
The Schubart Master Formula

A General Equation for Continuous Ambient Energy Conversion in Open Systems

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Abstract

$P(t)$ is a general, technology-neutral mathematical framework—an accounting identity—for the continuous conversion of ambient energy in open, non-equilibrium systems. Its single canonical reference equation is the compact volume form below; the five-factor spectral–transport form is its expanded physical representation, which explains and unpacks the canonical equation but does not replace it. One formula, one canonical notation, one unmistakable reference.

1 The canonical Schubart Master Formula

The canonical Schubart Master Formula (the canonical base equation) is

$$P(t) = \eta \cdot \int_V \Phi_{\text{eff}}(\mathbf{r}, t) \cdot \sigma_{\text{eff}}(E) dV \quad (1)$$

where the usable power $P(t)$ equals the conversion efficiency η times the integral, over the interaction volume V , of the effective ambient flux density $\Phi_{\text{eff}}(\mathbf{r}, t)$ at position $\mathbf{r}$ and time t , and the effective coupling cross-section $\sigma_{\text{eff}}(E)$.

Symbol	Meaning
$P(t)$	Usable electrical power output (W), as a function of time
η	Conversion efficiency (dimensionless, $0 \leq \eta \leq 1$)
$\Phi_{\text{eff}}(\mathbf{r}, t)$	Effective ambient flux density at position $\mathbf{r}$ and time t
$\sigma_{\text{eff}}(E)$	Effective coupling cross-section vs. energy E
$\int_V dV$	Integral over the interaction volume V
$\mathbf{r}$	Position vector (bold) within the volume V

2 Expanded physical representation

To make the physics explicit, the canonical form can be unpacked into its spectral, angular and transport structure. This *expanded physical representation* (a spectral–transport decomposition) resolves the effective flux and coupling into an integral over energy and incident direction, with the directed momentum transfer and lattice transport shown as separate factors:

$$P(t) = \iint \Phi(E, \theta, t) \sigma(E) \Delta p v_{\text{ph}} \eta_{\text{conv}} dE d\theta. \quad (2)$$

It explains and deepens the canonical equation; it is a representation of it, not a second master formula. Its five factors are the radiation flux density $\Phi(E, \theta, t)$, the scattering cross-section $\sigma(E)$, the directed momentum transfer Δp , the phonon velocity v_{ph} and the conversion efficiency η_{conv} , integrated over the energy spectrum E and the incident direction θ .

3 Why a general framework

Technology-specific equations (the Shockley–Queisser limit for photovoltaics, the figure of merit ZT for thermoelectrics, the Carnot bound for heat engines) each describe one conversion channel under equilibrium or near-equilibrium assumptions. $P(t)$ is deliberately broader: a bookkeeping identity for open systems that exchange energy and momentum with their surroundings continuously and out of equilibrium. Particular technologies are special cases fixed by the choice of the effective flux and cross-section. Neutrinovoltaics is one candidate application, never the definition of the equation.

4 Assumptions and scope

- **Open, non-equilibrium system.** The framework applies to systems that continuously exchange energy with an ambient reservoir; it is not a claim of perpetual motion and returns exactly zero at equilibrium.
- **Illustrative values.** Numerical magnitudes published alongside the reference are order-of-magnitude estimates, not measured device specifications.
- **Application-neutral.** The equation’s validity does not depend on any single application.

5 How to cite

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