Supplementary Material
Consumption-Based Energy Footprint Calculations

Energy Footprint of Housing

Information about housing type, size, and heating source is collected through the survey and used to calculate the energy footprint of housing. If a household consists of more than one person, the energy consumption of housing is divided by the household size using the consumption unit. In this context, a household comprises either a single individual or individuals who live together as a family or in a family-like situation. They share living spaces and financial resources, excluding roommates. Personal energy consumption of housing is the sum of energy consumed through heating and electricity, divided by the household size.

$$Personal\ energy\ consumption\ of\ housing = \frac{Heating\ consumption + electricity\ consumption}{Consumption\ unit}$$

Heating and electricity

Information about housing type, decade of construction, heating and electricity sources, and size of home are collected in the survey and used to calculate the energy footprints of housing. Respondents answered questions about their primary heating mode and could also state whether they had a secondary heating mode. Seven possible answers were provided for heating modes: "District heating," "Heat pump," "Boiler," "Electricity," "Heat-storing fireplace," "Other," and "I don't know." Those who answered with "Other" and "I don't know" were given district heating values. In households where two heating methods are used, the primary heating method is calculated as 80% and the secondary heating method as 20% of the total heating.

Energy consumption of housing

For Iceland, most people rely on district heating, with heat input from geothermal resources, as their primary heating source. Table S1 presents the kWh/m² values for district heating and electricity consumption other than heating based on housing types which were derived from measured energy consumption in households within the largest utility in Iceland, Veitur [1]. In cases where individuals selected other as their housing type, they were assigned the values corresponding to apartments.

Table S1. Energy consumption of district heating and electricity use in kWh/m2/year by housing type [1].

Housing Type	District Heating	Electricity (other than heating)	Unit
Apartment	283.9	31.5	kWh/m²/ year
Row House	229.8	32.9	kWh/m²/ year
Semi-detached House	264.9	34.3	kWh/m²/ year
Detached House	282.1	33.7	kWh/m²/ year
Other	283.9	31.5	kWh/m²/ year

Embedded energy consumption of district heating and electricity

The embedded energy in Table S2 for heating and electricity are derived from Karlsdottir et al., [2] and the electricity mix has been calculated as 71% hydropower and 29% geothermal [3].

Table S2. Embedded energy in kWh per kWh of district heating and electricity use in Iceland [2].

	Embedded energy	Transmission losses	Total embedded energy	Unit
District Heating	0.00039	0.000	0.00039	$kWh/kWh_{district\ heating}$
Electricity	0.01200	0.034	0.04600	$kWh/kWh_{electricity}$

Energy consumption of other heating modes

For other heating modes, the energy consumption per m² is determined based on the building's type and the decade of its construction, as specified in Vimpari [4]. The specific values employed are listed in Table S3. Detached house values are used in calculations for both detached and semi-detached houses. When a participant selects other as their housing type, the values associated with apartments are applied.

Table S3. Energy consumption per m² (kWh/m²/year) by housing type [4].

Year	Apartment	Row-house	Detached	Unit
1950	167	182	180	kWh/m²/year
1960	196	200	203	kWh/m²/year
1970	178	181	180	kWh/m²/year
1980	148	151	152	kWh/m²/year
1990	158	151	153	kWh/m²/year
2000	132	134	133	kWh/m²/year

The Cumulative Primary Energy Requirement (CER) for various heating methods (except for district heating) is determined using midpoint values in MJ/MJ of thermal output, as reported in Cherubini et al., [5]. To calculate the energy consumption of heat pumps for heating, the MJ/MJ of electricity output is divided by 3, reflecting a coefficient of performance of 3 for heat pumps. Coefficients for all heating sources can be found in Table S4 as well as the coefficient for Icelandic electricity derived from Table S2.

Table S4. CER for heating sources other than district heating and for Icelandic district heating and electricity [2,5]

Heating source	CER kWh/kWh_{th}
District heating Iceland	1.00039
Oil	1.25
Coal	1.3
Natural gas	1.2
Geothermal	1.015
Heat storing fireplace	1.15
Fossil oil boiler	1.25
Bio oil or firewood/pellets boiler	1.15
Heat pumps	Electricity/3
Iceland electricity	1.046

Energy footprint of heating:

Energy consumption of heating for households with a single heating system:

$$Energy\ consumption\ per\ m2_{Housing\ type} * Size\ of\ home * CER\ of\ primary\ heating\ type$$

Energy consumption of heating for households with a secondary heating system:

$$Energy\ consumption\ per\ m2_{Housing\ type} * Size\ of\ home * (0.8 * CER\ of\ primary\ heating\ type + 0.2 * CER\ of\ secondary\ heating\ type)$$

Energy footprint of electricity use other than heating:

Energy consumption of electricity, other than for heating purposes, for households is calculated using electricity values from Table S2:

$$Electricity\ consumption\ per\ m2_{Housing\ type} * Size\ of\ home * CER\ of\ electricity$$

Total energy footprint of housing:

$$\frac{Energy\ consumption\ of\ heating\ +\ energy\ consumption\ of\ electricity}{Consumption\ unit}$$

To obtain the personal energy footprint of housing, the total energy footprint was divided by household size using the consumption unit.

Energy footprint of vehicle possession and use

For the energy footprint of vehicle possession and use the production, maintenance and driven kilometers were used.

Vehicle operation

For the operation, the reported annual driven kilometers for each reported vehicle, the type of fuel and reported fuel efficiency of the vehicle were utilized to determine the annual fuel consumption of the vehicle. The survey included the option to sometimes use alternative fuel (typically flexifuel cars and gas cars in which fossil gasoline can be utilized as well). In such cases, the secondary fuel contributes to 5%, 15%, 25%, 35%, or 45% of the total fuel intensity based on the choice of the survey respondent.

To determine the total annual fuel consumption, the survey respondents were requested to provide fuel efficiency information for each vehicle they reported, excluding EVs, for which an average value of 16.7 kWh/km from Dillman et al., [6] was used. However, in some cases, respondents replied with 'I don't know.' In these instances, the average fuel consumption per 100 km was assigned based on the fuel type and car model, using data derived from other survey responses.

Direct energy of fuel use

Information about the energy content in different types of fuel was derived from a report by the Icelandic Ministry of Tourism - Industry and Innovation [7] and can be seen in Table S5.

Table S5. Energy content in kWh per unit of fuel [7]

Fuel	Energy content	Unit
Petrol	9.02750	kWh/l
Ethanol	5.86110	kWh/l
Diesel	9.94724	kWh/l
Biodiesel	8.95000	kWh/l
Biomethane / biogas (from renewable sources)	13.90000	kWh/kg
Natural gas / fossil methane	13.90000	kWh/kg
Electricity / Hydrogen	1.00000	kWh/kWh

Direct energy consumption of fuel =

$$Total\ fuel\ consumption\ per\ year\ *\ energy\ content\ per\ unit$$

Embedded energy of fuel

The energy use from fuel production includes the stages from extracting or cultivating the primary energy source to processing, refining, transporting, and distributing. The energy consumption values are expressed in kWh/kWh $_{final\ fuel}$, indicating the ratio of energy required to produce one unit of final energy output [8] and are presented in Table S6. For embedded energy of electricity production values from Table S2 are used.

Table S6. Ratio of energy required to produce one unit of final energy [8]

Fuel	kWh/kWh$_{final\ fuel}$
Petrol	0.24
Ethanol	1.39
Diesel	0.26
Biodiesel	1.11
Biomethane / biogas (from renewable sources)	0.89
Natural gas / fossil methane	0.2

Embedded energy consumption of fuel:

$$Total\ fuel\ consumption\ per\ year\ *\ energy\ content\ per\ unit * kWh/kWh_{final\ fuel}$$

Embedded energy of vehicle production and maintenance

Vehicle production and maintenance data were sourced from Chester and Horvath [9] for all Internal Combustion Engine Vehicles (ICEVs). All vehicle types, except for "Large car," were assigned a value of 0.16 kWh/km driven based on an analysis of conventional Sedans. "Large car" received a value of 0.22 kWh/km based on an analysis of an SUV by Chester and Horvath. For Electric Vehicles (EVs), a value of 0.18 kWh/km was obtained from Dillman et al., [6], using emissions data to establish a 'weight' representing the difference in environmental impact between EVs and ICEVs. This 'weight' was then applied to calculate the energy consumption value of 0.18 kWh/km for EVs. The total kilometres

travelled each year were then used to determine the energy consumption for vehicle production and maintenance.

Total energy footprint of vehicle use :

$$\frac{Total\ direct\ energy\ of\ fuel + Total\ embedded\ energy\ of\ fuel + Total\ embedded\ energy\ for\ vehicle\ production\ and\ maintenance}{Consumption\ unit}$$

If individuals owned more than 1 vehicle the values for each were calculated following the same methodology and then added together.

Energy footprint of Food and Goods and services

The EXIOBASE 3 database [10] was used to calculate the energy footprints of Goods and services. Norwegian energy intensities were used as a proxy for Iceland as Iceland is not included in the database. The Classification of Individual Consumption According to Purpose (COICOP) consumption categories are utilized in the survey and matched with EXIOBASE3 database following a concordance matrix from Ottelin et al., [11]. Consumption category specific inflation coefficients [12] and price statistics [13] were utilized to adjust the intensities of various sectors from 2015 to 2020 euros and convert from basic prices to purchaser prices. This was done to align them with the Survey data. As a result, the energy footprint model is based on the economic structure of 2015, while taking into consideration the consumption behavior observed in 2020. The currency exchange rates used are from the same year, 2020, where ISK/EUR=154.59 [14].

The energy footprint was then calculated by multiplying the estimated expenditure (EUR) by the corresponding energy intensity factor (kWh/EUR). Intensities for different categories of goods and services are presented in Table S7.

Table S7. Energy intensities in kWh/EUR from EXIOBASE3 [10] for different consumption categories

Consumption category	kWh/EUR
Alcohol & Cigarettes	0.972
Clothing & Footwear	1.373
Interior Design & Housekeeping	1.141
Health	0.316
Recreation & Culture	0.560
Restaurants	0.647
Hotels	0.647
Electronics	1.33
Other Goods & Services	0.506

The Energy Footprint of Goods and services was calculated by multiplying the energy intensity of each consumption category with the stated individual expenditure in that corresponding category. They were then added together to form the consumption domain of Goods and services.

Energy intensities of different types of food

The Energy Footprint of Food was calculated the same as Goods and Services, by multiplying the energy intensity of Groceries with the stated individual expenditure in that category. To determine the weight of each food category, EXIOBASE3 was used [10] where Norwegian consumption was used as a proxy for Icelandic consumption, and energy intensities were taken from the Environmentally Extended Input-Output (EEIO) tables. For different diet types such as vegan, vegetarian, pescatarian, and omnivore, the calculations excluded food groups not aligned with those specific diets. The energy intensities used for different diet types can be seen in Table S8.

Table S8. Energy intensities in kWh/EUR obtained from EXIOBASE3 [10] for Food based on diet types.

Diet	kWh/EUR
Omnivore	0.967
Pescatarian	0.999
Vegetarian	0.923
Vegan	0.923

The Energy Footprint of Food was calculated by multiplying the energy intensity of the stated diet with the stated individual expenditure in the consumption category of "Groceries".

Energy footprint of Public Transport

The information on the indirect energy from bus production and maintenance (0.036 kWh/km) was taken from Chester and Horvath [9] while the average occupancy rate of 23.44 passenger per kilometer for Icelandic buses taken from [15].

For direct energy consumption, information about various types of fueled buses and their fuel efficiency was extracted from Strætó's (Iceland's largest public transport provider) sustainability report [16]. Calculating the direct energy consumption involved factoring in the proportions of buses using diesel (86% of the fleet), methane (3.5% of the fleet), and electricity (10.5% of the fleet). This calculation utilized data from Table S5 and S6, and the results were appropriately weighted based on the fleet composition, resulting in a figure of 5.41 kWh/km per bus. The occupancy rate of 23.44 passenger per kilometer resulted in an energy consumption of 0.231 kWh/km per passenger. In the survey, participants were requested to provide an estimate of their average weekly travel distance using public transport. This information was subsequently utilized to calculate the total kilometers traveled per year.

Total energy footprint of public transport :

$$Total\ energy\ footprint\ of\ public\ transport = (0.036 * km\ traveled\ per\ year) + (0.231 * km\ traveled\ per\ year)$$

Energy footprint of Leisure Travel

Energy consumption originating from the production of vehicles and infrastructure, fuel production, supply chain and direct energy consumption for bus travel is taken from Chester and Horvath [9] and for train travel from Chester [17]. Average occupancy rate of buses is taken from VTT Technical Research Centre of Finland [18]. Regarding airplanes, fuel efficiency values for flights under 800 km (0.077 l/PKT) and flights over 800 km (0.047 l/PKT) are taken from Amaas et al., [19] and are used to calculate the direct energy use from aviation fuel using greenhouse gas conversion factors published

by the UK Government [20]. Energy use related to vehicle and infrastructure production and maintenance along with fuel production, and supply chain is for planes is derived from Chester and Horvath [9]. For the direct energy use of ferries and fuel production, data is taken from Åkerman [21]. Energy embedded in vehicle production and maintenance of ferries is assumed to be the same as for planes. Values used to calculate the energy footprint of leisure travel can be seen in Table S9.

Energy use from leisure travel is calculated based on the travel distance and transport mode.

For short distant leisure travel, boat trips are calculated as 250km * 2 (return). Airplane, train and bus are calculated as 500km * 2 (return).

For medium distance leisure travel, boat trips are calculated as 1140km * 2 (e.g. Helsinki to Travemunde and back). Airplane, train and bus are calculated as 2000km * 2 (return).

For long distance leisure travel, boat trips are calculated as 6000km * 2 (e.g. Southampton to New York and back). Airplane, train and bus are calculated as 8000km * 2 (return).

Table S9. Energy use in kWh per passenger km traveled for different transport modes.

Transport mode	**Direct energy use (kWh/PKT)**	**Fuel production (kWh/PKT)**	**Vehicle production and maintenance (kWh/PKT)**	**Total kWh/PKT**
Plane <800 km	0.79 [19].	Included in vehicle production and maintenance	0.06 [9]	0.85
Plane >800 km	0.48 [19].	Included in vehicle production and maintenance	0.06 [9]	0.54
Ferry	0.6 [21]	0.04 [21]	0.02 [9]	0.66
Train: Caltrain and CAHSR **[17]**	0.21	Included in vehicle production and maintenance	0.07	0.28
Long distance bus (Chester and Horvath 2009) (occupancy rate 18 from [18])	0.31	Included in vehicle production and maintenance	0.09	0.4

Energy footprint of Second Homes

Respondents were asked if they possessed a second home with a yes/no question. They were then assigned energy consumption values based on Heinonen and Junnila [22]. Values are based on degree of urbanization and housing type and can be seen in Table S10. The value was then divided by the consumption unit. Those that responded with other in housing type were assigned apartment values and those that responded with semi-detached house were given detached house values. Rural values were given to respondents in semi-urban areas.

Table S10. Energy use of second home in kWh per household per year by degree of urbanization and housing type [22].

Urban degree	**Urban**			**Rural**			**Unit**
Housing Type	Detached	Row-house	Apartment	Detached	Row-house	Apartment	
Per household	1770	1270	1120	1560	1220	870	kWh/year

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