Hidden Energy Flows: justice and responsibility in outsourcing goods and services

ORTZI AKIZU[1]*, GORKA BUENO[2],
JOSE MANUEL LOPEZ-GUEDE[3]

[1]*Department of Graphic Expression and Engineering Projects,*
University of the Basque Country UPV/EHU, Nieves Cano 12, 01006 Vitoria-Gasteiz, Spain
[2]*Department of Electronics Engineering,*
University of the Basque Country UPV/EHU, Bilbao, Spain
[3]*Department of Engineering Systems and Automatics,*
University of the Basque Country UPV/EHU, Vitoria-Gasteiz, Spain

**ortzi.akizu@ehu.eus* -- *http://www.ehu.eus*

Abstract: Who is responsible for the impacts produced by the current energy system, good producers or good consumers? The aim of this paper has been to discuss how to be aware of impacts and their respective citizens' responsibilities, due to the outsourcing of production chains of Global North countries to Global South ones. Recognition of the total energy consumption of the so-called developed countries plays an important role in this conflict. Currently, the total energy consumption of the Global North life styles is not internationally recognized, and this makes it harder to understand what the current "exemplary sustainable energy countries" to be followed are. Based on Input-Output analysis, this paper aims to discuss solutions to avoid the Hidden Energy Flows effect in international energy justice.

Key-Words: energy transition, responsibility, energy literacy, energy justice, hidden energy flows, energy footprint

1 INTRODUCTION

The outsourcing of the industries of the so-called developed countries, in order to survive in the globalized economic market system, is apparently making the Global North countries lower energy consumers. Due to the massive outsourcing of industrial manufacturing, food production and services, less energy is consumed in the Global North countries. In consequence, Global North countries appear to be more and more sustainable.

The outsourcing phenomena started in the 1970`s [1], firstly in the context of the car industry and later with the development of the Information Technology (IT) sector [2]. Nevertheless, sources in other fields apart from economics strongly related with social analysis, have linked the outsourcing phenomena with a new form of colonialism either in the energy sector [3], agriculture [4], or the industrial sector [5]. The use of new Energy Infrastructures (EI) and the development of transportation systems and logistics permits the massive use of other country resources, with no fair economic exchange, ignoring the devastating social and environmental effects that those unfair acts may have [3].

In consequence, several researchers have already pointed to the connections between individual choices and global affections, such as how the massive use of cars may generate global oil wars [6]. This enables us to link global justice with energy consumption choices, creating the concept of energy justice.

The idea of having a responsibility ("respons abilitas", the capacity to react) given the impacts of our current energy model is nothing new. Hans Jonas, back in 1979, manifested the possible consequences of the fossil-fuel based energy system during the next thousands of years [7]. Jonas also mentioned that human greed and myopia leads to the misuse of new energy-generation technologies; arguing that it is essential to understand the natural limits or risk thresholds of the planet before exploiting the resources, with all the analysis complexity that this involves. Meanwhile new energy generation technologies, such as nuclear power or hydraulic fracturing, should be used with caution. Jonas showed that current energy system impacts have five characteristics: they may not be immediate, are not visible, are exponential, are not believable with the current mindset and they are not linked to the action or omission of a single human being. This is why we are facing a difficult challenge when trying to link impacts to causal, and therefore responsible, agents.

When sharing these responsibilities, there is a tendency in social and environmental movements to accuse large capitalist transnational corporations for being responsible for major impacts [8]. On the other hand, according to Hannah Arendt, not all individuals have the same responsibility as a fact, but citizens are not just a simple cog in a large machine: we are active actors creating our future [9]. Vittorio Hösle [10] goes further and affirms that the increase in technical rationality and biological knowledge was paradoxically reducing ethics and moral awareness and integration and equality between human beings.

In order to link “science” to “ethics”, in this case energy model impacts to their responsible actors, awareness about them should be developed. This means linking energy consumption to its consumers. Several attempts have been made to understand what the real final energy consumption of citizens is, taking into account the energy embodied in products and services [11], or trying to break down the global energy footprint [12]. Furthermore, shared consumer and producer responsibility [13] have been formulated either in a theoretical or a practical way [14].

This paper aims to analyse how current energy model impacts could be faced in a conscious way by the actors that benefit from energy consumption. For this purpose, section 2 explains the methodology followed in this research, and section 3 identifies socio-environmental impacts provoked by the current energy model. Section 4 identifies the actors that participate in the current energy model, in order to give a clear panorama. Section 5 shows the main work of this paper, showing the Hidden Energy Flow (HEF) results and explaining the HEF concept. Finally section 6 comments on the conclusions and proposals.

2 METHODOLOGY

Initially, the 3rd and 4th section have been developed using a literature review as a base.

However, Multi Regional Input-Output (MRIO) has been used as main methodology, in section 5, to obtain the Total Primary Energy Footprint (TPEF) –TPEF has been defined in the same section– from the initial Total Primary Energy Supply (TPES) obtained from the IEA. This has been done using the 26 sector based EORA database economic information for 189 countries [15], [16]. Leontief extrapolation has been used in order to cross economic data with energy data. The direct energy consumption of each country has been extracted from 9 energy sectors identified in the EORA database of energy usage: Natural Gas, Coal, Petroleum, Nuclear Electricity, Hydroelectric Electricity, Geothermal Electricity, Wind Electricity, Solar, Tide and Wave Electricity and Biomass and Waste Electricity

Section 5 also deals with describing the concept of the Hidden Energy Flow (HEF).

3 IDENTIFICATION OF CURRENT ENERGY MODEL IMPACTS

In order to identify the impacts of the current energy model, they have been summarized in three main groups: environmental impacts [17], social impacts [18] (including affects on human health [19]) and economic impacts [20], as shown in Figure 1. The chart aims to give a broad view of the current energy model impacts, according to types, effects and indicators.

Within the environmental impacts, climate change has been the main one that the international community has tried to deal with. The latest agreement is outlined in the Paris Climate Accord, within 196 countries. According to the AR5 of the IPCC, “Total anthropogenic GHG emissions have continued to increase over 1970 to 2010 with larger absolute increases between 2000 and 2010”. In 1970 27 $GtCO_2$ eq/year were emitted, until the year 2000 emissions have been increasing 1.3% per year, from 2000 to 2010 the annual increment has been 2.2%/year, reaching the amount of 49 $GtCO_2$ eq/year [21]. The current fossil-fuel based energy model is a relevant agent responsible for a great part of these emissions [22].

Regarding the social impacts, energy poverty and

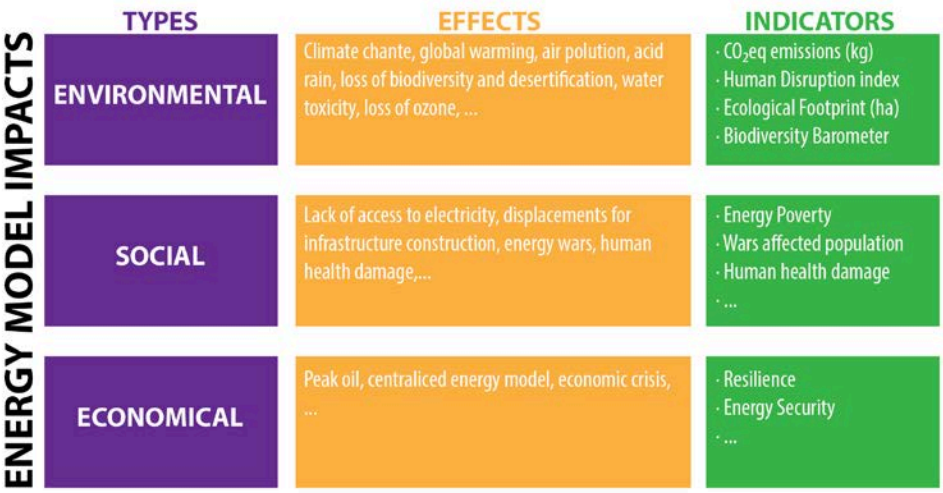

Figure 1: Energy model impacts (developed by authors).

energy wars have been the main global issues. The current energy model is based on a non-uniform sharing model of resources, creating the Energy Poverty phenomena. Although this concept has traditionally been used to capture problems of inadequate access to energy in developing countries, nowadays in the so-called developed countries there have been detected and denounced by social movements numerous and increasing cases of "inability to attain a socially and materially necessitated level of domestic energy services" [23]. New indicators such as the Multidimensional Energy Poverty Index (MEPI) have been developed to define Energy Poverty [24].

On the other hand, energy wars, despite being internationally recognized [25], could hardly be measured with their own indicator. Similarly, it becomes hard to distinguish the real role of energy concerns in the wars, e.g. it is stated that "Energy can be the primary cause and objective in a conflict" [26], e.g. the case of Iraq in 2003 [27] but no final assumptions could be reached.

Lastly, according to the impacts that the current energy model has on the economy, the peak-oil effect has been especially dealt with. According to 2015 IEA data, the current global energy model is based 83.7% on fossil-fuels and nuclear power, and due to the upcoming unavoidable Peak Oil [28], the security of the energy supply is at risk. Peak Oil is not only forecasted as a simple upcoming energy crisis but as a global economic crisis [29]. Nevertheless, some research studies consider Peak Oil as a risk which can be overcome. As in the Cuban case, where Richard Heinberg pointed out "Cuba survived an energy famine during the 1990s, and how it did so constitutes one of the most important and hopeful stories of the past few decades. It is a story not just of individual achievement, but of the collective mobilization of an entire society to meet an enormous challenge" [30]. Cuba showed the world that Peak Oil could be faced and overcome in a collective way. Energy transitions would be necessary to move from a economically non sustainable energy situation to a new one, and not always do these transitions succeed [31]. Due to this, other research studies have attempted to create a new proposal to face the economic crisis created by Peak Oil in an aim to avoid vulnerability [29].

4 ACTORS IN THE ENERGY MODEL

In order to link energy production to consumers, the actors of the current energy model have been mapped out in Figure 2. An actor's scheme has been developed, integrating the energy flows, economic flows and ethical requirements, considering these from the global level to the personal level. The figure follows the typical structure of the Multilevel Perspective Methodology (MLP), where macro, meso and micro levels are identified.

Figure 2 shows how public policy, knowledge and ethical requirements of citizens act against regional, national and transnational companies. As a data gathering entity, the IEA plays an important role, together with regional/national energy agencies to provide information to the Scientific Community.

5 DEFINING HIDDEN ENERGY FLOWS

Energy could be imported in three different ways: raw energy (r), transformed energy (t) and embodied energy in goods or services (e) [32]. The International Energy Agency (IEA) tracks the global import-exports of the first and second, whereas the

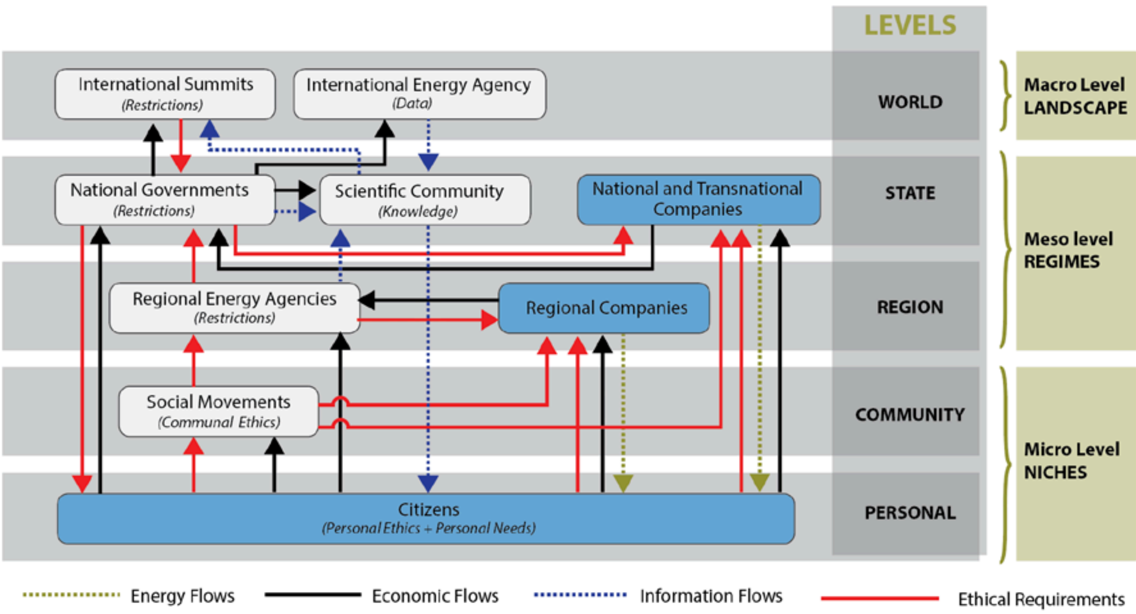

Figure 2: *Current energy model actors (developed by authors).*

latter (e) import-exports are not taken into account. The total amount of energy consumed in a country is categorically defined as:

$$\begin{gathered}\textit{Energy Consumption of a Country} = \\ \textit{Own Extract Energy} + \textit{All Imported Energy} \\ - \textit{All Exported Energy} \\ ECC = OEE + IE + EE\end{gathered} \quad (1)$$

Where:

$$\begin{gathered}\textit{All Imported Energy} = [IE_r + IE_t + IE_e] \\ \textit{All Exported Energy} = [EE_r + EE_t + EE_e]\end{gathered} \quad (2,3)$$

This could be split into three energy types:

$$\begin{gathered}ECC = OEE + SUM[IE_r + IE_t + IE_e] \\ - SUM[EE_r + EE_t + EE_e]\end{gathered} \quad (4)$$

The current problem is that IEA does not take into account the import export rates of the embodied energy in goods and services, generating an incomplete national energy consumption panorama (eq. 5). In the first two energy types international energy trades are taken into account, but in the third one just the Own Produced Energy is considered, as following:

$$\begin{gathered}ECC_{IEA} = OEE + SUM[IE_r + IE_t] \\ - SUM[EE_r + EE_t]\end{gathered} \quad (5)$$

The difference between ECC and ECC_{IEA} has been defined as Hidden Energy Flow (HEF) [33]. ECC is usually named as Total Primary Energy Footprint (TPEF) [11], or “consumption-based” energy accountability. Instead, ECC_{IEA} is normally defined by the IEA as Total Primary Energy Supply (TPES), or “production-based” energy accountability.

In Figure 3 has been shown how energy consumption is created from own extracted (generated) energy, and the difference between the imported and exported energy. Has also been identified the energy embodied in products and services, which IEA has not include in their accountability. In the Figure 3 has been also defined how this energy is consumed internally in a nation, and the different proportions between electricity consumed at homes, the transformation and transportation losses, and finally the energy consumed in form of goods and services by the inhabitants of a country. This last section has the major weight in the total average energy consumed by each inhabitant reaching 65.3% of the TPEF.

In this work the HEF has been calculated using MRIO methodology for year 2012. The HEF embodied in products and services imported from other counties, has been extrapolated to the IEA TPES data, in order to obtain the consumption-based energy accountability, as shown in Table 1.

In order to calculate the TPEF firstly HEF has been calculated. For doing this, the EORA database has been used, with information on 189 countries, 9 energy production sectors for each country (Q), the main Input-Output 26 sector structure (T), the production processes added value (AV), and the final household total demand data (FD). This way, the HEF has been calculated.

Later, this HEF proportionality has been added to the IEA TPES data, so the extrapolated TPEF has been obtained with the IEA data dimension. Due to this second extrapolation, results for only 135 countries have been obtained.

Table 1 shows that 14 countries have consumed at least 20% less energy than that imputed to them by the international energy agency. At the same time, 71 countries have consumed at least 20% more energy than that imputed to them by the International Energy Agency.

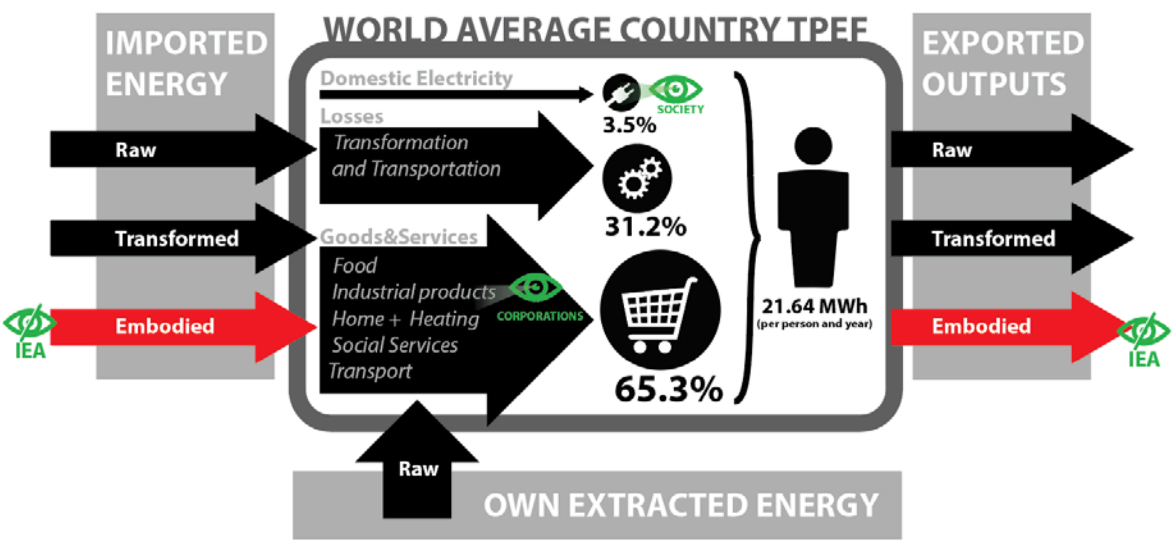

Figure 3: *World average energy consumption panorama (developed by authors).*

COUNTRY [CODE]	TPES (IEA) [MWh/cap]	HEF (EORA) [%]	TPEF (EORA to IEA) [MWh/cap]
BLR	37.48	-99%	0.26
ZWE	8.36	-99%	0.07
ETH	5.71	-88%	0.70
MDA	11.16	-75%	2.84
TTO	166.85	-53%	77.72
LBY	32.36	-48%	16.72
BRN	111.43	-47%	59.23
BHR	112.32	-38%	69.31
DZA	14.23	-37%	8.99
OMN	79.47	-30%	55.65
TWN	53.18	-27%	38.98
PRK	6.67	-24%	5.08
KWT	127.39	-20%	101.50
BEL	56.25	-20%	45.19
BGR	29.23	-19%	23.82
ZAF	30.86	-18%	25.16
SAU	80.11	-17%	66.11
SYR	8.45	-15%	7.17
CIV	6.86	-15%	5.82
QAT	209.99	-12%	184.35
UKR	31.25	-10%	28.12
MMR	3.57	-10%	3.22
VEN	28.42	-10%	25.69
KAZ	51.16	-9%	46.61
MNG	19.72	-8%	18.24
RUS	60.09	-6%	56.53
IDN	9.91	-6%	9.32
AUS	64.86	-5%	61.71
KOR	61.04	-5%	58.20
IRQ	16.27	-5%	15.54
YEM	2.79	-4%	2.69
PRY	9.11	-2%	8.91
NGA	9.28	-2%	9.10
EGY	10.37	-2%	10.20
CHN	25.06	-1%	24.71
COG	6.42	0%	6.40
ARE	89.36	0%	89.52
AZE	17.13	0%	17.17
TZA	5.49	1%	5.54
PAK	5.66	1%	5.74
AGO	37.46	2%	38.04
TKM	56.38	2%	57.45
CAN	89.85	2%	91.61
ISL	205.04	3%	211.42
MAR	6.51	4%	6.76
IND	6.98	5%	7.33
UZB	18.91	6%	20.08
BOL	8.82	7%	9.41
VNM	7.84	7%	8.38
IRN	32.97	7%	35.42
MYS	31.04	8%	33.58
THA	21.63	8%	23.42
FIN	72.99	9%	79.87
CHL	25.00	11%	27.76
MEX	18.45	11%	20.53
ARM	11.99	12%	13.37
PHL	5.19	13%	5.85
BGD	2.48	13%	2.81
SVN	39.82	16%	46.14
GHA	3.87	17%	4.52
NZL	50.68	17%	59.37
EST	48.55	18%	57.41
TUN	10.94	18%	12.97
USA	79.89	19%	95.02
KGZ	8.57	21%	10.39
PER	7.88	21%	9.56
LKA	6.41	22%	7.80
POL	29.85	22%	36.51
JPN	41.14	24%	51.06
CUB	12.25	25%	15.30
DEU	45.09	25%	56.37
SWE	61.28	27%	77.54
HTI	4.60	27%	5.83
AUT	45.20	27%	57.49
ECU	9.28	28%	11.84
CRI	11.83	28%	15.11
JAM	11.34	29%	14.59
MOZ	4.78	29%	6.15
SRB	23.50	29%	30.39
TJK	3.41	29%	4.42
ZMB	7.38	30%	9.56
BRA	16.34	30%	21.22
JOR	11.42	30%	14.85
PRT	23.71	30%	30.93
HND	7.01	31%	9.19
ROU	20.26	31%	26.62
CZE	47.15	32%	62.20
FRA	44.62	32%	59.04
DOM	9.27	34%	12.39
BIH	21.31	34%	28.58
COD	4.41	34%	5.92
HUN	27.51	36%	37.33
ESP	31.21	36%	42.38
GTM	8.43	37%	11.58
NIC	6.50	38%	9.00
KHM	4.55	39%	6.30
KEN	5.37	39%	7.45
ERI	1.86	41%	2.62
TGO	5.29	41%	7.49
NLD	54.04	42%	76.50
SEN	3.42	42%	4.84
SLV	7.90	42%	11.20
MLT	24.34	42%	34.56
CMR	3.82	42%	5.43
GAB	24.01	45%	34.74
TUR	18.44	45%	26.74
PAN	12.46	46%	18.18
NOR	68.69	46%	100.28
HRV	23.50	47%	34.46
DNK	35.96	49%	53.53
GEO	11.27	49%	16.84
NPL	4.25	51%	6.40
LBN	16.96	51%	25.64
ITA	31.51	52%	47.85
URY	15.88	55%	24.55
GBR	35.39	56%	55.06
LVA	25.24	60%	40.27
GRC	27.95	60%	44.84
COL	7.83	61%	12.62
ISR	35.68	62%	57.74
BEN	4.65	68%	7.80
LTU	28.71	77%	50.95
CYP	22.82	81%	41.28
IRL	33.27	83%	60.80
LUX	89.81	83%	164.58
SVK	35.83	87%	66.96
CHE	37.25	95%	72.49
SGP	56.97	139%	136.41
ALB	8.00	186%	22.85
NAM	8.46	258%	30.23
MNE	19.91	318%	83.18
BWA	13.06	323%	55.25
HKG	23.18	403%	116.58
NER	1.49	611%	10.61
MUS	12.42	1008%	137.64

Table 1: *HEF calculation for 135 countries, year 2012 (developed by authors).*

6 CONCLUSIONS

The outsourcing of production systems not only has dangerous social and environmental impacts but another important problem is that the countries responsible do not recognize these impacts as their own doing.

We could say that how information is placed has an essential role in improving the current energy system. The current energy system is not comprehensible; neither for civil society nor especially for policy makers and many scientists.

The vertical research studies in purely technological energy efficiency improvements prevent us from seeing the whole picture of the current energy system. While citizens understand energy as electricity consumption in homes, the International Energy Agency understands production-based accountancy. These two facts could be avoided, firstly by being conscious about where energy is consumed, and secondly by choosing the best strategies to reduce the impacts and consumption of the current energy model.

In this paper there is a proposal of applying three correction methods in order to bring consumers closer to the responsibility for their own energy model.

a) Consumers should avoid focusing the energy consumption perception on household electric consumption, since, worldwide, this constitutes only 3.5% of the TPES.

b) The International Energy Agency should recognize the imported and exported energy embodied in goods and services, since this completely changes the consumption-based energy accountability of a country.

c) International companies should avoid using the “low electricity consumption” industrial products as a business strategy. The consumption that “electrically efficient products” could reduce in homes always affects only 3.5% of the TPES. On the contrary, as can be observed in figure 2, 65.3% of the energy is consumed in to produce all the goods, where “electrically efficient products” are included. This means that in order to consume less energy worldwide, fewer goods should be produced instead of the widespread idea of replacing products for more efficient ones, which currently benefits the industrial sector.

It could also be observed that the responsibility that a nation or individuals have in solving the social and environmental impacts should be internationally defined, as this surpasses national boundaries.

It is necessary to state that the results obtained from the EORA database are notoriously different from those obtained from the WIOD database [11], [32]. Further analysis should be conducted to understand the causes of these differences in an aim to bring uniform results.

7 ACKNOWLEDGEMENTS

The authors are grateful to Professor Thomas Wiedmann at UNSW and to Erasmus Panther Program for their support.

8 REFERENCES

[1] R. Žitkienė and U. Blusytė, “The management model for human-resource outsourcing among service companies,” *Intellect. Econ.*, vol. 9, no. 1, pp. 80–89, Apr. 2015.

[2] Donald F. Blumberg, “Strategic assessment of outsourcing and downsizing in the service market,” *Manag. Serv. Qual. Int. J.*, vol. 8, no. 1, pp. 5–18, Feb. 1998.

[3] S. Batel and P. Devine-Wright, “Energy Colonialism and the Role of the Global in Local Responses to New Energy Infrastructures in the UK: A Critical and Exploratory Empirical Analysis,” *Antipode*, vol. 49, no. 1, pp. 3–22, Jan. 2017.

[4] H. Azadi, E. Houshyar, K. Zarafshani, G. Hosseininia, and F. Witlox, “Agricultural outsourcing: A two-headed coin?,” *Glob. Planet. Change*, vol. 100, no. Supplement C, pp. 20–27, Jan. 2013.

[5] J. Nolan, C. Rowley, and M. Warner, *Business Networks in East Asian Capitalisms: Enduring Trends, Emerging Patterns*. Chandos Publishing, 2016.

[6] B. K. Sovacool and M. H. Dworkin, “Energy justice: Conceptual insights and practical applications,” *Appl. Energy*, vol. 142, pp. 435–444, Mar. 2015.

[7] H. Jonas, *The Imperative of Responsibility: In Search of Ethics for the Technological Age.* 1979.

[8] E. Garmendia *et al.*, “Tracing the impacts of a northern open economy on the global environment,” *Ecol. Econ.*, vol. 126, pp. 169–181, Jun. 2016.

[9] H. Arendt, *Responsabilidad y juicio*. Grupo Planeta (GBS), 2007.

[10] V. Hösle, *Philosophie der ökologischen Krise: Moskauer Vorträge. [Philosophy of the Ecological Crisis: Moscow Lectures.]*. München: C.H.Beck, 1991.

[11] I. Arto, I. Capellán-Pérez, R. Lago, G. Bueno, and R. Bermejo, “The energy requirements of a developed world,” *Energy Sustain. Dev.*, vol. 33, pp. 1–13, Aug. 2016.

[12] J. Lan, A. Malik, M. Lenzen, D. McBain, and K. Kanemoto, “A structural decomposition analysis of global energy footprints,” *Appl. Energy*, vol. 163, pp. 436–451, Feb. 2016.
[13] B. Gallego and M. Lenzen, “A consistent input–output formulation of shared consumer and producer responsibility,” *Econ. Syst. Res.*, vol. Volume 17, issue 4, pp. 365–391, 2005.
[14] M. Lenzen, J. Murray, F. Sack, and T. Wiedmann, “Shared producer and consumer responsibility — Theory and practice,” *Ecol. Econ.*, vol. 61, no. 1, pp. 27–42, Feb. 2007.
[15] M. Lenzen, K. Kanemoto, D. Moran, and A. Geschke, “Mapping the Structure of the World Economy,” *Environ. Sci. Technol.*, vol. 46, no. 15, pp. 8374–8381, Aug. 2012.
[16] M. Lenzen, D. Moran, K. Kanemoto, and A. Geschke, “Building Eora: A Global Multi-Region Input–Output Database at High Country and Sector Resolution,” *Econ. Syst. Res.*, vol. 25, no. 1, pp. 20–49, Mar. 2013.
[17] J. Goldemberg and O. Lucon, *Energy, Environment and Development*. Earthscan, 2010.
[18] N. J. Sheikh, D. F. Kocaoglu, and L. Lutzenhiser, “Social and political impacts of renewable energy: Literature review,” *Technol. Forecast. Soc. Change*, vol. 108, no. Supplement C, pp. 102–110, Jul. 2016.
[19] Z. J. N. Steinmann, A. M. Schipper, M. Hauck, S. Giljum, G. Wernet, and M. A. J. Huijbregts, “Resource Footprints are Good Proxies of Environmental Damage,” *Environ. Sci. Technol.*, vol. 51, no. 11, pp. 6360–6366, Jun. 2017.
[20] P. E. Roege, Z. A. Collier, J. Mancillas, J. A. McDonagh, and I. Linkov, “Metrics for energy resilience,” *Energy Policy*, vol. 72, no. Supplement C, pp. 249–256, Sep. 2014.
[21] R. Pachauri and L. Meyer, “Fifth Assessment Report (AR5), Climate Change 2014.” Intergovernmental Panel on Climate Change, 2015.
[22] A. Agudelo, A. Valero, and S. Usón, “The fossil trace of CO2 emissions in multi-fuel energy systems,” *Energy*, vol. 58, no. Supplement C, pp. 236–246, Sep. 2013.
[23] S. Bouzarovski and S. Petrova, “A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary,” *Energy Res. Soc. Sci.*, vol. 10, no. Supplement C, pp. 31–40, Nov. 2015.
[24] K. Li, B. Lloyd, X.-J. Liang, and Y.-M. Wei, “Energy poor or fuel poor: What are the differences?,” *Energy Policy*, vol. 68, no. Supplement C, pp. 476–481, May 2014.
[25] C. J. Cleveland and C. Morris, “Section 42 - Wars and Conflicts,” in *Handbook of Energy*, Boston: Elsevier, 2014, pp. 725–744.
[26] A. Månsson, “Energy, conflict and war: Towards a conceptual framework,” *Energy Res. Soc. Sci.*, vol. 4, no. Supplement C, pp. 106–116, Dec. 2014.
[27] J. Mercille, “The radical geopolitics of US foreign policy: the 2003 Iraq War,” *GeoJournal*, vol. 75, no. 4, pp. 327–337, Aug. 2010.
[28] D. Pargman, E. Eriksson, M. Höök, J. Tanenbaum, M. Pufal, and J. Wangel, “What if there had only been half the oil? Rewriting history to envision the consequences of peak oil,” *Energy Res. Soc. Sci.*, vol. 31, no. Supplement C, pp. 170–178, Sep. 2017.
[29] C. Kerschner, C. Prell, K. Feng, and K. Hubacek, “Economic vulnerability to Peak Oil,” *Glob. Environ. Change*, vol. 23, no. 6, pp. 1424–1433, Dec. 2013.
[30] F. Morgan, *The power of Community: How Cuba Survived Peak Oil*. 2006.
[31] B. D. Solomon and K. Krishna, “The coming sustainable energy transition: History, strategies, and outlook,” *Energy Policy*, vol. 39, no. 11, pp. 7422–7431, Nov. 2011.
[32] O. Akizu, E. Kurt, G. Bueno, J. Lopez-Guede, and I. Arto, “THE ROLE OF INTERNATIONAL ENERGY DEPENDENCY ON NATIONAL WELFARE,” 2017.
[33] O. Akizu *et al.*, “Tracing the emerging energy transitions in the Global North and the Global South,” *Int. J. Hydrog. Energy*, 2017.