

# Ninety Per Cent Twice Leaves Eighty-One

— Charging at **0.90** and discharging at **0.90** gives a round-trip of **0.8100**, with losses **1.9000** times the one-way figure — six stages at **0.85** leave **0.3771** — the quoted efficiency is one-way, not round-trip — [Paper 459]

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— *From thinking to syncing.* —

## Abstract

A battery quoted at 90 per cent is taken to lose only 10. This paper shows that a round trip loses 19—the loss is **1.9000** times the one-way figure, which is the closed form  $1 + \eta$ . No new theorem or law is claimed. First, 0.90 and 0.90 give a round-trip of **0.810000000000** (Section 2). Second, the round-trip loss is **1.9000** times the one-way, not twice (Section 2). Third, this is the core of the paper. Adding stages costs exponentially—six stages at 0.95 give 0.7351, at 0.85 give **0.3771** (Section 3). Fourth, at 0.90 the halving point is **6.5788** stages, and the count drops below at the seventh (Section 3). Fifth, one-way and round-trip differ by **9.0000** points (Section 2). Sixth, the separator is whether the passage is one-way or a round trip (Section 4). **Keywords:** round-trip efficiency, battery storage, conversion efficiency, product of efficiencies.

Scope of this paper (scope note): No new theorem or law is claimed—round-trip efficiency and the product of efficiencies in series are entirely standard. No battery is designed—chemistry, internal resistance, degradation and thermal management are not the subject. No product is discussed—0.90 and 0.85 are representative, not measured. No grid is discussed—balancing, transmission and tariffs are not the subject. No economics is treated—cost effectiveness and payback are not the subject; only the product of efficiencies. Relation to earlier papers: Paper 458 showed that the lift coefficient acts only through a square root—there too, an exponent defeated intuition. Paper 300 showed that common root and distinct root can be decided—“one-way efficiency” and “round-trip efficiency” are distinct roots by that criterion. Paper 446 showed that a floor moves with the demand—there too, a quantity stated without its condition misled. What is added is giving the round trip for three one-way efficiencies, giving the loss ratio as 1.9000 and matching it to the closed form  $1 + \eta$ , rejecting the wrong closed form  $2 - \eta$ , giving the six-stage values as 0.7351 and 0.3771, confirming the halving point by closed form and by counting, and placing the separator at one-way versus round trip.

# 1. Notation and the Question

Setting: A store with charging efficiency  $\eta_c$  and discharging efficiency  $\eta_d$  has round-trip efficiency

$$\eta_{rt} = \eta_c \eta_d$$

and  $n$  conversions of the same efficiency  $\eta$  in series give

$$\eta_n = \eta^n$$

Below,  $\eta$  is the one-way efficiency and  $\eta_c = \eta_d = \eta$ .

### Observation 1.1

A battery quoted at 90 per cent is taken to lose only 10. That is the number on the datasheet—and it is the natural reading.

### Observation 1.2

But electricity goes in and comes out. To be used, it passes twice—a one-way number is being read as a round-trip one.

Question: By how much do they differ.

## 2. A Round Trip Multiplies the Loss by 1.9000

Computation 2.1: Take the round trip for three one-way efficiencies.

| One-way | Round trip    |
|---------|---------------|
| 0.95    | 0.9025        |
| 0.90    | <b>0.8100</b> |
| 0.85    | 0.7225        |

#### Observation 2.2

0.90 and 0.90 give **0.810000000000.9.0000** points below the one-way figure—a 10 per cent loss becomes 19.

#### Observation 2.3

The loss is **1.9000** times the one-way, not twice. Losing twice does not double it—because the second loss falls only on what survived the first.

#### Observation 2.4

The closed form is  $1 + \eta(1 - \eta^2)/(1 - \eta) = 1 + \eta$ —giving 1.9000 at  $\eta = 0.90$ , matching the numerical value exactly.

#### Observation 2.5

I first wrote this as  $2 - \eta$  and was wrong.  $2 - 0.90 = 1.10$ , far from the computed 1.90—the test caught it, and a test that rejects the wrong closed form is now in place.

### 3. Adding Stages Costs Exponentially

Computation 3.1: Take the value for six stages of the same efficiency.

| One-way | 2 stages | 4 stages | 6 stages      |
|---------|----------|----------|---------------|
| 0.95    | 0.9025   | 0.8145   | <b>0.7351</b> |
| 0.85    | 0.7225   | 0.5220   | <b>0.3771</b> |

#### Observation 3.2

At 0.95, six stages still hold **0.7351**. Five per cent lost per stage—only 26.5 per cent lost over six.

### Observation 3.3

At 0.85, six stages fall to **0.3771**. Below half—a one-way gap of 10 points opens to 36 over six stages.

Computation 3.4: Take the number of stages that halves 0.90, by closed form and by counting.

The closed form gives  $\log 0.5 / \log 0.90 = \mathbf{6.5788}$ ; counting drops below at the seventh.

### Observation 3.5

The two agree.  $6 \leq 6.5788 \leq 7$ —the continuous answer brackets the discrete one correctly.

### Observation 3.6

So efficiency cannot be stated without counting the stages. Generation, transmission, charging, discharging, transmission, use—each called efficient, and the product a different number entirely.

## 4. The Separator

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The separator: one-way, or a round trip.

### Observation 4.1

One-way, and the quoted number applies as it stands. 0.90 means 0.90—it reads like addition.

### Observation 4.2

A round trip, and it becomes multiplication.  $0.90 \times 0.90$ —and with more stages, a power.

### Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “efficiency”—one a property of one stage, one of the whole path.

#### Observation 4.4

This stands where Paper 458 stands. There, the coefficient acted only through a square root—here efficiency acts through a power. In both, missing the exponent means misreading the quantity.

#### Observation 4.5

It overlaps Paper 446 as well. There, “how many times the floor” was undetermined without the recovery—here, “90 per cent efficient” is undetermined without the number of stages.

#### Observation 4.6

So when efficiencies are compared, align the boundaries. From where to where was counted—the same device reads 0.90 or 0.81 depending on that choice.

#### Observation 4.7

To be honest—0.90 and 0.85 are representative. Real values move with chemistry, current, temperature and age—but the conclusion that the product is a power does not depend on the values.

## 5. Roll Call and Closing

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1. 0.90 round trip is 0.810000000000 (Computation 2.1): 9.0000 points down.
2. The loss is 1.9000 times (Observation 2.3): not twice.
3. The closed form is  $1 + \eta$  (Observation 2.4): exact agreement.
4.  $2 - \eta$  was my error (Observation 2.5): the test caught it.
5. Six stages at 0.95 give 0.7351 (Computation 3.1): the core.
6. At 0.85 they give 0.3771 (Computation 3.1): below half.
7. 10 points become 36 (Observation 3.3): the gap opens.
8. Halving at 6.5788 stages (Computation 3.4): the seventh by count.
9. The separator is one-way or round trip (Observation 4.3): distinct roots by Paper 300.

10. Align the boundaries (Observation 4.6): **0.90** or **0.81** for one device.

Closing: A battery quoted at 90 per cent is taken to lose only 10—that is the number on the datasheet, and it is the natural reading. But electricity goes in and comes out: to be used it passes twice, so a one-way number is being read as a round-trip one. A round trip nearly doubles the loss—0.90 and 0.90 give **0.810000000000**, **9.0000** points below the one-way figure, so a 10 per cent loss becomes 19. The loss is **1.9000** times the one-way and not twice, because the second loss falls only on what survived the first. The closed form is  $(1 - \eta^2)/(1 - \eta) = 1 + \eta$ , giving 1.9000 at  $\eta = 0.90$  and matching exactly. I first wrote this as  $2 - \eta$  and was wrong:  $2 - 0.90 = 1.10$  is far from the computed 1.90. The test caught it, and a test that rejects the wrong closed form is now in place. And adding stages costs exponentially—at 0.95 six stages still hold **0.7351**, losing only 26.5 per cent. At 0.85 they fall to **0.3771**, below half: a one-way gap of 10 points opens to 36 over six stages. 0.90 halves at **6.5788** stages by closed form and at the seventh by counting, so the continuous answer brackets the discrete one correctly. So efficiency cannot be stated without counting the stages—generation, transmission, charging, discharging, transmission and use are each called efficient, and the product is a different number entirely. One thing separates them—one-way, or a round trip. One-way, and the quoted number applies as it stands: 0.90 means 0.90, and it reads like addition. A round trip, and it becomes multiplication, and with more stages a power. They are distinct roots by the criterion of Paper 300, one a property of one stage and one of the whole path. This stands where Paper 458 stands, where the coefficient acted only through a square root: in both, missing the exponent means misreading the quantity. It overlaps Paper 446 too, where “how many times the floor” was undetermined without the recovery: here “90 per cent efficient” is undetermined without the number of stages. So when efficiencies are compared, align the boundaries—the same device reads 0.90 or 0.81 depending on where the counting starts and stops. To be honest—0.90 and 0.85 are representative, and real values move with chemistry, current, temperature and age. But the conclusion that the product is a power does not depend on the values.

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