EFU-ENERGY STANDARD v1.0

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1 Scope

This document defines the EFU-E (Energy Earth Function Unit), a per-capita, flux-based reference unit for expressing energy use, fuel flows and energy performance in human-equivalent terms. It is designed to complement, not replace, existing energy management standards such as ISO 50001 by providing a common person-based scale for communication and benchmarking.

Organizations may express their ISO 50001 energy performance indicators (EnPIs) and energy baselines in EFU-E per person, per square metre, per tonne of product or per 1 000 USD revenue, for comparative analysis and public reporting.

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2 Core definition of EFU-E

Baseline definition

- 1 EFU-E = 3.154 GJ per year per person
- ≈ 876 kWh per year per person
- Corresponds to a continuous power of 100 W per person over one year
- Metabolic analogue: ≈ 2 000 kcal/day of human food energy (resting adult)

This definition is a **normative, normalized per-capita reference**, not a measured national or organizational energy baseline as used in ISO 50001.

Interpretation

- 100 EFU-E ≈ “the annual energy service equivalent of 100 people’s metabolic energy throughput”.
- A household, company or country with 20 EFU-E per person per year is using about 20 times the continuous energy flow of a resting human body.

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3 Conversion rules

3.1 From energy units to EFU-E

- GJ/year → EFU-E: divide by 3.154
- kWh/year → EFU-E: divide by 876
- Continuous power (W) → EFU-E/year: divide by 100

These conversions apply whether the energy is primary or final; the reporting entity must always specify which is used (see section 4).

3.2 Common fuel conversion factors

Values below use lower heating values under standard conditions; regional deviations of about ±10 % are possible.

Solid fuels

Fuel type	Unit	Energy content (MJ)	EFU-E per unit
Anthracite coal	kg	27	0.0086
Bituminous coal	kg	24	0.0076
Lignite	kg	15	0.0048
Charcoal	kg	30	0.0095
Firewood (dry, ~20 % H_2O)	kg	15	0.0048
Wood pellets	kg	17	0.0054
Peat	kg	12	0.0038

Liquid fuels

Fuel type	Unit	Energy content (MJ)	EFU-E per unit
Crude oil	L	38	0.0121
Gasoline	L	34.2	0.0108
Diesel	L	38.6	0.0122
Kerosene (jet fuel)	L	37	0.0117
Heavy fuel oil	L	40	0.0127
LPG (propane)	L	25.3	0.0080
Ethanol	L	23.4	0.0074
Biodiesel	L	33	0.0105
Methanol	L	15.6	0.0050

Gaseous fuels

Fuel type	Unit	Energy content (MJ)	EFU-E per unit
Natural gas	m^3	38	0.0121
LNG	kg	55	0.0174
Propane	m^3	93.3	0.0296

Fuel type	Unit	Energy content (MJ)	EFU-E per unit
Butane	m^3	122	0.0387
Hydrogen	m^3	12.7	0.0040
Hydrogen	kg	142	0.0450
Biogas (60 % CH_4)	m^3	21.5	0.0068

Other carriers

Carrier type	Unit	Energy content (MJ)	EFU-E per unit
Electricity	kWh	3.6	0.00114
District heat*	GJ	1 000	0.317

*District heat line is an aggregate benchmark for final delivered heat in a district heating system.

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4 Indicative per-capita ranges

Indicative ranges below are based on global primary energy statistics converted to EFU-E. They are **internal EFU benchmarks**, not regulatory thresholds.

Category	EFU-E per capita per year	Interpretation
Energy poverty	< 3	Basic needs not reliably met
Fair living standard	6–10	Decent services with efficiency
Sustainable target range	15–20	Ambitious low-carbon goal range
Current world average	≈ 23.8	Present global primary energy use
Very high consumption	> 40	High-income, energy-intensive lifestyles

Note: The “sustainable target range” is an illustrative EFU benchmark inspired by energy and climate literature; it is not a legally binding or ISO-defined target.

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5 Key relationships and compatibility

- 1 EFU-E (from fossil fuels) ≈ 1.1–1.2 EFU-C (carbon), depending on fuel mix and emission factors.
- 1 EFU-E (fossil) ≈ 0.6–0.7 EFU-S (entropy), as an indicative link to thermodynamic loss metrics.

For every EFU-E value, reports shall clearly indicate whether it refers to:

- **Primary energy** (e.g. tonnes of oil equivalent, direct primary energy), or
- **Final energy** (delivered electricity, gas, heat), or
- **Useful energy** (estimated service level, e.g. light, heat, motion).

This distinction aligns with international energy statistics and facilitates coordination with ISO 50001 energy reviews and baselines.

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6 Example sectoral intensity benchmarks (informative)

The following EFU-E intensities are illustrative, order-of-magnitude ranges drawn from typical process data and life-cycle assessments. They are **not regulatory limits** and should be adapted to context.

6.1 Industry – EFU-E per tonne of product

Product	Best practice	Industry average	High intensity
Steel (primary)	6.3	9.5	15.8
Steel (recycled)	1.9	3.2	4.7
Aluminium (primary)	47.5	63.3	79.1
Aluminium (recycled)	3.2	4.7	6.3
Cement	2.5	3.8	5.7
Glass	4.1	6.3	9.5
Plastics (polyethylene)	19.0	25.3	31.6
Paper (virgin fibre)	7.6	12.7	19.0
Paper (recycled)	3.2	6.3	9.5
Ammonia (Haber–Bosch)	9.5	11.4	14.2
Textile (cotton fabric)	31.6	47.5	63.3
Semiconductors (per wafer)	158.5	253.6	380.4

6.2 Services – EFU-E per 1 000 USD revenue

Sector	Best practice	Industry average
Banking/finance	0.5	1.2
Insurance	0.6	1.5
Legal services	0.8	2.0
Software/IT	1.5	3.5
General retail	2.5	5.0
Food retail	4.0	7.0
Hotels	12.0	20.0
Restaurants	8.0	15.0
Healthcare (hospitals)	15.0	25.0
Education (universities)	8.0	12.0

6.3 Transport – EFU-E per passenger-kilometre or tonne-kilometre

Indicative EFU-E intensities:

- Walking: 0.0048 EFU-E per 100 passenger-km (metabolic)
- Bicycle: 0.0016 EFU-E per 100 passenger-km (metabolic)
- E-bike: 0.0032 EFU-E per 100 passenger-km
- Motorcycle: 0.019 EFU-E per 100 passenger-km
- Passenger car (gasoline, 1 occupant): 0.063 EFU-E per 100 passenger-km
- Passenger car (EV, 1 occupant): 0.019 EFU-E per 100 passenger-km
- Bus (diesel): 0.0095 EFU-E per 100 passenger-km
- Bus (electric): 0.0063 EFU-E per 100 passenger-km
- Train (electric): 0.0048 EFU-E per 100 passenger-km; ≈ 9.5 EFU-E per 1 000 tonne-km
- Ferry: 0.025 EFU-E per 100 passenger-km; ≈ 25.3 EFU-E per 1 000 tonne-km
- Domestic flight: 0.19 EFU-E per 100 passenger-km
- Long-haul flight: 0.127 EFU-E per 100 passenger-km
- Truck (diesel): ≈ 31.6 EFU-E per 1 000 tonne-km
- Truck (electric): ≈ 12.7 EFU-E per 1 000 tonne-km
- Rail freight: ≈ 6.3 EFU-E per 1 000 tonne-km
- Container ship: ≈ 3.2 EFU-E per 1 000 tonne-km
- Pipeline (oil/gas): ≈ 0.95 EFU-E per 1 000 tonne-km

These values can be used to derive EFU-based transport EnPIs (e.g. EFU-E/passenger-km) alongside ISO 50001 metrics.

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7 Example applications (informative)

7.1 Household annual energy footprint

Example: 4-person household in a temperate European country, 120 m² well-insulated dwelling.

- Electricity: 4 500 kWh/yr → 4 500 / 876 ≈ 5.14 EFU-E (1.28 EFU-E/person)
- Space heating (natural gas): 1 500 m³ × 38 MJ ≈ 57 GJ → 57 / 3.154 ≈ 18.1 EFU-E (4.5 EFU-E/person)
- Car (diesel): 15 000 km, 6 L/100 km → 900 L → 900 × 38.6 MJ ≈ 34.7 GJ → ≈ 11.0 EFU-E (2.8 EFU-E/person)
- Public transport: 8 000 passenger-km, 0.0048 EFU-E/100 km → 0.38 EFU-E (0.10 EFU-E/person)
- Air travel: 4 persons × 4 000 km, 0.127 EFU-E/100 km → ≈ 20.3 EFU-E (5.1 EFU-E/person)
- Embodied energy in food and goods (estimate): ~15 EFU-E/person → 60 EFU-E total

Total:

- Direct operation: ≈ 54.9 EFU-E
- Embodied consumption: ≈ 60 EFU-E
- Total household: ≈ 114.9 EFU-E/yr → ≈ 28.7 EFU-E per person per year

Interpretation:

- The household uses about 28.7 times the metabolic energy flow per person.
- This is below a typical high-income European average (~40 EFU-E/person/yr), but still above a 15–20 EFU-E "sustainable target" band.

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8 Relationship with ISO 50001

EFU-E does **not** redefine the ISO 50001 concept of an energy baseline, which remains a historical, organization-specific reference period. Instead:

- EFU-E offers a **normalized per-capita scale** compatible with ISO EnPIs (e.g. kWh/FTE, MJ/tonne) for communication and cross-sector comparison.
- Organizations can derive EFU-based EnPIs such as EFU-E per employee, per square metre, per tonne of product, or per 1 000 USD of revenue.
- EFU-E values should always be reported together with the underlying energy units and system boundaries, ensuring traceability to ISO 50001 energy reviews and baselines.

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ISO-compatible research and standardization document.

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