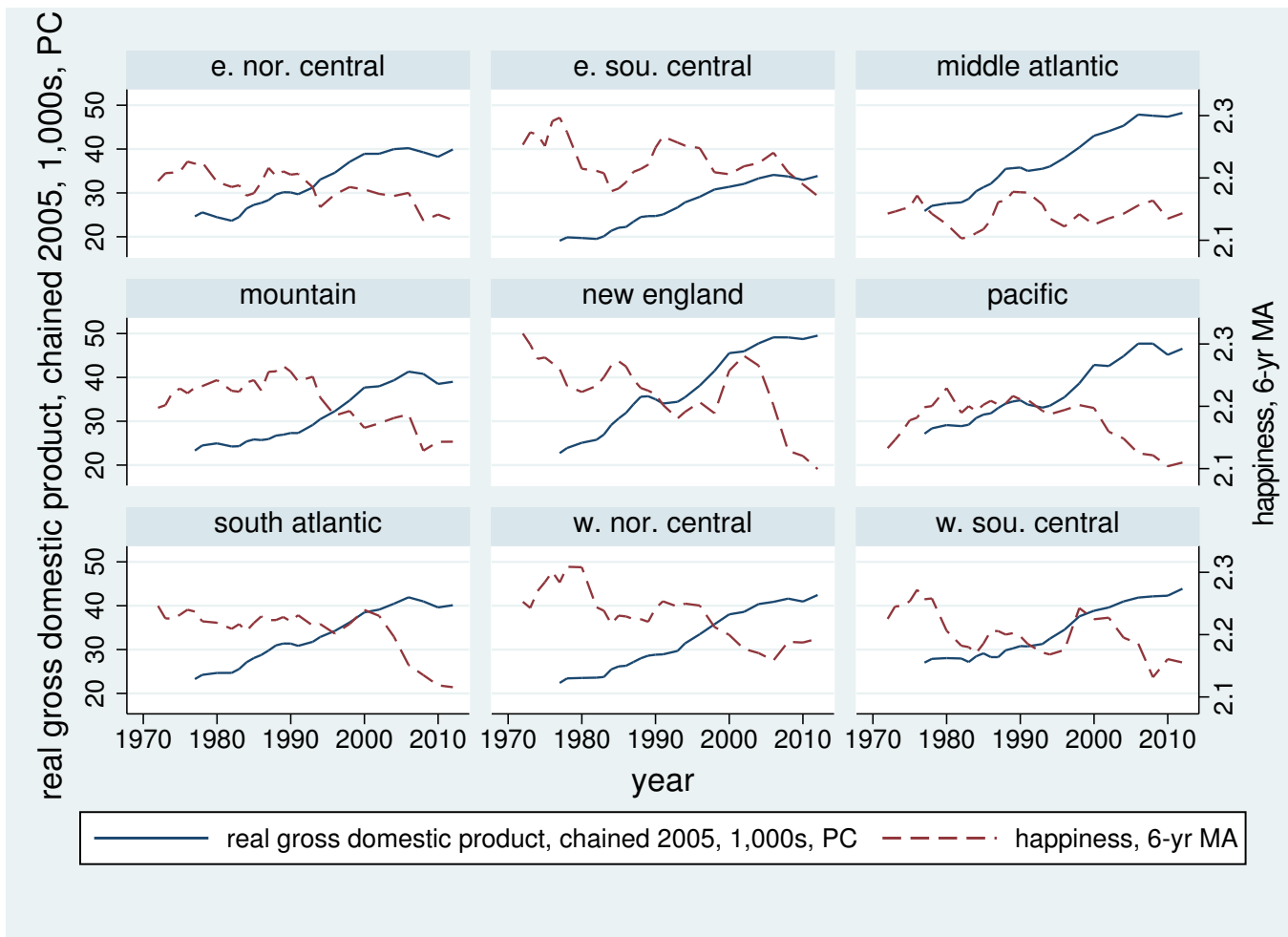


Figure S3: Happiness and Real Gross Domestic Product (GDP) per capita across census regions.

3 US energy use descriptive statistics

How do we use energy in the US? Energy use in the US has been fairly flat over past 40 years at 70m btu pc. (<http://www.eia.gov/todayinenergy/detail.cfm?id=3590>), and coasts consume less than inland middle (<http://energy.gov/maps/2009-energy-consumption-page=0%2C1>). Use by sector in the US is following: 22% residential, 18% commercial, 32% industrial, and 28% transportation. (<http://www.eia.gov/consumption/>). Total energy consumption by end use is shown in table S2.

Table S2: Total energy consumption by end use; quadrillion Btu, 2011.

Space Heating	5.6
Space Cooling	2.6
Water Heating	2.7
Refrigeration	1.2
Cooking	0.6
Clothes Dryers	0.7
Freezers	0.2
Lighting	2
Clothes Washers	0.1
Dishwashers 1/ 0.307437 Televisions and Related Equipment	1
Computers and Related Equipment	0.4
Furnace Fans and Boiler Circulation Pumps	0.4
Other Uses	3.7

How is electricity used in US homes? Data are shown in table S3. It is important to note that end uses of energy changed over time, for instance from 1993 to 2009: appliances share increased from 24% to 35% and space heating dropped from 53% to 41% (<http://www.eia.gov/todayinenergy/detail.cfm?id=10271&src=%E2%80%B9%20Consumption%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20%28RECS%29-b1>).

Table S3: Estimated US residential electricity consumption by end use, 2012 (www.eia.gov/tools/faqs/faq.cfm?id=96&t=3).

End Use	Quadrillion Btu	Billion kilowatthours	% Share of total
Space cooling	0.85	250	18.00%
Lighting	0.64	186	14.00%
Water heating	0.45	130	9.00%
Refrigeration	0.38	111	8.00%
Televisions and related equipment	0.33	98	7.00%
Space heating	0.29	84	6.00%
Clothes dryers	0.2	59	4.00%
Computers and related equipment	0.12	37	3.00%
Cooking	0.11	31	2.00%
Dishwashers	0.1	29	2.00%
Furnace fans and boiler circulation pumps	0.09	28	2.00%
Freezers	0.08	24	2.00%
Clothes washers ³	0.03	9	1.00%
Other uses	1.02	299	22.00%
Total consumption	4.69	1375	