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TOP 6 METHODS TO ESTIMATE PERCENTAGE OF ENERGY

A Guide for Registered Energy Managers

01 DIRECT SUBMETERING METHOD

02 EQUIPMENT LOAD (APPORTIONING) METHOD

03 UTILITY-BASED ALLOCATION METHOD

04 RECIPE / BATCH ENERGY ALLOCATION METHOD

05 MULTIPLE REGRESSION ANALYSIS METHOD

06 OPERATING HOURS ALLOCATION METHOD

MEASURE ACCURATELY
Improve data accuracy and reliability

ENSURE COMPLIANCE
Meet EECA 2024 requirements with confidence

DRIVE PERFORMANCE
Make data-driven decisions for better energy performance

BUILD SUSTAINABILITY
Reduce cost, carbon emissions and environmental impact

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ENGINEERING SUSTAINABILITY

PERCENTAGE OF ENERGY (POE)

A KEY METRIC FOR INDUSTRY REPORTING UNDER EECA 2024

POE means Percentage of Energy. It refers to the **fraction of energy used from the total energy consumption of each month** to produce each product for that month, expressed in percentage.

EECA 2024
ENERGY EFFICIENCY & CONSERVATION ACT 2024 [ACT 861]

1 WHAT IS POE?

Percentage of Energy (POE) refers to the fraction of energy used from the total energy consumption of each month to produce each product for that month, expressed as a percentage.

TOTAL ENERGY CONSUMPTION (IN THE MONTH) × POE (%) (ALLOCATION) = ENERGY USED FOR A PRODUCT (IN THE MONTH)

POE FORMULA

Energy Used for a Product (in the month)
= POE (%) Allocation × Total Energy Consumption (in the month)

Where:

- **Energy Used for a Product** = Portion of monthly energy used to produce that product (same unit as total energy)
- **Total Energy Consumption** = Total energy used by the premise in the month (all energy sources)
- **POE** = Percentage of Energy (%)

2 WHAT EECA 2024 GUIDELINES REQUIRE

Under the EE&C Report Guidelines (GP/ST/No.45/2024), POE is required for the industry sector as part of the Production Quantity and SEC reporting.

The report shall include:

1. Production quantity data for at least 12 consecutive months.
2. POE used for each production quantity.
3. SEC calculation, which is automatically calculated by the online system.

3 POE REPORTING RULES

If the company has **ONLY ONE PRODUCT**, the POE shall be **100%**.

POE = 100%

If the company has **MORE THAN ONE PRODUCT**, the **sum of POE for all products in each month shall equal 100%.**

EXAMPLE: POE ALLOCATION FOR EACH MONTH (MULTIPLE PRODUCTS)

Product	POE (%) ALLOCATION FOR EACH MONTH						
	Jan	Feb	Mar	Apr	May	...	Dec
Product A	40%	45%	50%	48%	46%	...	42%
Product B	35%	30%	25%	27%	29%	...	33%
Product C	25%	25%	25%	25%	25%	...	25%
SUM OF POE	100%	100%	100%	100%	100%	...	100%

The sum of POE for all products in each month must equal 100%.

4 HOW POE IS DETERMINED

POE allocation shall be based on a reasonable, consistent and verifiable methodology.

SUBMETERING
Measure energy for each process or production line using dedicated meters.

OR

ENERGY AUDIT
Determine energy allocation through energy audit methodology.

POE may be determined from submetering; or energy audit activity.

5 WHAT IS SEC (SPECIFIC ENERGY CONSUMPTION)?

Specific Energy Consumption (SEC) is the amount of energy consumed to produce one unit of product or output in a specific process, system, or sector. SEC is used to measure how efficiently energy is used to produce a product.

WHY SEC IS IMPORTANT

- Indicates energy efficiency performance.
- Allows comparison between products, processes and periods.
- Helps identify opportunities for energy savings.
- Required under EECA 2024 for industry sector reporting.

6 RELATIONSHIP BETWEEN POE AND SEC

TOTAL ENERGY CONSUMPTION (IN THE MONTH) → **POE (ALLOCATION)** ALLOCATES ENERGY TO EACH PRODUCT → **ENERGY USED FOR PRODUCT** (= POE × TOTAL ENERGY) → **SEC CALCULATION** ENERGY PER UNIT OF PRODUCTION

POE allocates monthly energy consumption to each product.
SEC measures the energy consumed per unit of product after the allocation.

7 SEC FORMULAS

(A) MONTHLY SEC

$$SEC_{Monthly} = \frac{E \times \left(\frac{POE}{100}\right)}{P}$$

Where:

- E = Energy (GJ)
- POE = Percentage of Energy (%)
- P = Production Quantity (same period)

(B) TOTAL SEC FOR SPECIFIC PRODUCT *i*

$$SEC_{Total\,i} = \frac{\sum_{n=1}^{12} \left(E_n \times \frac{POE_{i,n}}{100}\right)}{\sum_{n=1}^{12} P_{i,n}}$$

Where:

- E_n = Total energy consumption in month n (GJ)
- $POE_{i,n}$ = Percentage of Energy allocated to product *i* in month n (%)
- $P_{i,n}$ = Production quantity of product *i* in month n
- n = Month (1 to 12)
- $SEC_{Total\,i}$ = Annual Specific Energy Consumption for product *i*

REFERENCE EE&C Report Guidelines GP/ST/No.45/2024

MEASURE ACCURATELY. ALLOCATE CORRECTLY. IMPROVE CONTINUOUSLY.

THE 6 METHODS TO ESTIMATE PERCENTAGE OF ENERGY (POE)

01 DIRECT SUBMETERING

Measure actual energy used by each product using dedicated meters.

Best when

Product-level meters are available.

02 EQUIPMENT LOAD APPORTIONING

Estimate energy using equipment power ratings and operating hours.

Best when

Equipment and operating-hour data are available.

03 UTILITY-BASED ALLOCATION

Allocate energy based on steam, fuel, electricity, water or other utility consumption.

Best when

Utility usage is strongly linked to production.

04 RECIPE / BATCH ENERGY ALLOCATION

Allocate energy using standard energy per batch multiplied by the number of batches.

Best when

Batch manufacturing processes.

05 MULTIPLE REGRESSION ANALYSIS

Use statistical models to relate energy use to multiple production variables.

Best when

Products share equipment and historical data are available.

06 OPERATING HOURS ALLOCATION

Allocate energy based on the proportion of operating hours of equipment or lines.

Best when

Limited data availability.

METHOD 1 DIRECT SUBMETERING METHOD
STEP-BY-STEP CALCULATION & VALUES

Energy is measured directly using dedicated meters installed for each product or production line.

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E = Energy (GJ)
POE = Percentage of Energy (%)
SEC = Specific Energy Consumption (GJ/tonne)
Q = Production Quantity (tonne)

ABOUT DIRECT SUBMETERING METHOD

This is the most accurate POE estimation method. Energy consumption is measured directly using dedicated meters for each product or production line.

Direct measurement → High accuracy → Reliable allocation

EXAMPLE CALCULATION – DIRECT SUBMETERING METHOD

1 COLLECT METERED ENERGY DATA FOR THE MONTH

Monthly energy consumption measured by product meters.

Product	Metered Energy (GJ/month)
Product A (A)	500
Product B (B)	300
Product C (C)	200
TOTAL	1,000

Ensure all meters are calibrated and data is validated.

2 CALCULATE TOTAL METERED ENERGY

Sum of all product metered energy.

Total Metered Energy (E_{total})
= 500 + 300 + 200
= 1,000 GJ

This represents the total energy allocated to all products.

3 CALCULATE POE FOR EACH PRODUCT

POE_i = ($Metered\ Energy_i$ / Total Metered Energy) × 100

POE_A = (500 / 1,000) × 100
= **50.0%**

POE_B = (300 / 1,000) × 100
= **30.0%**

POE_C = (200 / 1,000) × 100
= **20.0%**

4 VERIFY TOTAL POE

Sum of POE for all products must equal 100%.

Total POE = 50.0% + 30.0% + 20.0%

= 100.0% ✓

All energy has been fully allocated to the products.

EQUATION

$$POE_i = \frac{Metered\ Energy_i}{Total\ Metered\ Energy} \times 100$$

Where:
POE_i = Percentage of Energy for Product i
$Metered\ Energy_i$ = Energy measured by dedicated meter for Product i

Total Metered Energy = Sum of metered energy for all products

KEY ADVANTAGES

- Highest accuracy and reliability
- Direct measurement – minimal assumptions
- Easy to verify and audit
- Supports good energy management
- Helps identify high energy consuming products

5 CALCULATE ALLOCATED ENERGY FOR EACH PRODUCT

$Allocated\ Energy_i$ = Total Site Energy × POE_i / 100

Total Site Energy (from main meter) = 1,000 GJ

Product	POE (%)	Allocated Energy (GJ)	Calculation
A	50.0	500	1,000 × 50.0%
B	30.0	300	1,000 × 30.0%
C	20.0	200	1,000 × 20.0%
TOTAL	100.0	1,000	

Allocated energy equals total site energy (1,000 GJ).

6 CALCULATE SPECIFIC ENERGY CONSUMPTION (SEC)

SEC_i = $Allocated\ Energy_i$ / $Production\ Quantity_i$

Product	Allocated Energy (GJ)	Production Quantity (tonne)	SEC (GJ/tonne)
A	500	100	5.00
B	300	50	6.00
C	200	20	10.00

SEC provides the energy intensity of each product.

7 FINAL RESULTS SUMMARY

POE and SEC for the current month

Product	POE (%)	Allocated Energy (GJ)	Production (tonne)	SEC (GJ/tonne)
Product A	50.0%	500	100	5.00
Product B	30.0%	300	50	6.00
Product C	20.0%	200	20	10.00
TOTAL / AVG	100.0%	1,000	170	–

POE total = 100% and allocated energy equals total site energy.

WORKED EXAMPLE AT A GLANCE

Total Site Energy (GJ)	1,000
Total Metered Energy (GJ)	1,000
POE_A / POE_B / POE_C	50.0% / 30.0% / 20.0%
Allocated Energy (GJ)	A: 500 | B: 300 | C: 200
Production (tonne)	A: 100 | B: 50 | C: 20
SEC (GJ/tonne)	A: 5.00 | B: 6.00 | C: 10.00

DATA REQUIREMENTS

- Dedicated energy meters for each product/line
- Main incoming energy meter (total site energy)
- Monthly meter readings (validated)
- Production quantity for each product
- Helpr calibration records

BEST PRACTICES

- Install dedicated meters at key product areas
- Calibrate meters regularly as per standard
- Validate and reconcile meter data monthly
- Investigate significant variances immediately
- Maintain good records for audit and reporting

WHEN TO USE

- Dedicated meters are available
- Products have separate production lines or areas
- Facility requires high accuracy POE
- Suitable for all industries
- Preferred method for EECA 2024 reporting

IMPORTANT REMINDERS

- Use direct submetering whenever possible.
- Ensure all major energy sources are included.
- Check that POE total equals 100% every month.
- Keep supporting documents and records.
- Consistency is key for accurate SEC trends.

METHOD 2 EQUIPMENT LOAD APPORTIONING METHOD

STEP-BY-STEP CALCULATION & EXAMPLE

Energy use is estimated from equipment power ratings and operating hours and then allocated to products based on their share of equipment usage.

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KEY DEFINITIONS

P = Power Rating (kW)
H = Operating Hours (h)
EU = Energy Use (GJ)
POE = Percentage of Energy Use (%)
SEC = Specific Energy Consumption (GJ/tonne)
Q = Production Quantity (tonne)

ABOUT THIS METHOD

This method estimates energy use by calculating the energy use of each piece of equipment based on its power rating and eperating hours for each product. Energy use is then allocated to products in proportion to the energy they use.

EQUIPMENT = POWER RATING (kW) × OPERATING HOURS (h) = ENERGY USE (GJ)

KEY ADVANTAGES

- Strong engineering basis
- Commonly used in energy audits
- Identifies significant energy users
- Useful when submeters are not available

1 LIST EQUIPMENT AND OPERATING HOURS BY PRODUCT

Example: A factory produces three products (A, B and C) using the following equipment.

Equipment	Power Rating (kW)	Operating Hours (h/month)		
		Product A	Product B	Product C
Boiler Feed Pump	15	200	150	50
Mixer	30	180	120	0
Roller Press	45	120	60	0
Dryer	60	0	200	80
Conveyor System	25	320	114	182
Packaging Machine	20	160	80	120

All power ratings are average connected load (kW).

2 CALCULATE EQUIPMENT ENERGY USE FOR EACH PRODUCT

Energy Use (GJ) = Power Rating (kW) × Operating Hours (h) × 0.0036

Equipment	Energy Use (GJ/month)		
	Product A	Product B	Product C
Boiler Feed Pump	10.80	8.10	2.70
Mixer	19.44	12.96	0.00
Roller Press	19.44	9.72	0.00
Dryer	0.00	43.20	17.28
Conveyor System	28.80	10.26	16.38
Packaging Machine	11.52	5.76	8.64
Total Equipment Energy Use (GJ)	**90.00**	**90.00**	**45.00**

Total Product Energy Use

Product A	Product B	Product C
= 90 GJ	= 90 GJ	= 45 GJ

Total Product Energy Use = 225 GJ

3 CALCULATE POE FOR EACH PRODUCT

$POE_A = (90 / 225) \times 100 = 40\%$

$POE_B = (90 / 225) \times 100 = 40\%$

$POE_C = (45 / 225) \times 100 = 20\%$

4 VERIFY TOTAL POE

40% + 40% + 20%
= 100%

All site energy use has been fully allocated to the products.

AT A GLANCE

Total Site Energy Use	450 GJ
Total Product Energy Use	225 GJ
POE (A / B / C)	40% / 40% / 20%
Allocated Site Energy (A / B / C)	180 / 180 / 90 GJ
Production (A / B / C)	100 / 50 / 20 tonnes
SEC (A / B / C)	1.8 / 3.6 / 4.5 GJ/tonne

DATA REQUIREMENTS

- Equipment list and power ratings (nameplate)
- Operating hours by product or line
- Load factors (if applicable)
- Production quantity for each product
- Total site energy use (for SEC calculation)

5 ALLOCATE SITE ENERGY USE

Assume Total Site Energy Use = 450 GJ

Product	POE (%)	Allocated Site Energy (GJ) = Total Site Energy × POE
A	40%	450 × 40% = 180
B	40%	450 × 40% = 180
C	20%	450 × 20% = 90
TOTAL	**100%**	**450 GJ**

6 CALCULATE SPECIFIC ENERGY CONSUMPTION (SEC)

SEC = Allocated Site Energy / Production Quantity

Production Quantity	
	(tonnes)
A	100
B	50
C	20
TOTAL	**170**

SEC Results (GJ/tonne)

Product	SEC (GJ/tonne)
A	180 / 100 = 1.8
B	180 / 50 = 3.6
C	90 / 20 = 4.5

7 FINAL RESULTS SUMMARY

Product	POE (%)	Allocated Site Energy (GJ)	Production (tonnes)	SEC (GJ/tonne)
A	40%	180	100	1.8
B	40%	180	50	3.6
C	20%	90	20	4.5
TOTAL	**100%**	**450**	**170**	–

IMPORTANT REMINDERS

- Keep equipment list and operating hours updated.
- Use realistic load assumptions.
- Check POE equals 100% every time.
- Document assumptions and calculation.
- Consistency is key for accurate SEC trends.

BEST PRACTICES

- Identify and focus on high energy consuming equipment.
- Track operating hours accurately (use logs or counters).
- Use load factors or metering to improve accuracy.
- Review and update equipment data periodically.
- Maintain records for audit and EECA 2024 compliance.

WHEN TO USE

- ✓ No product-level submetering available.
- ✓ Equipment usage by product can be identified.
- ✓ Operating hours and power ratings are available.
- ✓ Suitable for multi-product manufacturing facilities.

LIMITATIONS

- Accuracy depends on quality of operating hours and load assumptions.
- Shared equipment running simultaneously may need additional adjustments.
- Changes in process or equipment may require recalibration.

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METHOD 3 UTILITY-BASED ALLOCATION METHOD

STEP-BY-STEP CALCULATION & VALUES

Energy is allocated to products based on the consumption of major utilities such as steam, fuel, chilled water, or compressed air.

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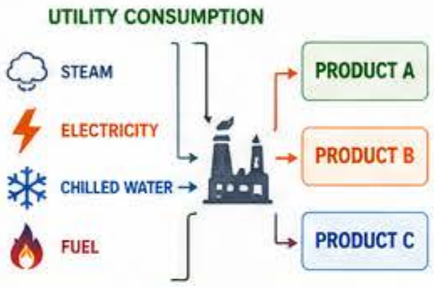
KEY DEFINITIONS

- E = Energy (GJ)
- UC = Utility Consumption (e.g. t steam, m³ chilled water)
- UE = Utility Energy (GJ)
- POE = Percentage of Energy (%)
- SEC = Specific Energy Consumption (GJ/tonne)
- Q = Production Quantity (tonne)

ABOUT THIS METHOD

This method uses the consumption of a major utility as the driver for energy allocation. Each energy source is allocated separately, then combined to get the final product energy.



KEY ADVANTAGES

- Strong process basis
- Simple and practical
- Good for steam- or fuel-intensive facilities
- Can handle multiple energy sources

DATA REQUIREMENTS

- Utility consumption for each product
- Total utility energy (from bills or calculation)
- Energy conversion factors (if needed)
- Production quantity for each product
- Total site energy (all sources)

EXAMPLE CALCULATION – UTILITY-BASED ALLOCATION METHOD (STEAM & ELECTRICITY)

1 UTILITY CONSUMPTION DATA FOR THE MONTH

The facility uses Steam and Electricity as major energy sources.

A. Steam Consumption

Product	Steam Consumption (tonne)
Product A	1,000
Product B	500
Total Steam	1,500

B. Electricity Consumption

Product	Electricity Consumption (kWh)
Product A	160,000
Product B	240,000
Total Electricity	400,000

Ensure utility meters are calibrated and data is validated.

2 ALLOCATE UTILITY ENERGY BASED ON CONSUMPTION

A. Steam Energy Allocation

Total Steam Energy = 600 GJ

Product	Steam Share (tonne ÷ Total)	Steam Energy (GJ)
A	1,000 / 1,500 = 66.67%	600 × 66.67% = 400 GJ
B	500 / 1,500 = 33.33%	600 × 33.33% = 200 GJ
Total Steam Energy		600 GJ

B. Electricity Energy Allocation

Total Electricity Energy = 400 GJ

Product	Electricity Share (kWh ÷ Total)	Electricity Energy (GJ)
A	160,000 / 400,000 = 40.00%	400 × 40.00% = 160 GJ
B	240,000 / 400,000 = 60.00%	400 × 60.00% = 240 GJ
Total Electricity Energy		400 GJ

Each utility source is allocated separately.

3 COMBINE ENERGY FROM ALL SOURCES TO GET FINAL PRODUCT ENERGY

Product	Steam Energy (GJ)	Electricity Energy (GJ)	Final Product Energy (GJ)
A	400	160	560
B	200	240	440
Total Site Energy			1,000 GJ

Final Product Energy = Steam Energy + Electricity Energy (+ Other Sources if any)

Total Site Energy (all sources) = 1,000 GJ

4 CALCULATE POE FOR EACH PRODUCT

POE_i = (Final Product $Energy_i$ / Total Site Energy) × 100

Product	Final Product Energy (GJ)	POE (%)
A	560	(560 / 1,000) × 100 = 56.00%
B	440	(440 / 1,000) × 100 = 44.00%
Total	1,000	100.00%

Total POE = 100% and all energy is fully allocated.

5 CALCULATE SPECIFIC ENERGY CONSUMPTION (SEC)

SEC_i = Allocated $Energy_i$ / Production $Quantity_i$

Product	Final Product Energy (Allocated Energy, GJ)	Production Quantity (tonne)	SEC (GJ/tonne) = Energy / Quantity
A	560	100	560 / 100 = 5.60
B	440	50	440 / 50 = 8.80
Total / Avg	1,000	150	—

6 RESULTS SUMMARY

POE and SEC for the current month

Product	POE (%)	Allocated Energy (GJ)	Production (tonne)	SEC (GJ/tonne)
Product A	56.00%	560	100	5.60
Product B	44.00%	440	50	8.80
TOTAL / AVG	100.00%	1,000	150	—

AT A GLANCE

Total Site Energy (All Sources)	1,000 GJ
Steam Energy	600 GJ
Electricity Energy	400 GJ
POE_A / POE_B	56.00% / 44.00%
SEC_A / SEC_B (GJ/tonne)	5.60 / 8.80

WHEN TO USE

- ✔ When a utility (e.g. steam, fuel, chilled water) is the dominant energy driver.
- ✔ When utility meters are available for each product/process.
- ✔ When allocation based on utility consumption represents actual energy usage.

BEST PRACTICES

- Allocate each major energy source separately.
- Use accurate conversion factors for energy (e.g. t steam to GJ).
- Include all significant energy sources.
- Review allocations periodically.
- Keep supporting documents and calculations.

LIMITATIONS

- Not suitable if utility consumption does not represent total energy use.
- Multiple utilities require separate allocation and good data quality.
- Shared utilities and common facility energy must be treated properly.
- Changes in process or equipment may affect utility-to-energy efficiency.

TIPS

- ✔ Validate utility data against bills and trends.
- ✔ Use energy audit data to support allocation.
- ✔ Document assumptions and methodology.
- ✔ Verify POE equals 100% every month.

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METHOD 4 RECIPE / BATCH ENERGY ALLOCATION METHOD

STEP-BY-STEP CALCULATION & VALUES

Energy is estimated based on standard energy requirement per batch (or recipe) and the number of batches (or quantity) produced.

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KEY DEFINITIONS

- E = Energy (GJ)
- EPB = Energy per Batch (GJ/batch)
- POE = Percentage of Energy (%)
- SEC = Specific Energy Consumption (GJ/tonne)
- Q = Production Quantity (tonne or unit)

ABOUT THIS METHOD

This method uses standard energy requirement per batch or recipe, multiplied by the number of batches produced, to estimate the energy used by each product.

STANDARD ENERGY PER BATCH (EPB) × NUMBER OF BATCHES (N) = PRODUCT ENERGY

KEY ADVANTAGES

- Reflects actual process and recipe characteristics
- Suitable for batch and recipe-based industries
- Easy to understand and implement
- Supports detailed energy analysis by product

DATA REQUIREMENTS

- Standard energy per batch/recipe
- Number of batches produced
- Recipe or formulation details (if applicable)
- Total site energy (from utility bills or meters)
- Production quantity for SEC calculation

EXAMPLE CALCULATION – RECIPE / BATCH ENERGY ALLOCATION METHOD

1 DETERMINE STANDARD ENERGY PER BATCH (EPB)

From historical data, energy audit, or engineering calculations.

Product	Energy per Batch (EPB) (GJ/batch)
Product A	5.0
Product B	7.0
Product C	3.0

EPB should be reviewed periodically to ensure accuracy.

2 RECORD NUMBER OF BATCHES PRODUCED

For the current reporting month.

Product	Number of Batches Produced (N)
Product A	20
Product B	15
Product C	25

Ensure batch records are complete and validated.

3 CALCULATE PRODUCT ENERGY

Product Energy = EPB × Number of Batches

Product	EPB (GJ/batch)	Batches (N) (batch)	Product Energy (GJ)
Product A	5.0	20	100
Product B	7.0	15	105
Product C	3.0	25	75

Total Product Energy ($\Sigma E_{product}$) = 100 + 105 + 75 = **280 GJ**

4 CALCULATE POE FOR EACH PRODUCT

POE_i = (Product Energy$_i$ / Total Product Energy) × 100

POE_A = (100 / 280) × 100 = **35.71%**

POE_B = (105 / 280) × 100 = **37.50%**

POE_C = (75 / 280) × 100 = **26.79%**

5 VERIFY TOTAL POE

Sum of POE for all products must equal 100%.

Total POE = 35.71% + 37.50% + 26.79% = 100.00%

= 100.00%

All energy has been fully allocated to the products.

6 CALCULATE ALLOCATED ENERGY FOR EACH PRODUCT

Allocated Energy$_i$ = Total Site Energy × POE_i / 100

Assume Total Site Energy for the month = 1,200 GJ

Product	POE (%)	Allocated Energy (GJ) = 1,200 × POE / 100
Product A	35.71%	428.57
Product B	37.50%	450.00
Product C	26.79%	321.43
TOTAL	100.00%	1,200.00

Allocated energy equals total site energy (1,200 GJ).

7 CALCULATE SPECIFIC ENERGY CONSUMPTION (SEC)

SEC_i = Allocated Energy$_i$ / Production Quantity$_i$

Product	Allocated Energy (GJ)	Production Quantity (Q) (tonne)	SEC (GJ/tonne)
Product A	428.57	100	4.29
Product B	450.00	50	9.00
Product C	321.43	80	4.02

SEC indicates the energy intensity of each product.

8 RESULTS SUMMARY

POE and SEC for the current month

Product	POE (%)	Allocated Energy (GJ)	Production (tonne)	SEC (GJ/tonne)
Product A	35.71%	428.57	100	4.29
Product B	37.50%	450.00	50	9.00
Product C	26.79%	321.43	80	4.02
TOTAL / AVG	100.00%	1,200.00	230	–

POE total = 100% and allocated energy equals total site energy.

AT A GLANCE

Total Site Energy	1,200 GJ
Total Product Energy	280 GJ
POE_A / POE_B / POE_C	35.71% / 37.50% / 26.79%
Allocated Energy (GJ)	A: 428.57 | B: 450.00 | C: 321.43
Production (tonne)	A: 100 | B: 50 | C: 80
SEC (GJ/tonne)	A: 4.29 | B: 9.00 | C: 4.02

BEST PRACTICES

- Develop and maintain accurate standard energy per batch (EPB) values.
- Review EPB periodically based on process changes, efficiency improvements, and audits.
- Maintain complete batch production records.
- Include all relevant utilities in total site energy.
- Document assumptions and calculation methodology.

WHEN TO USE

- When products are produced in batches or recipes.
- When energy usage varies by recipe or batch size.
- When standard energy per batch can be reasonably estimated.
- Ideal for pharmaceutical, food, specialty chemical, and other batch industries.

LIMITATIONS

- Requires reliable standard energy per batch values.
- Inaccurate batch records will lead to incorrect allocation.
- May not suit continuous or mixed production facilities.
- Process changes may require recalibration of EPB.

TIPS

- Validate EPB using actual metered data whenever possible.
- Use historical data trend analysis to refine EPB.
- Consider significant energy users in each batch.
- Verify POE equals 100% every month.

METHOD 5 MULTIPLE REGRESSION ANALYSIS METHOD

STEP-BY-STEP CALCULATION & VALUES

Energy is estimated using a statistical regression model that relates total energy consumption to the production quantities of multiple products.

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KEY DEFINITIONS

- E = Energy (GJ)
- a = Base energy (GJ)
- b_i = Energy intensity coefficient for product i (GJ/tonne)
- P_i = Production quantity of product i (tonne)
- POE_i = Percentage of Energy for product i (%)
- SEC_i = Specific Energy Consumption (GJ/tonne)

ABOUT THIS METHOD

Multiple Regression Analysis uses historical data of total energy consumption and production quantities to statistically estimate the energy intensity (coefficient) of each product and the base energy that is not directly related to production.

TOTAL ENERGY (E) = BASE ENERGY (a) + PRODUCTION-RELATED ENERGY ($\Sigma b_i P_i$)

Best suited for facilities with products sharing common equipment and utilities.

KEY ADVANTAGES

- Accounts for base (non-production) energy
- Uses historical data for objective estimation
- Effective for complex multi-product facilities
- Supports continuous improvement over time

DATA REQUIREMENTS

- At least 12–24 months of historical data
- Monthly total energy consumption (GJ)
- Monthly production quantity for each product
- Data should be screened and validated (remove abnormal months)

EXAMPLE CALCULATION – MULTIPLE REGRESSION ANALYSIS METHOD

1 REGRESSION MODEL RESULT

From statistical analysis of 24 months of data, the following regression model is obtained:

$$E = 250 + 4P_A + 6P_B + 10P_C$$

Where:

- 250 = Base energy (GJ)
- 4, 6, 10 = Energy intensity coefficients (GJ/tonne)
- P_A, P_B, P_C = Production quantity (tonne)

Model statistics:
$R^2 = 0.92$ | p-value < 0.01
Model is statistically significant.

2 CURRENT MONTH PRODUCTION DATA

Product	Production, P_i (tonne)
Product A (A)	100
Product B (B)	50
Product C (C)	20
Total Production	170

Use actual production for the reporting month.

3 CALCULATE PRODUCTION ENERGY ($b_i \times P_i$)

Product	Coefficient (GJ/tonne)	Production (tonne)	Production Energy (GJ) = $b_i \times P_i$
A	4	100	400
B	6	50	300
C	10	20	200
Total Production Energy ($\Sigma b_i P_i$)			900 GJ

This is the energy directly related to production.

4 ALLOCATE BASE ENERGY TO PRODUCTS

Base Energy (a) = 250 GJ

Allocate proportionally based on production energy share.

Product	Share of Production Energy (%)	Allocated Base Energy (GJ)
A	400 / 900 = 44.44%	111.11
B	300 / 900 = 33.33%	83.33
C	200 / 900 = 22.22%	55.56
Total Allocated Base Energy		250.00 GJ

Share (%) = $(b_i P_i / \Sigma b_i P_i) \times 100$

5 CALCULATE FINAL PRODUCT ENERGY

Final Product Energy = Production Energy + Allocated Base Energy

Product	Production Energy (GJ)	Allocated Base Energy (GJ)	Final Product Energy (GJ)
A	400	111.11	511.11
B	300	83.33	383.33
C	200	55.56	255.56
Total Final Product Energy			1,150.00 GJ

Check: 250 (base) + 900 (production) = 1,150 GJ (matches model prediction)

6 CALCULATE POE FOR EACH PRODUCT

POE_i = (Final Product Energy$_i$ / Total Site Energy) × 100

Product	Final Product Energy (GJ)	POE_i (%)
A	511.11	44.44%
B	383.33	33.33%
C	255.56	22.22%
Total	1,150.00	100.00%

Sum of POE must equal 100%.
(Minor difference due to rounding is acceptable.)

7 CALCULATE SPECIFIC ENERGY CONSUMPTION (SEC)

SEC_i = Allocated Energy$_i$ / Production Quantity$_i$

Product	Allocated Energy (Final Product Energy, GJ)	Production (tonne)	SEC_i (GJ/tonne)
A	511.11	100	5.11
B	383.33	50	7.67
C	255.56	20	12.78

SEC indicates the energy intensity of each product.

8 RESULTS SUMMARY

POE and SEC for the current month

Product	POE (%)	Allocated Energy (GJ)	Production (tonne)	SEC (GJ/tonne)
A	44.44%	511.11	100	5.11
B	33.33%	383.33	50	7.67
C	22.22%	255.56	20	12.78
TOTAL / AVG	100.00%	1,150.00	170	–

Total Site Energy (from bills) = 1,150 GJ

AT A GLANCE

Regression Model	$E = 250 + 4P_A + 6P_B + 10P_C$
Base Energy (a)	250 GJ
Production Energy ($\Sigma b_i P_i$)	900 GJ
Total Site Energy (E)	1,150 GJ
POE_A / POE_B / POE_C	44.44% / 33.33% / 22.22%
Allocated Energy (GJ)	A: 511.11 | B: 383.33 | C: 255.56
Production (tonne)	A: 100 | B: 50 | C: 20
SEC (GJ/tonne)	A: 5.11 | B: 7.67 | C: 12.78

BEST PRACTICES

- Use at least 12–24 months of good quality data.
- Remove abnormal months (shutdown, maintenance, etc.).
- Check model assumptions and statistical indicators (R^2, p-value).
- Rebuild the model periodically as process changes.
- Document methodology, assumptions and data sources.

WHEN TO USE

- When products share common equipment and utilities.
- When direct measurement or allocation methods are not available.
- When sufficient historical data exists.

LIMITATIONS

- Requires sufficient and good quality historical data.
- Does not represent physical allocation; it is a statistical estimate.
- Accuracy depends on stability of process and data.
- Model may need to be updated if major changes occur.

TIPS

- Validate the model with recent data.
- Compare SEC trends with benchmarks and engineering judgement.
- Support the model with process knowledge.
- Verify POE equals 100% every month.

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METHOD 6 OPERATING HOURS ALLOCATION METHOD

STEP-BY-STEP CALCULATION & VALUES

Energy is allocated to products based on the operating hours of major equipment or production lines used by each product.

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KEY DEFINITIONS

E	=	Energy (GJ)
OH	=	Operating Hours (h)
POE	=	Percentage of Energy (%)
SEC	=	Specific Energy Consumption (GJ/tonne)
Q	=	Production Quantity (tonne)

ABOUT THIS METHOD

This method allocates total energy based on the proportion of operating hours that major equipment or production lines are used for each product.

OPERATING HOURS (h) × AVERAGE POWER DEMAND (kW) = ENERGY (kWh or GJ)

Suitable when submetering or detailed energy data are not available. Lowest accuracy among the methods.

KEY ADVANTAGES

- Simple and easy to implement
- Requires minimal data
- Useful when detailed measurements are not available
- Can be applied to any facility

DATA REQUIREMENTS

- Operating hours for each product (on equipment or line basis)
- Total site energy consumption (from utility bills or meters)
- Production quantity for each product (for SEC calculation)
- List of major equipment/lines (if allocation is done at equipment level)

EXAMPLE CALCULATION – OPERATING HOURS ALLOCATION METHOD

1 RECORD OPERATING HOURS FOR EACH PRODUCT

Operating hours of the main production line/equipment used by each product for the current month.

Product	Operating Hours (h)
Product A (Line 1)	120
Product B (Line 1)	60
Product C (Line 1)	40
TOTAL	220

Ensure operating hours are accurate and validated.

2 CONFIRM TOTAL SITE ENERGY

Total energy consumption for the current month (from utility bills or meters).

Total Site Energy (E_{total}) = 1,100 GJ

Include all energy sources (electricity, steam, fuel, etc.).

3 CALCULATE POE FOR EACH PRODUCT

POE_i = (Operating Hours$_i$ / Total Operating Hours) × 100

POE_A = (120 / 220) × 100 = **54.55%**

POE_B = (60 / 220) × 100 = **27.27%**

POE_C = (40 / 220) × 100 = **18.18%**

Sum of POE for all products must equal 100%.

4 CALCULATE ALLOCATED ENERGY FOR EACH PRODUCT

Allocated Energy$_i$ = Total Site Energy × POE_i

Product	POE (%)	Allocated Energy (GJ)
Product A	54.55%	1,100 × 54.55% = 600.05
Product B	27.27%	1,100 × 27.27% = 300.00
Product C	18.18%	1,100 × 18.18% = 199.95
TOTAL	100.00%	1,100.00

Minor differences due to rounding are acceptable.

5 VERIFY TOTAL POE

Sum of POE for all products must equal 100%.

Total POE = 54.55% + 27.27% + 18.18% = 100.00%

= 100.00%

All energy has been fully allocated to the products.

6 CALCULATE SPECIFIC ENERGY CONSUMPTION (SEC)

SEC_i = Allocated Energy$_i$ / Production Quantity$_i$

Product	Allocated Energy (GJ)	Production Quantity (tonne)	SEC (GJ/tonne)
A	600.05	100	6.00
B	300.00	50	6.00
C	199.95	20	10.00
TOTAL / AVG	1,100.00	170	–

SEC indicates the energy intensity of each product.

7 RESULTS SUMMARY

POE and SEC for the current month

Product	POE (%)	Allocated Energy (GJ)	Production (tonne)	SEC (GJ/tonne)
Product A	54.55%	600.05	100	6.00
Product B	27.27%	300.00	50	6.00
Product C	18.18%	199.95	20	10.00
TOTAL / AVG	100.00%	1,100.00	170	–

Total POE = 100% and allocated energy equals total site energy.

AT A GLANCE

Total Site Energy (E_{total})	1,100 GJ
Total Operating Hours	220 h
POE_A / POE_B / POE_C	54.55% / 27.27% / 18.18%
Allocated Energy (GJ)	A: 600.05 | B: 300.00 | C: 199.95
Production (tonne)	A: 100 | B: 50 | C: 20
SEC (GJ/tonne)	A: 6.00 | B: 6.00 | C: 10.00

IMPORTANT REMINDERS

- Use actual operating hours as far as possible.
- Include all major equipment/lines used for production.
- Consistent method is key for comparability.
- Review assumptions and update periodically.
- Verify POE equals 100% every month.

BEST PRACTICES

- Maintain daily or weekly operating hour logs.
- Use automated systems or DCS data where available.
- Cross-check hours with production records.
- Document assumptions and allocation basis.
- Review allocation when process changes occur.

WHEN TO USE

- When submetering is not available.
- When energy usage is proportional to equipment operating time.
- For simple processes with similar load during operation.
- As a fallback method with clear documentation.

LIMITATIONS

- Assumes energy use is proportional to operating time.
- Does not consider load variation during operation.
- Less accurate for processes with frequent start/stop or variable loads.
- Not suitable for equipment with standby or idle energy differences.

TIPS

- Group similar equipment to improve accuracy.
- Consider load factors if significant variation exists.
- Validate results with other methods periodically.
- Use higher ranking methods when data becomes available.

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