Simple Payback is Too Simple for the Task

PhiusCon 2025

October 8, 2025

Who is Steve Hennigan?

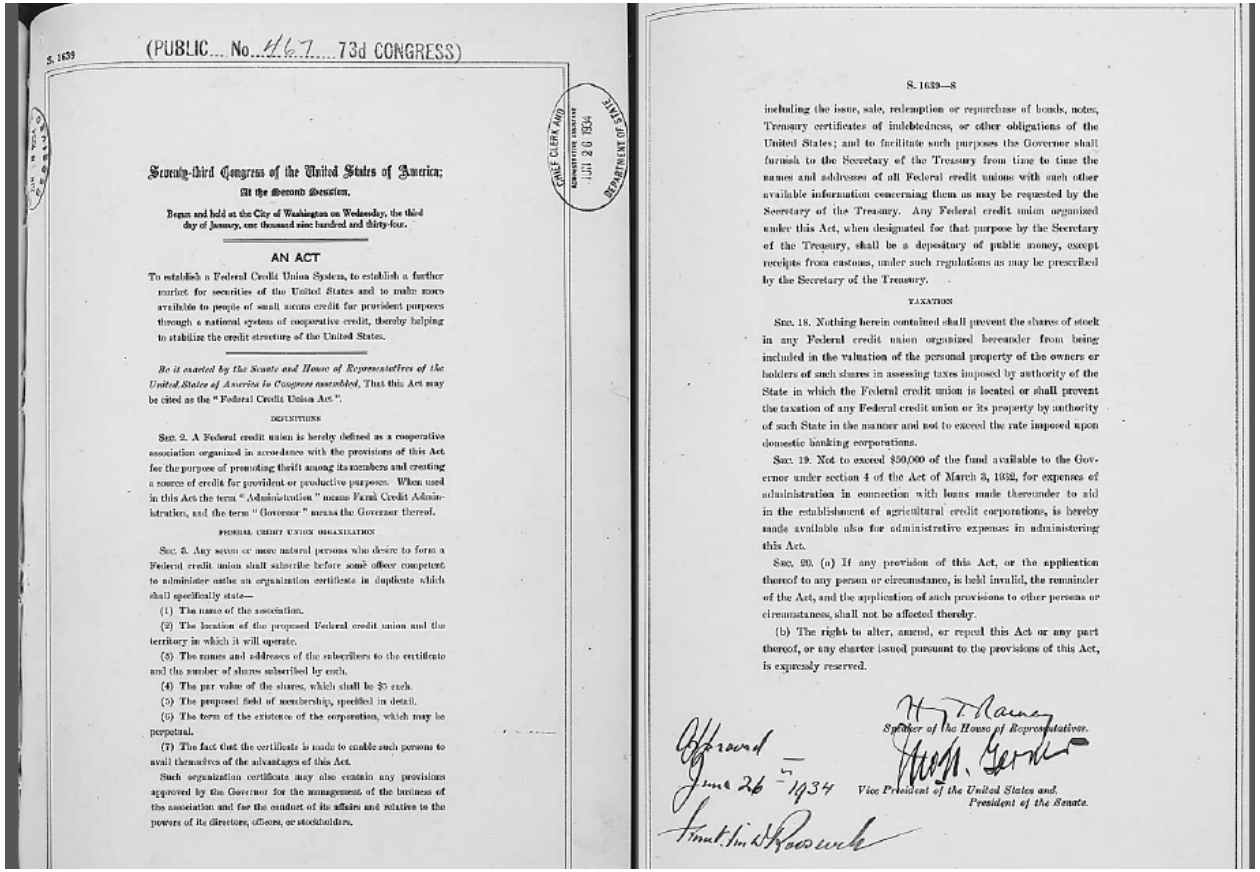
- I grew up in **New Orleans** in the 1960s and 70s—a time and place that taught me about systems long before I had that language: social, economic, and environmental systems all colliding in real life.
- I was educated in Catholic schools, where the Lasallian and Marianist traditions shaped my sense of purpose more than doctrine ever did. My Jesuit friends would say I'm a **Catholic in mystery:** I see vocation as **purpose, not duty**.
- I wanted to be a **physicist** but switched to **finance** when I realized biology wasn't my thing—at least not then. That shift led me to understand how human systems behave, and I eventually studied **system dynamics** at MIT to explore the same patterns I had first seen in nature and society.
- For the past three decades, I've worked in **financial services**. For over ten years, I served on the board of San Antonio's electric and gas utility, where we **pushed for one of the nation's most renewable portfolios**. That experience solidified my conviction that **money** is a human construct, **powerful only because we allow it to be**.
- Today, my family lives in a **net-zero home** that uses the **rain, sun, and earth** to sustain us—proof that biology and physics finally made sense to me.
- And I come here as **a student** of your field, not an expert. **Thank you for the invitation**—and for your patience if I fall short of your expectations.

To begin, some context from the finance industry is in order.

The Book of Genesis about the U.S. credit union system

There are clear artifacts that demonstrate a dynamic shift in the social mission since the 1934 Federal Credit Union Act (FCUA) that is relevant to your situation.

In 1934, the social mission was defined as "people of small means" in the eight-page law with a "single" paragraph on supervision and financial reporting.



S. 1639

(PUBLIC... No. 467 ... 73d CONGRESS)

Seventy-third Congress of the United States of America;
At the Second Session,

Begun and held at the City of Washington on Wednesday, the third day of January, one thousand nine hundred and thirty-four.

CHIEF CLERK AND ADMINISTRATIVE ASSISTANT JUN 26 1934 DEPARTMENT OF STATE

AN ACT

To establish a Federal Credit Union System, to establish a further market for securities of the United States and to make more available to people of small means credit for provident purposes through a national system of cooperative credit, thereby helping to stabilize the credit structure of the United States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Federal Credit Union Act".

DEFINITIONS

SEC. 2. A Federal credit union is hereby defined as a cooperative association organized in accordance with the provisions of this Act for the purpose of promoting thrift among its members and creating a source of credit for provident or productive purposes. When used in this Act the term "Administration" means Farm Credit Administration, and the term "Governor" means the Governor thereof.

FEDERAL CREDIT UNION ORGANIZATION

SEC. 3. Any seven or more natural persons who desire to form a Federal credit union shall subscribe before some officer competent to administer oaths an organization certificate in duplicate which shall specifically state—

(1) The name of the association.

(2) The location of the proposed Federal credit union and the territory in which it will operate.

(3) The names and addresses of the subscribers to the certificate and the number of shares subscribed by each.

(4) The par value of the shares, which shall be $5 each.

(5) The proposed field of membership, specified in detail.

(6) The term of the existence of the corporation, which may be perpetual.

(7) The fact that the certificate is made to enable such persons to avail themselves of the advantages of this Act.

Such organization certificate may also contain any provisions approved by the Governor for the management of the business of the association and for the conduct of its affairs and relative to the powers of its directors, officers, or stockholders.

S. 1639—8

including the issue, sale, redemption or repurchase of bonds, notes, Treasury certificates of indebtedness, or other obligations of the United States; and to facilitate such purposes the Governor shall furnish to the Secretary of the Treasury from time to time the names and addresses of all Federal credit unions with such other available information concerning them as may be requested by the Secretary of the Treasury. Any Federal credit union organized under this Act, when designated for that purpose by the Secretary of the Treasury, shall be a depository of public money, except receipts from customs, under such regulations as may be prescribed by the Secretary of the Treasury.

TAXATION

SEC. 18. Nothing herein contained shall prevent the shares of stock in any Federal credit union organized hereunder from being included in the valuation of the personal property of the owners or holders of such shares in assessing taxes imposed by authority of the State in which the Federal credit union is located or shall prevent the taxation of any Federal credit union or its property by authority of such State in the manner and not to exceed the rate imposed upon domestic banking corporations.

SEC. 19. Not to exceed $50,000 of the fund available to the Governor under section 4 of the Act of March 3, 1932, for expenses of administration in connection with loans made thereunder to aid in the establishment of agricultural credit corporations, is hereby made available also for administrative expenses in administering this Act.

SEC. 20. (a) If any provision of this Act, or the application thereof to any person or circumstance, is held invalid, the remainder of the Act, and the application of such provisions to other persons or circumstances, shall not be affected thereby.

(b) The right to alter, amend, or repeal this Act or any part thereof, or any charter issued pursuant to the provisions of this Act, is expressly reserved.

H. T. Rainey
Speaker of the House of Representatives.

Approved June 26 – 1934

Franklin D. Roosevelt

Vice President of the United States and President of the Senate.

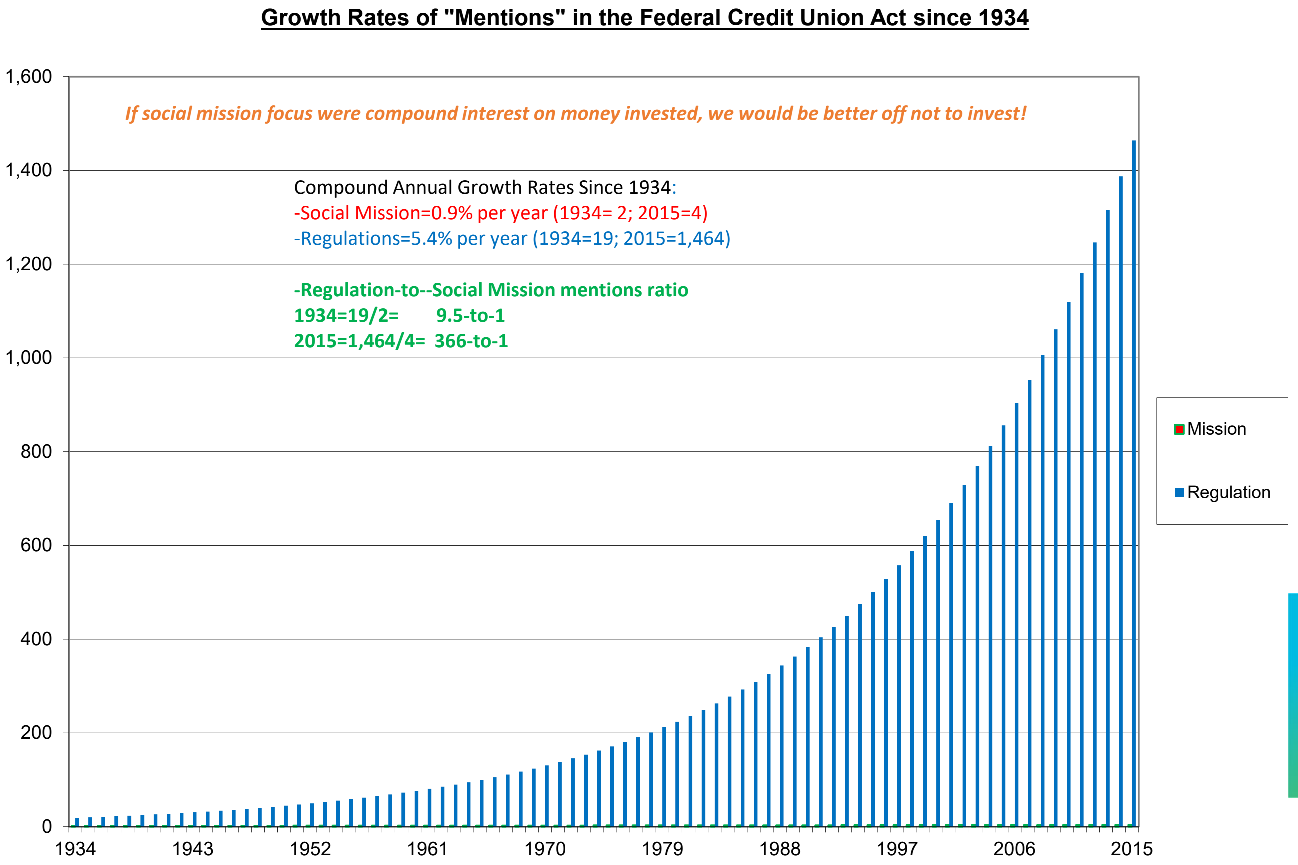
credit human

And then growth (non-linear) happened.

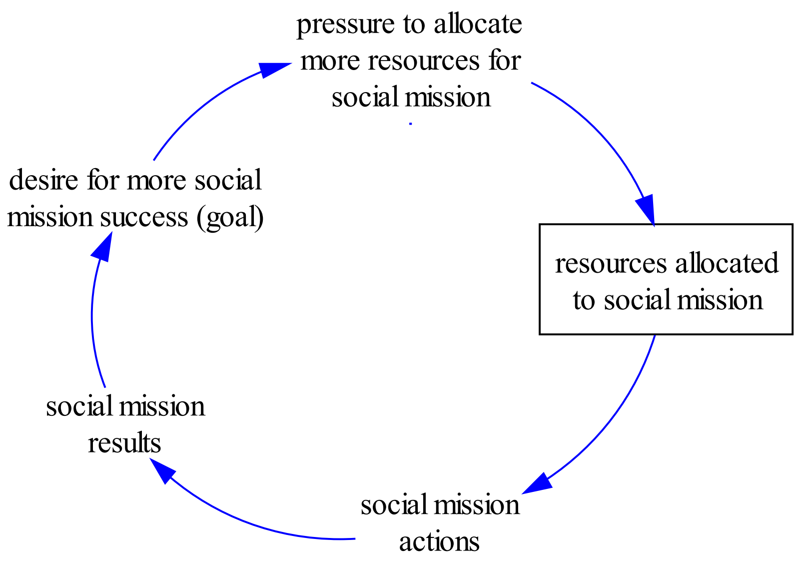
Over the years, the social mission has shifted very little, maintaining its original purpose.

In the 2015 version of the FCUA, the credit union system's "purpose" is listed four (4) times, while mentions of "regulation" occur 1,464 times in the current version of the 115-page law.

As of 2015, the "regulation-to-purpose" ratio word mentions has moved from 9-to-1 in 1934 to 366-to-1 over the 81 years.



The basic structure of internally derived resource allocation of federal credit unions between social mission and economic performance

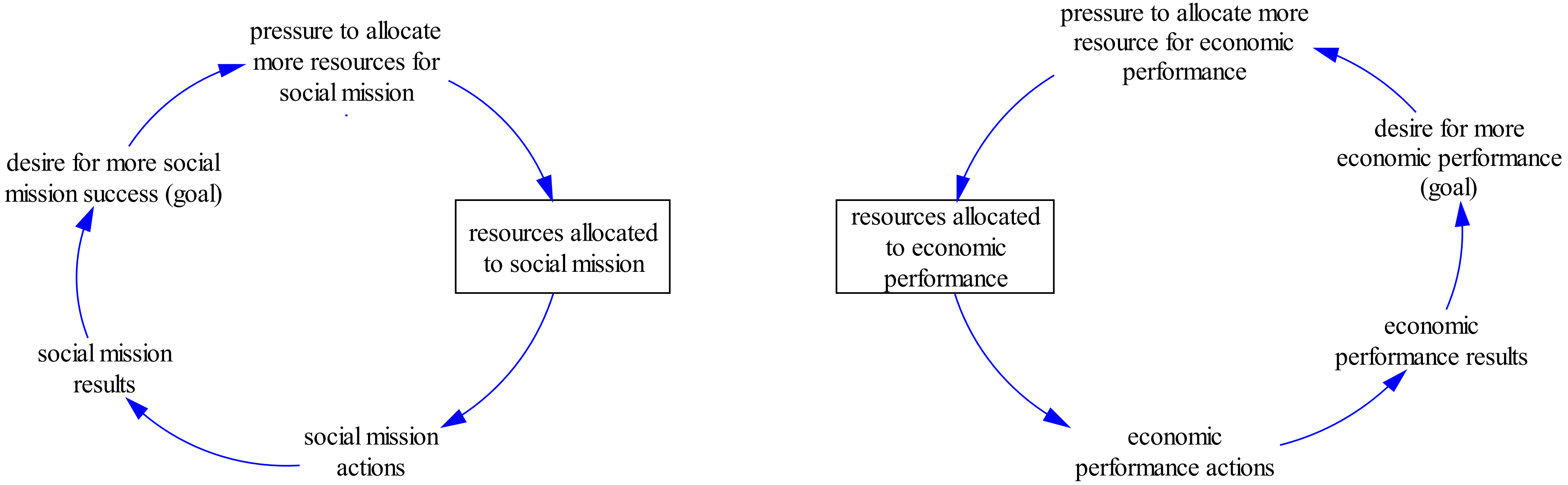


This is the primary, self-reinforcing causal loop, which in this case means the desire for success leads to allocating resources and taking action to realize results. As results are achieved, there is more desire, which will increase the goal and resources.

In other words, as success is realized, more success is desired such that the goal, resources, and results all grow in the same upward direction.

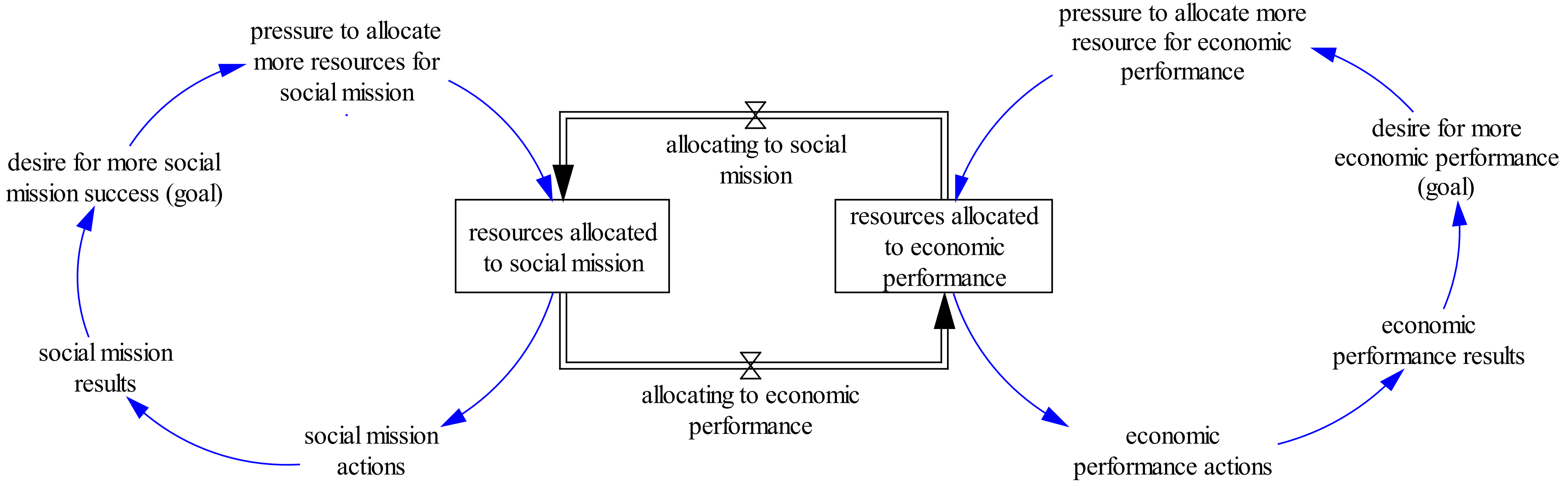
credit human

The basic structure of internally derived resource allocation of federal credit unions between social mission and economic performance



Economic (financial) performance is also an example of a reinforcing loop in which success drives toward greater success, such that growth of the goal and the results reinforce each other.

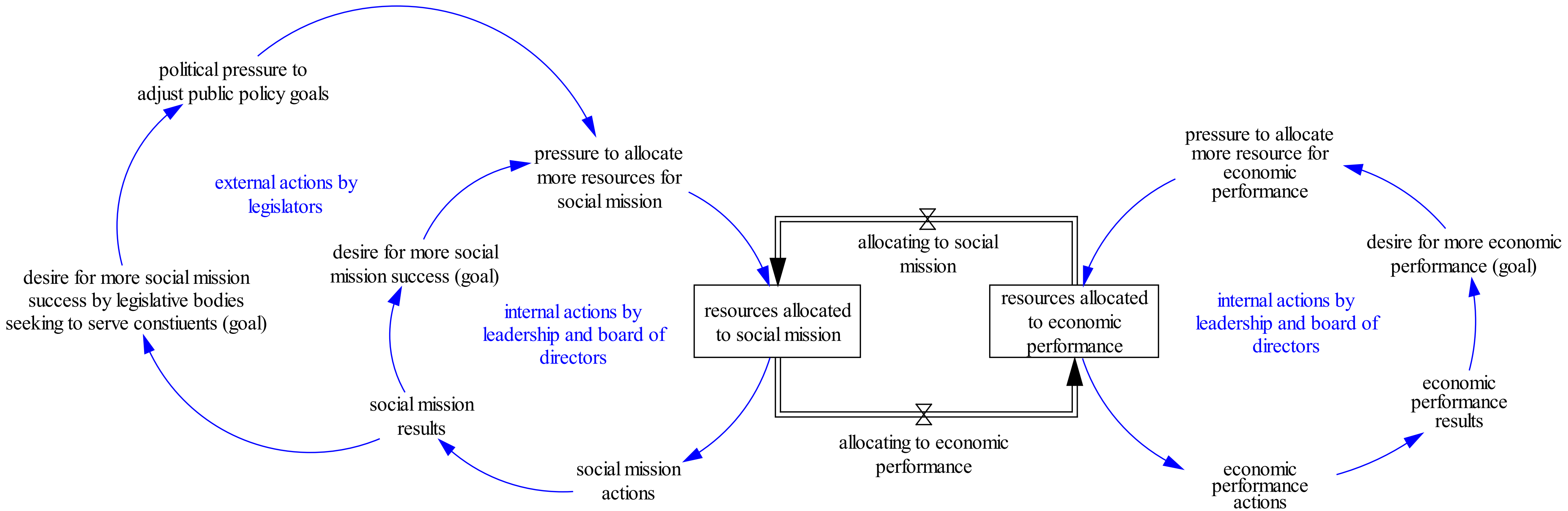
The basic structure of internally derived resource allocation of federal credit unions between social mission and economic performance



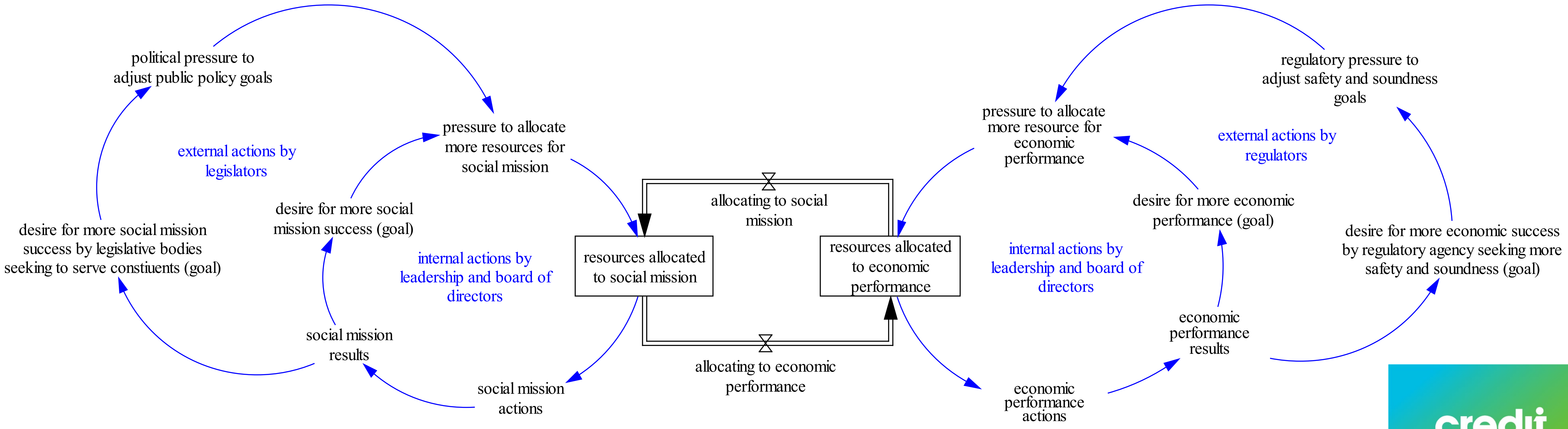
The basic structure within the organization is that there are two reinforcing loops (social mission and financial performance) that compete for resources.

credit human

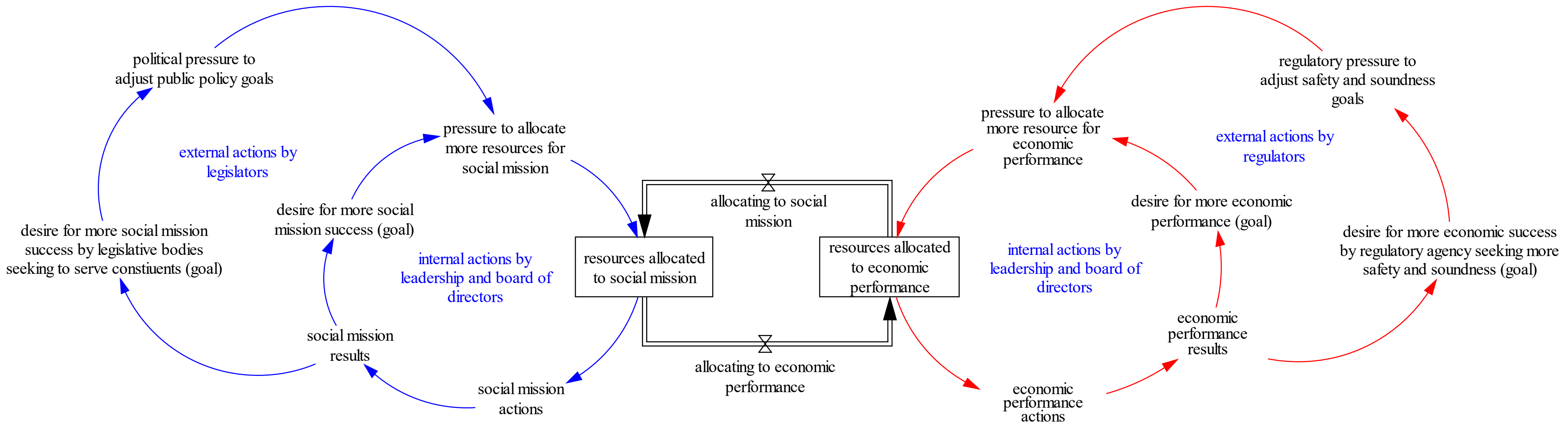
The basic structure of internally derived resource allocation of federal credit unions between social mission and economic performance



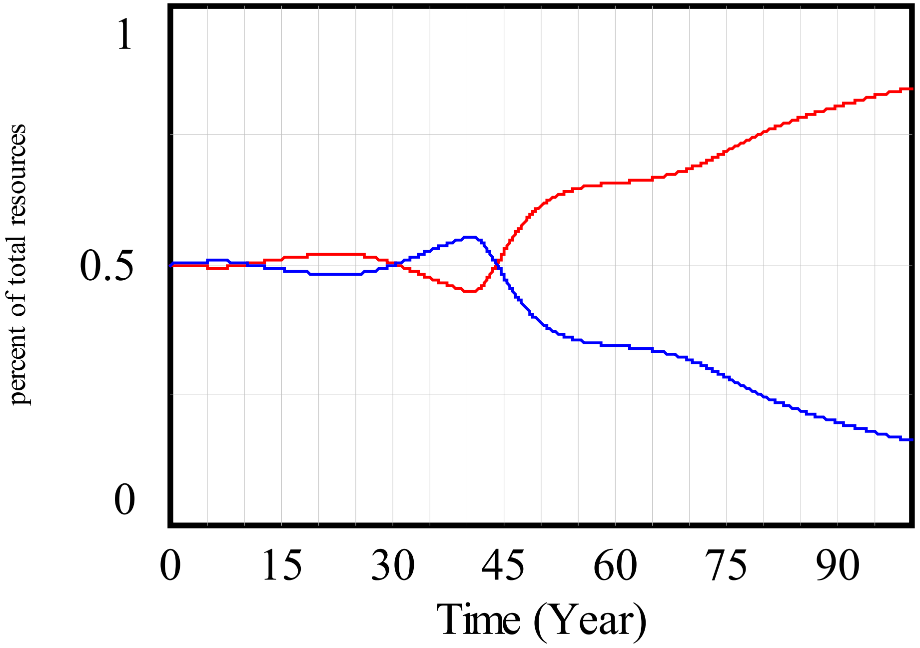
The basic structure of internally derived resource allocation of federal credit unions between social mission and economic performance



credit human

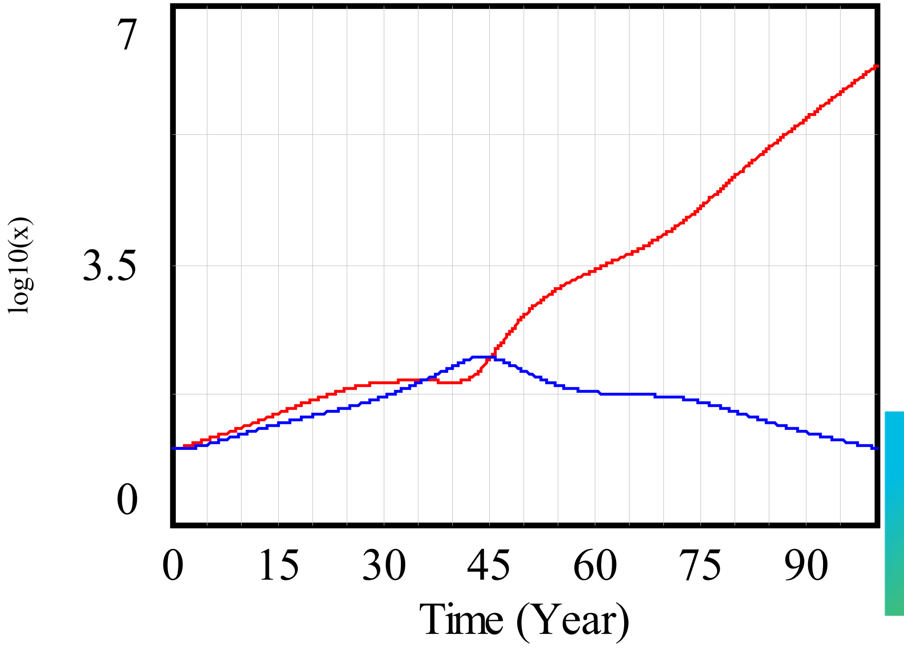


resource allocation percentage



social operations resource fraction : intraorganization-legislative-regulator loops
economic operations resource fraction : intraorganization-legislative-regulator loops

goal performance

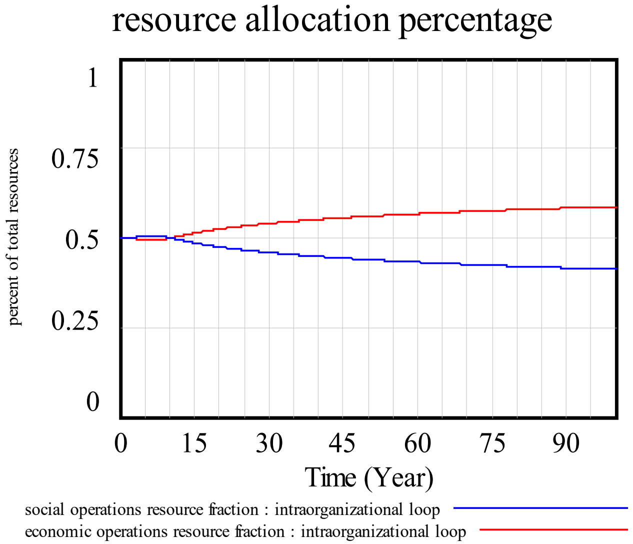


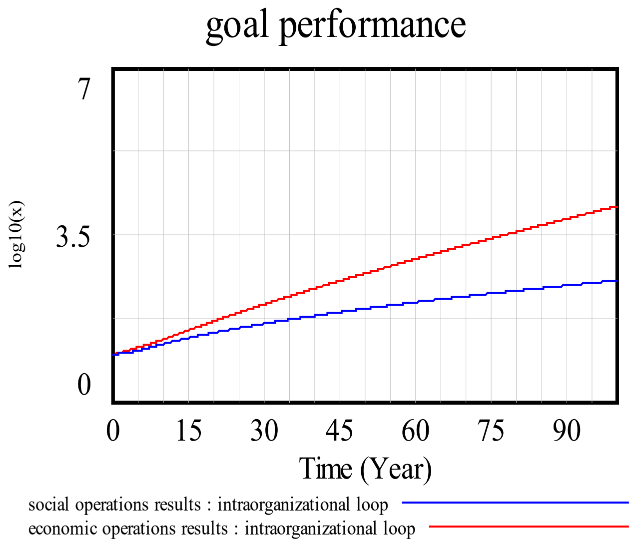
social operations results : intraorganization-legislative-regulator loops
economic operations results : intraorganization-legislative-regulator loops

Goal erosion dynamics at work with regulator loop

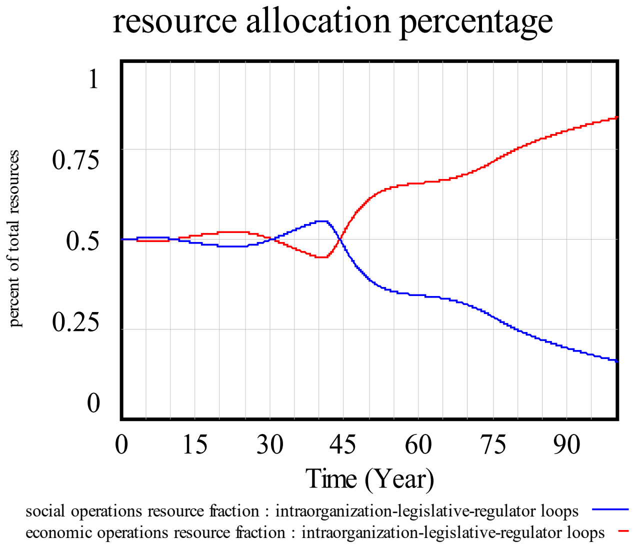
- In the intra-organizational case (top row) the social mission goal (blue) continues to grow, albeit at a slower pace than the economic performance goal (red), as management and the board of directors hold the goals within the organization.
- However, in the intra-organizational-legislative-regulator case (bottom row), the social mission goal initially grows for a period of years; however, then there is a shift as loop dominance occurs with the regulator increasing pressure on safety and soundness, which puts pressure on the credit union's economic performance goal, resulting in greater resource allocation to economic operations. Over time, the social mission goal erodes (bottom right).

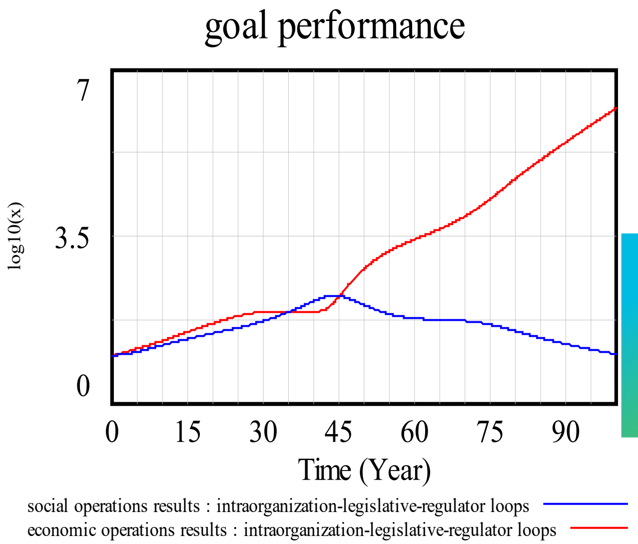
intra-organization case





intra-organization case with legislative and regulator pressures





You'll see the same reinforcing and eroding forces at work in the building industry's relationship with its mission to reduce energy consumption in buildings.

credit human

Let's shift to your environment…growing the paradigm of energy efficiency.

- What forces are acting as a **"foot on the brake"** while you all have your **"foot on the gas?"**
- I believe your industry has at least one **"limits to growth"** dynamic working against you, based upon my experiences with building professionals in the field.
- Let's look at your industry's use of the **"Simple Payback"**

credit human

Simple Payback explained:

$$Simple\ payback\ (years) = \frac{Initial\ capital\ cost}{Annual\ energy\ cost\ savings}$$

Where:

$$Annual\ energy\ cost\ savings = (Baseline\ annual\ energy\ use\ - Design\ annual\ energy\ use)\ x\ Energy\ price$$

This can be simplified as:

$$y = \frac{C}{(b - d)P} = \frac{C}{QP}$$

For the next couple of moments, let's focus on the denominator of **Q and P**

credit human

a “Simple” example

Initial capital cost ($/ft²) = $10
Baseline energy use (kWh/ft²/year) = 20
Design energy use (kWh/ft²/year) = 10
Energy price ($/kWh) = $0.10

Simple payback (years) = 10

$$y = \frac{C}{(b-d)P} = \frac{C}{QP} = \frac{\$10}{(20-10)(\$0.10)} = 10 \text{ years}$$

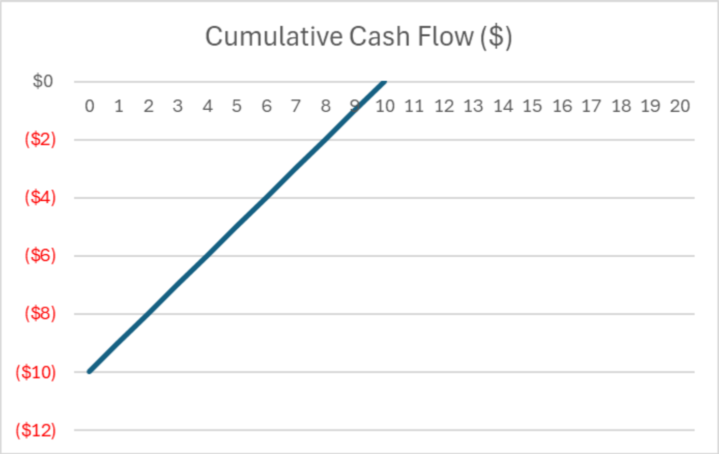
10 years…ok, **what does 10 years mean?**

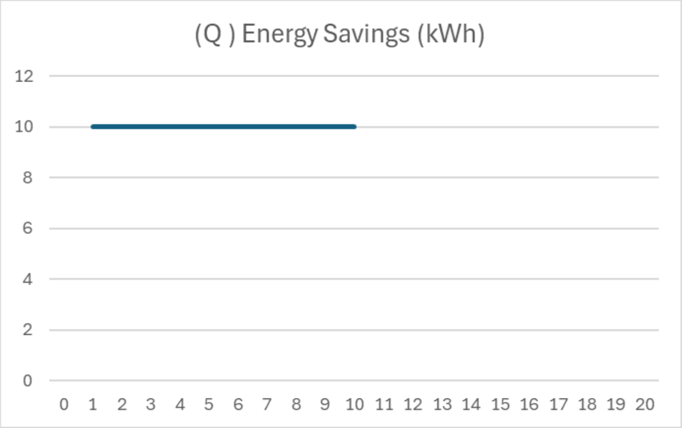
What are the **unexamined implicit assumptions** made by building professionals using this equation?

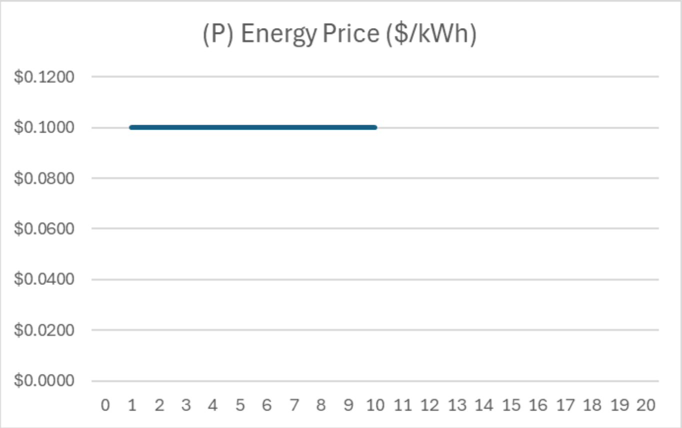
credit human

"Simple's" assumptions revealed

Period	Energy Savings (kWh)	Energy Price ($/kWh)	Cash flow ($)	Cumulative Cash Flow ($)
0			($10)	($10)
1	10	$0.1000	$1	($9)
2	10	$0.1000	$1	($8)
3	10	$0.1000	$1	($7)
4	10	$0.1000	$1	($6)
5	10	$0.1000	$1	($5)
6	10	$0.1000	$1	($4)
7	10	$0.1000	$1	($3)
8	10	$0.1000	$1	($2)
9	10	$0.1000	$1	($1)
10	10	$0.1000	$1	$0







Do you believe that Q and P are static (no change) for the 10-year payback period?

What is the **assumption after 10 years?**

Whatever it is, it is **"not" in the equation.**

credit human

"Simple" leads to under-investment by its own standard

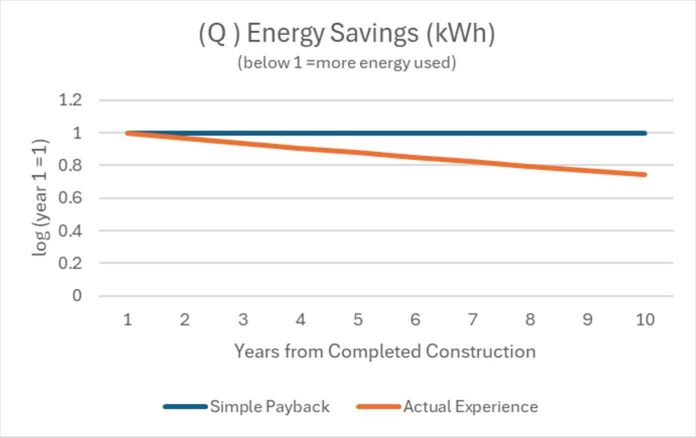
In comparison to one of Credit Human's buildings, **energy efficiency declined while the price of electricity increased** in the first 10 years (and throughout the life of the building)

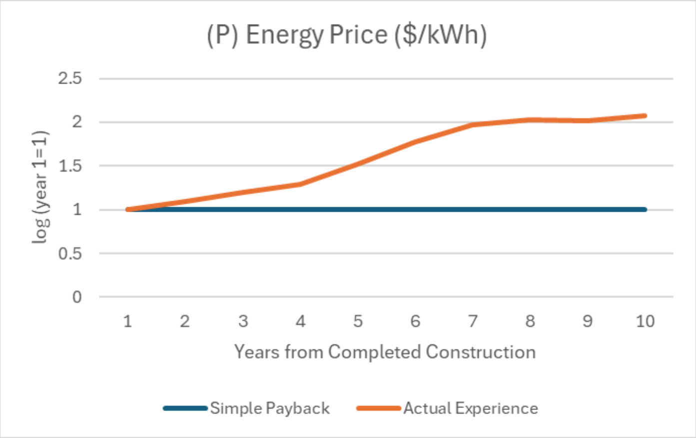
Assumed Payback = 10 years
Actual Payback = **7.75 years**

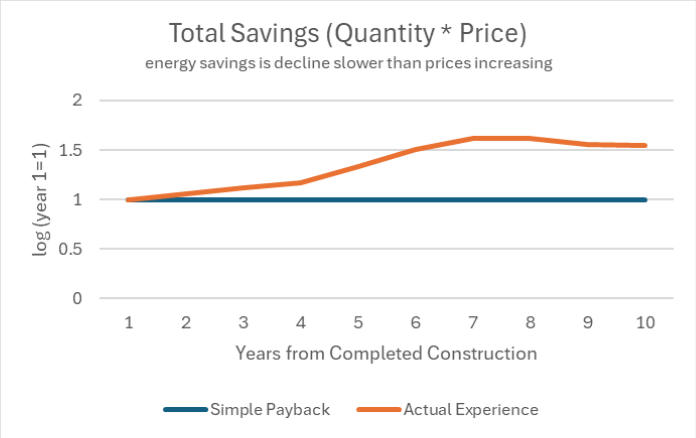
Simple payback **understated the benefit** because energy usage increased more slowly than prices increased.

So, what is really happening?

Answer: Exponential growth and decay



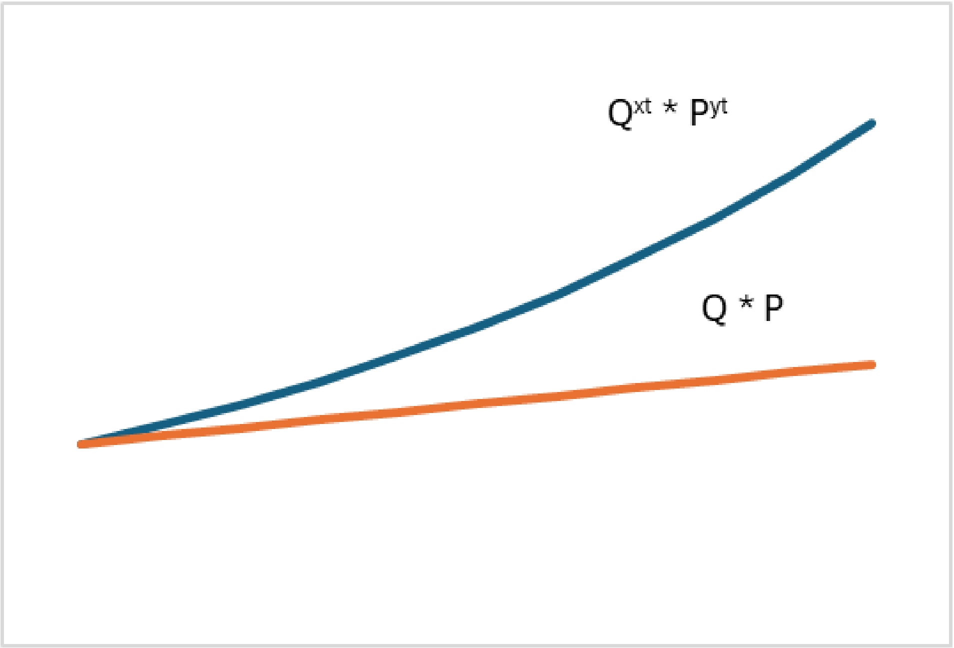




In this case, **underinvestment occurred,** and the **building could have benefited from additional investment** with a ten-year payback period.

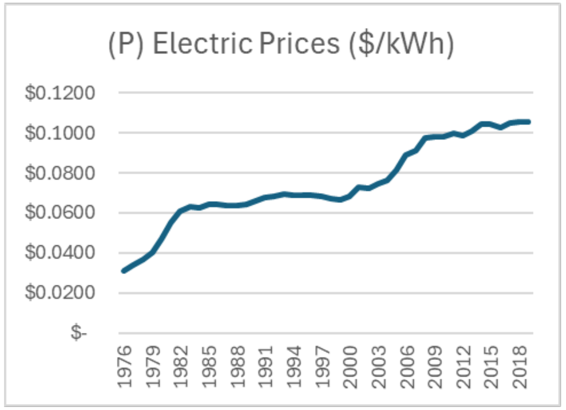
credit human

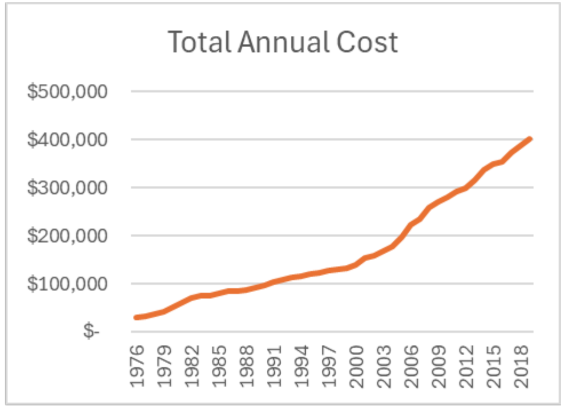
“Simple Payback” fails because it assumes linearity in a world governed by exponential dynamics of both decay and cost growth.

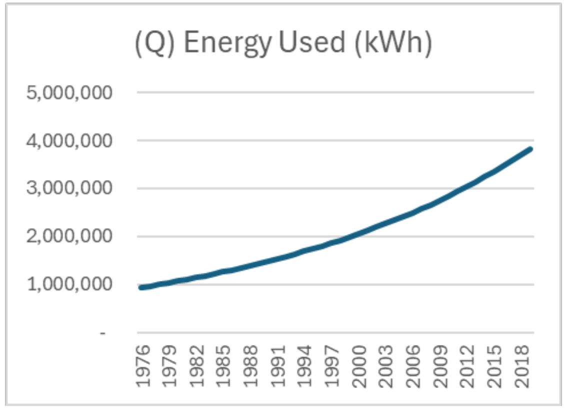


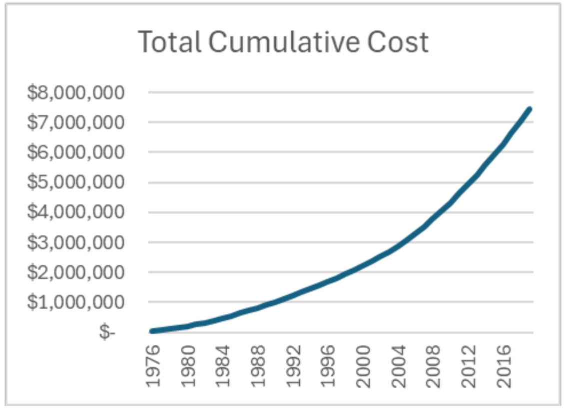
Forty-three years "in the building" and there was nothing linear about the Quantity and Price.

Year	Electric Price	Annual kWh Used	Annual Energy Costs
1976	$ 0.0310	935,484	$ 29,000
2019	$ 0.1054	3,812,505	$ 401,838
Growth rate over 43	340%	408%	1386%
Annual compounded growth rate	2.8%	3.3%	6.1%







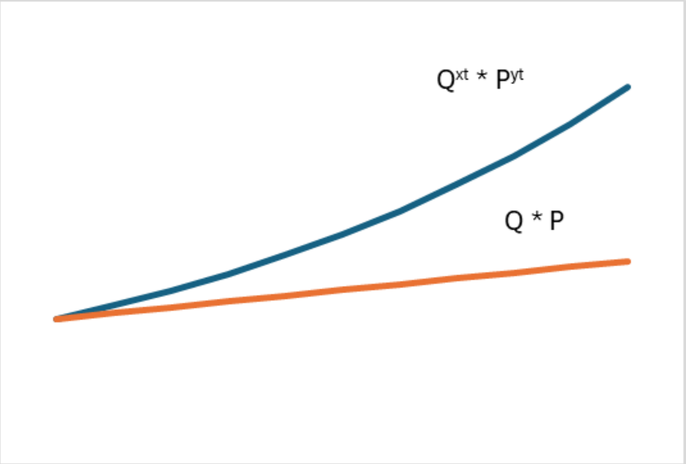


Reality behaves exponentially—even when our models stay linear.

$$Total\ Annual\ Costs\ = Q\ * P$$

If both the quantity (Q) of energy savings and the price of electricity (P) grow over time, then the equation changes to

$$= Q^{xt}\ * P^{yt}$$



This is a radically different equation and resulting behavior than the simple payback equation, in that the equation **is multiplicative of two exponential growth variables.**

The new equation reveals **persistent long-term forces** at work on both **decaying building infrastructure** that uses more energy **AND rising electric prices.**

The product of these **two exponentials drives super-exponential nonlinear growth** in lifetime electricity costs.

Recall the non-linear growth rates in regulations versus mission in my opening story about the credit union mission being **dominated by financial and regulatory performance system growth.**

credit human

The human mind's processing of exponential growth

Using American Family Field here in Milwaukee as an example.

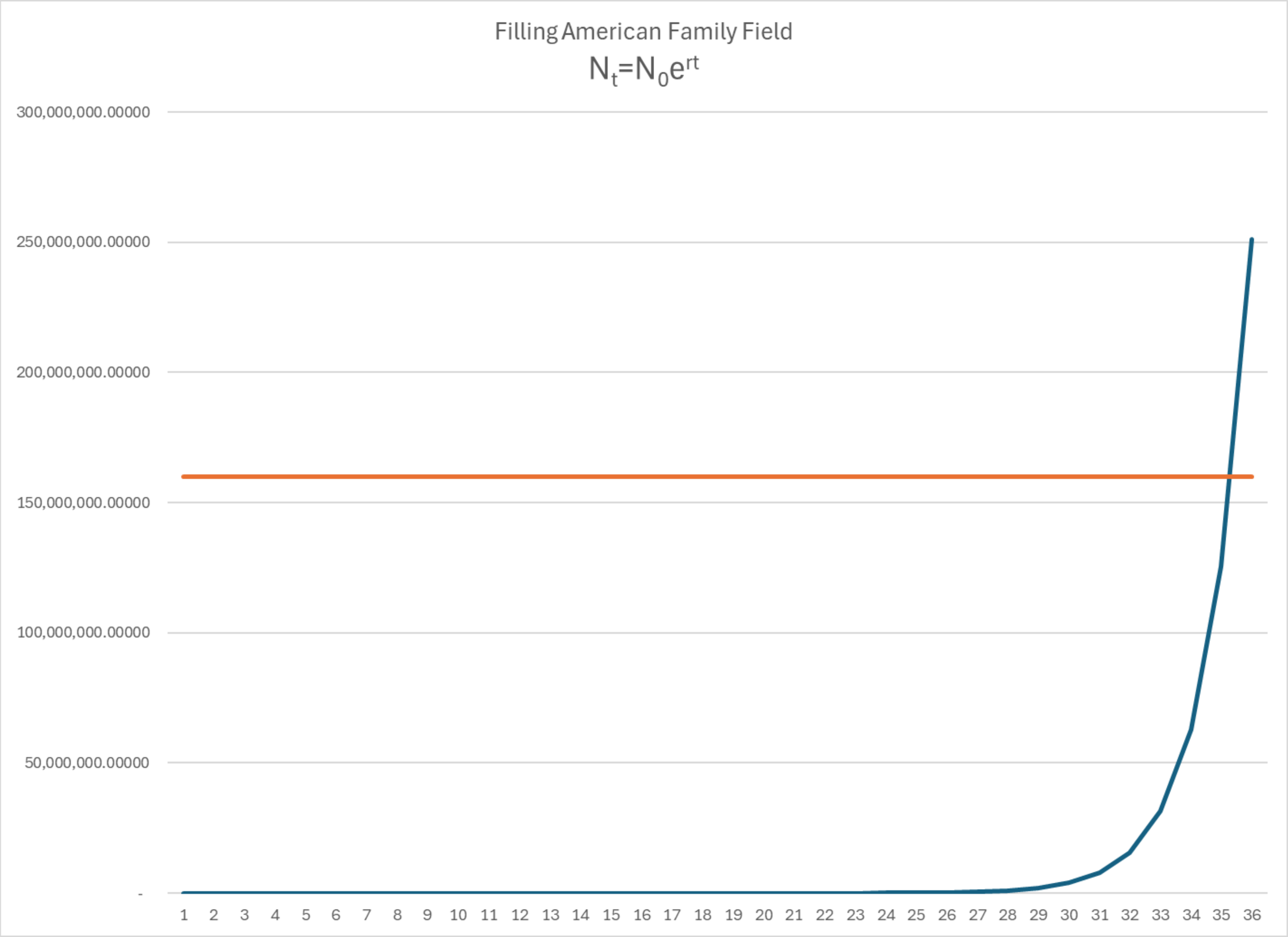
We start with a **single 7-ounce thimble of water,** which we pour on day one, and then on each subsequent day, we **double the size of the water added the previous day** (e.g., on day two, we add two thimbles of water, and four thimbles on day three, and so on)

The building has an approximate enclosed space of **160 MILLION cubic feet.**

How many days would it take **to fill Miller Park** to the top of its enclosure?

credit human

36 Days…



Filling American Family Field
$N_t=N_0e^{rt}$
300,000,000.00000
250,000,000.00000
200,000,000.00000
150,000,000.00000
100,000,000.00000
50,000,000.00000
-
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36

How do most people (including financial experts who use simple payback) approach problem-solving?

Optimal decision-making with perfect information is impossible. To cope with complexity, people and organizations have developed several ways to simplify the task of decision-making:

- **Habits and Routines:** Habits are procedures followed repeatedly and without significant deliberative effort. Instead of deciding what to do each morning by considering the cost and benefit of all options, most of us follow an unconscious routine. They are nearly automatic.

- **Rules of Thumb:** A rule of thumb is a procedure designed to yield a pretty good decision quickly and easily based on simplified, incomplete mental models of the situation. They rely on relatively certain information readily available. The "simple payback" calculation is a rule of thumb.

- **Managing Attention:** Since attention is a scarce resource, controlling the information people have access to and attend to is an essential source of resource control. Organizations have developed many structures and routines to control access to information, directing the attention of their members toward some cues and away from others. Financial statements of the current status are among the most used to direct attention.

credit human

More mental shortcuts

- **Goal Formation:** Instead of making decisions by explicitly solving optimization problems, people tend to set goals and adjust their behavior to meet them. Once goals are met, problem-solving efforts often cease, allowing the attention and cognitive resources they consume to be redirected elsewhere.

- **Satisficing:** This leads to "satisficing" (coined by Herbert Simon) to describe behavior in which effort is reduced once a satisfactory level of performance is attained. Students often reduce their study effort once they achieve the desired grades; consumers stop searching for bargains once a price low enough for the desired item is found; employers often hire the first candidate meeting the job requirements rather than searching for the best one.

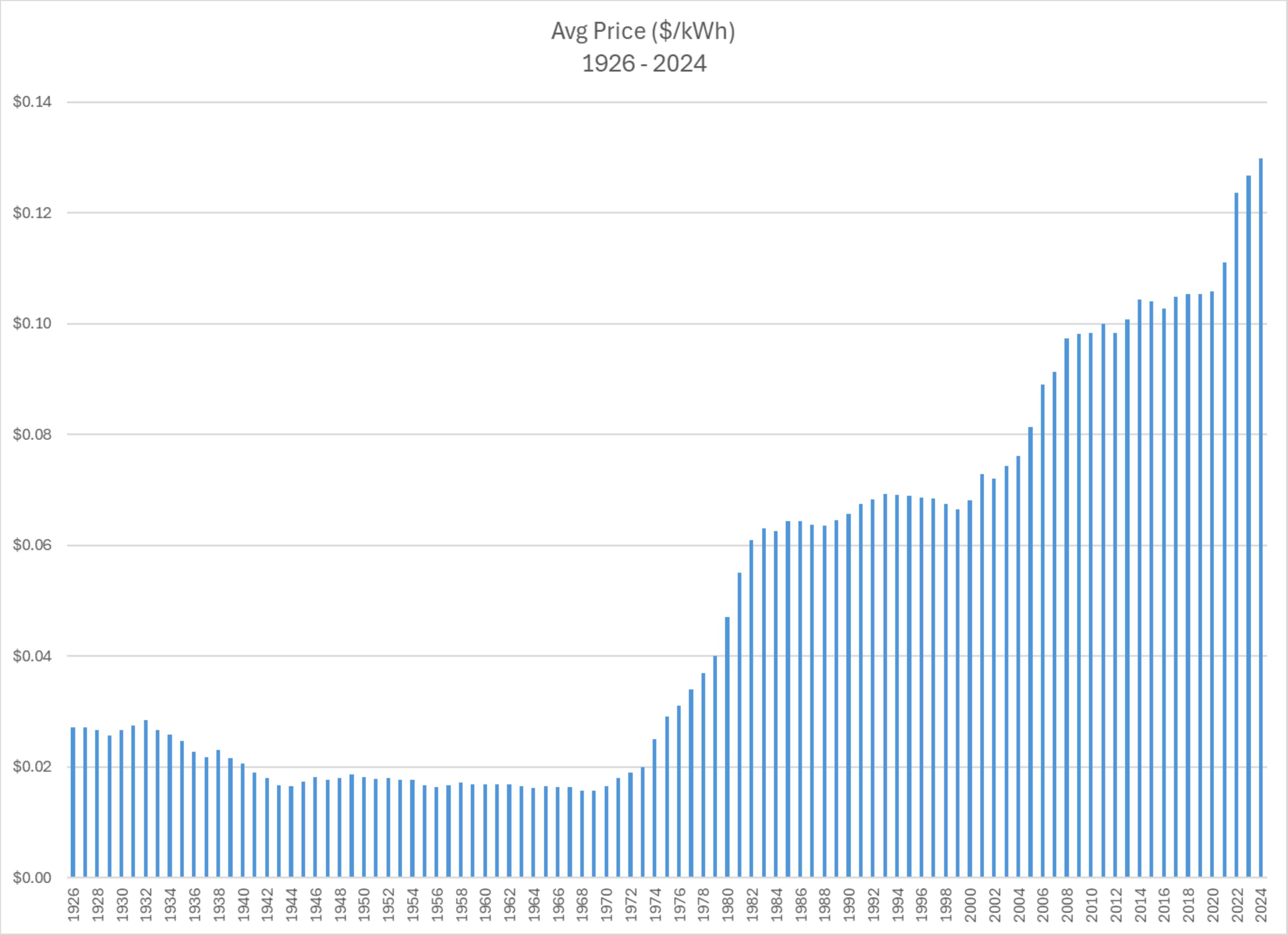
- **Drift:** Aspirations and goals themselves are adaptive and respond to experience. A student's desired grade point average tends to influence the actual grades received, often biased by a grading on a curve—a form of goal erosion—that encourages greater achievement.

Consider any **established scoring system in your industry** to see what it reveals about **habits, routines, rules of thumb, managing attention, goal formation, satisficing, and drift that may lead to discouraging further effort** to increase building performance, despite opportunities to do so, once the top points are achieved.

Critical Takeaway: Our minds simplify because our systems encourage simplification.

credit human

Back to $Q^{xt} * P^{yt}$ …let's review Electric Prices (P)

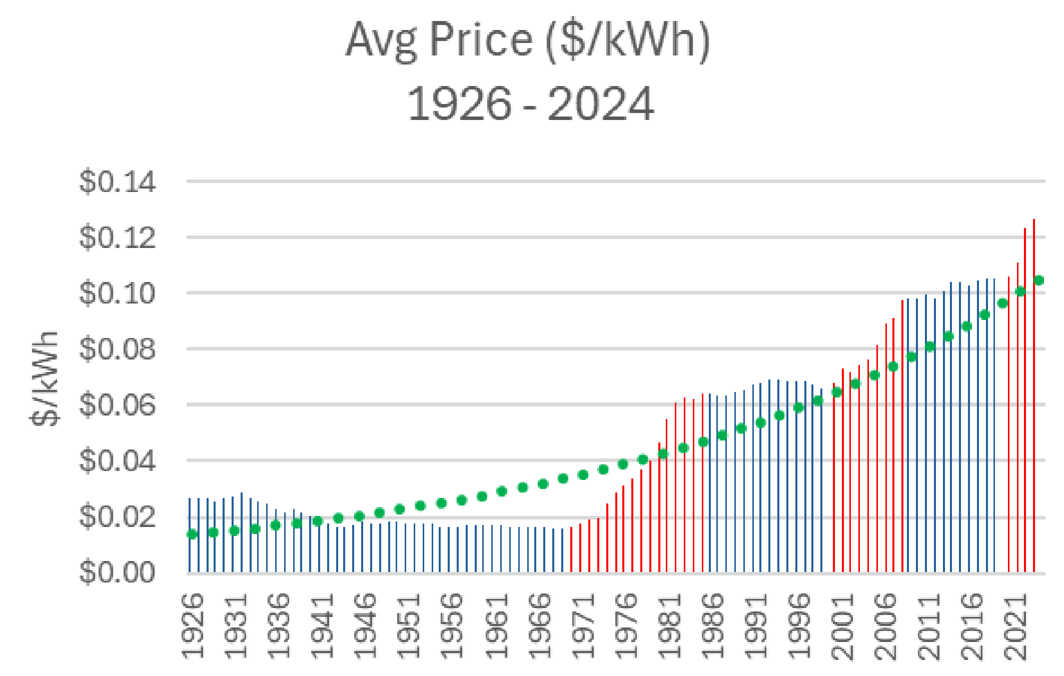


Electricity Prices Rise in Waves—Not Lines

Since 1932, U.S. retail electricity prices have increased through three distinct waves, each ending at a higher plateau.

- **1932–1970: Long Stability/Decline:** Rapid scale, minimal regulations, and cheap fuels
- **Wave 1 (1970–1985):** Oil shocks, nuclear cost overruns.
- **Wave 2 (2000–2008):** Natural gas volatility, grid expansion.
- **Wave 3 (2020–present):** Inflation, decarbonization, grid resilience.
- Short "pause periods" between waves mask a **long-term exponential upward trend.**

Each cycle **ends with higher prices** than the last—**compound growth disguised** as stability.



Source: *EIA Average Retail Price of Electricity*

credit human

Efficiency Stalled. True Costs Accelerated.

- Every 10–15 years, a new investment wave begins.
- Utility reinvestment follows a **predictable pattern**:
  Shock (fuel or policy)→ Capital **Buildout** → Cost **Recovery** → Temporary **Equilibrium** → **Shock**
- Each reinvestment cycle raises the cost floor for the next period.
- Generation **efficiency** (33–38%) has **barely improved** since the 1970s.
- Real **productivity** improvements now come from **capital turnover,** not thermodynamics.
- **Environmental controls and aging assets** offset incremental technology gains.
- Retail **prices** continue to climb due to **rising capital and fuel costs**.
- **Fuel cost** will continue to **increase** as the marginal cost **of accessing and extracting** available fossil fuel reserves **grows** with the **depletion of the easiest-to-access fuels,** and producers face higher exploration and development costs.
- **Externalized costs** are **not (yet) included** in U.S. prices. The actual price trajectory would **be steeper** and represent compounding silently alongside energy use (e.g., $50B/year U.S. health care costs from power plant pollution and carbon social impacts ≈ $190/ton by 2030)

Technology plateaued. Capital and fuel costs did not. Current prices understate the actual cost curve.

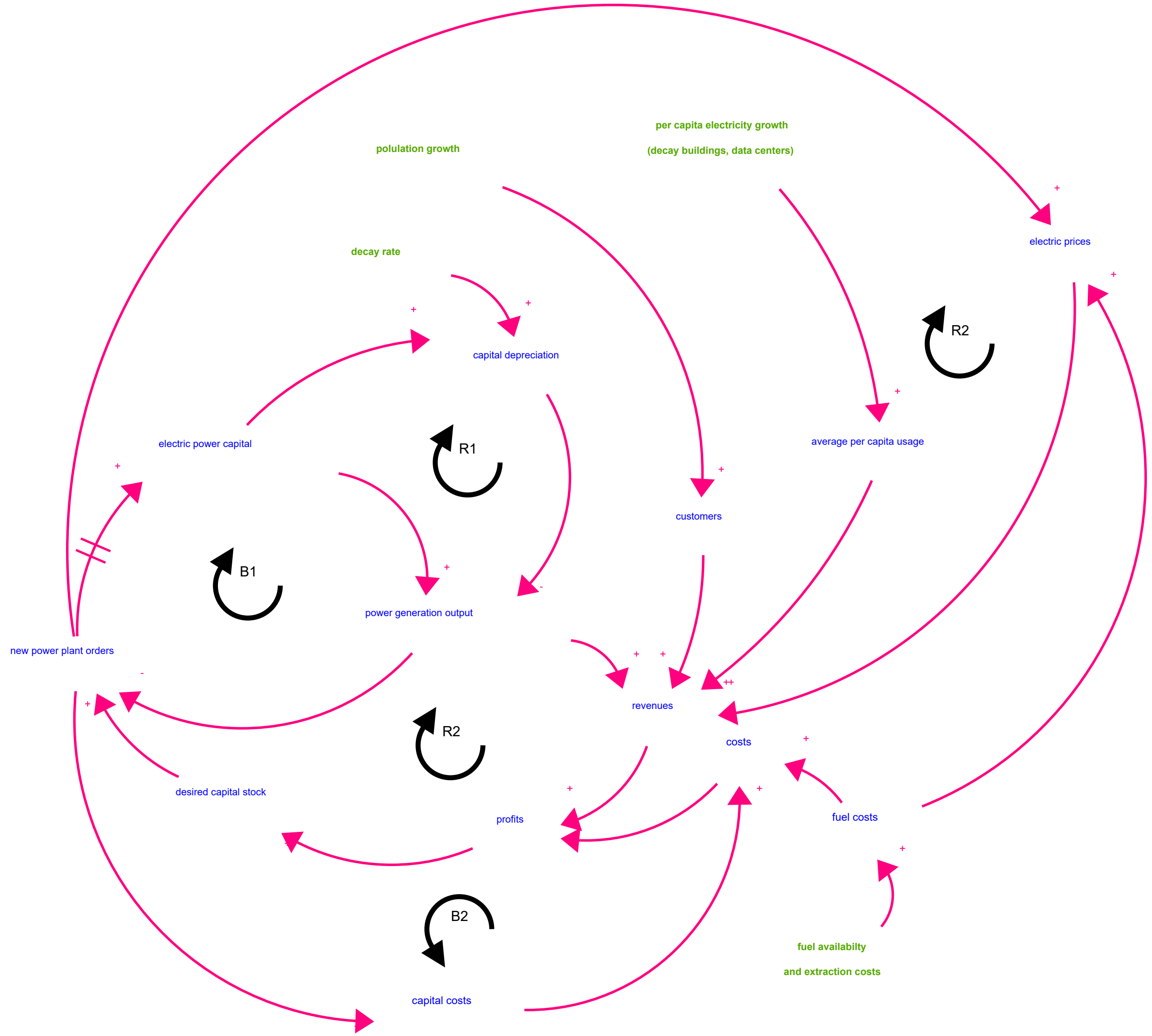
credit human®

The Reinforcing Loops Behind Rising Prices

This system is a **dominant reinforcing growth structure driven by capital decay and three exogenous forces**, which are also reinforcing loops (e.g., **population, energy usage intensity, and fuel extraction costs**).

This is the **same exponential structure** that drives **the growth in total building energy costs**.

Prices are beyond our control due to structural reasons, so we must **focus on the Quantity** of electricity used.



credit human

Back to $Q^{xt} * P^{yt}$ …since we can't control Prices, we must focus on Q^{xt} so here are our Project Team Commandments

- **To begin, set aside any notions of using Simple Payback as a guiding principle or decision-making rule**

  - The explicit assumptions are **linear,** even though the world behaves nonlinearly, so it **leads to underinvestment** in what is possible and therefore fails even to deliver the payback target.

  - The most serious failure (and my most significant criticism) of its use is that it is **not consistent with the portfolio approach** (finance world), in which building a portfolio of unrelated technologies can produce **synergistic** benefits where the sum of the parts is greater than the whole (reinforcing feedback).

- **NEVER START a project by setting a budget.**

  - **If you do**, then you have set the superordinate constraints, and l**earning** what's possible **will not happen** (e.g., the credit union financial performance loop constrained the purpose before it ever got a chance!)
  -

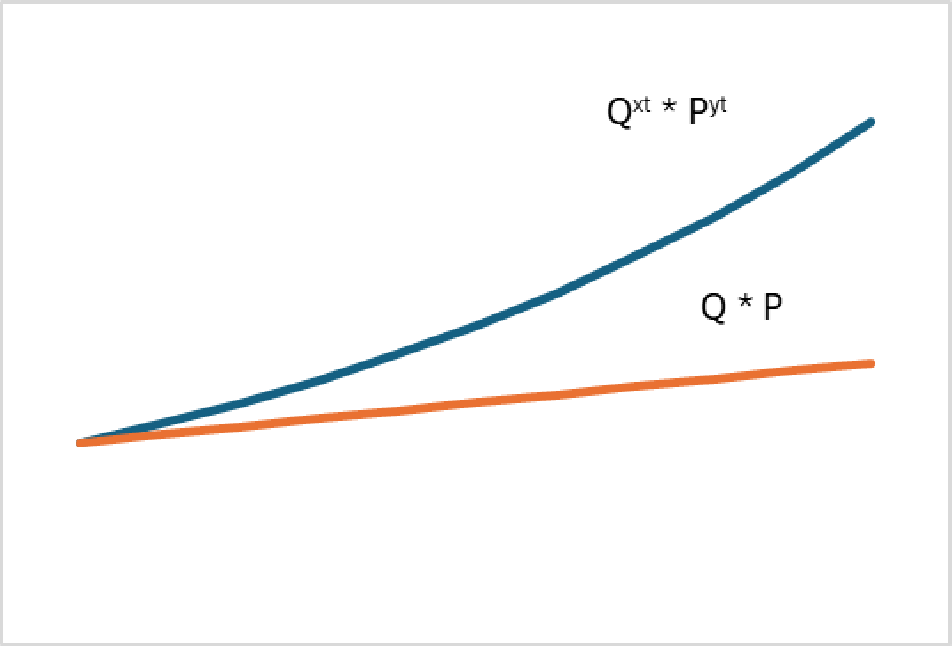
credit human

more Project Team Commandments

- **Prioritize learning to accumulate your choices and leave every option on the table in the early days**
  - The design question is, **"What is theoretically possible?"**
  - **Make Lemonade**: Can we really take the city's code requirements for stormwater retention and use the water for heat transfer? **Yes, you can!**
- **Give special attention to design elements that can flatten and reduce the rate of decay of a building's long-term performance.**
  - **Shaving** 0.50% off a building's annual exponential **decay rate** results in massive long-term **energy savings**.
  - Design elements that maximize building envelope demand reduction and enable mechanical equipment to be located in the conditioned space can result in longer equipment life and reduced maintenance.

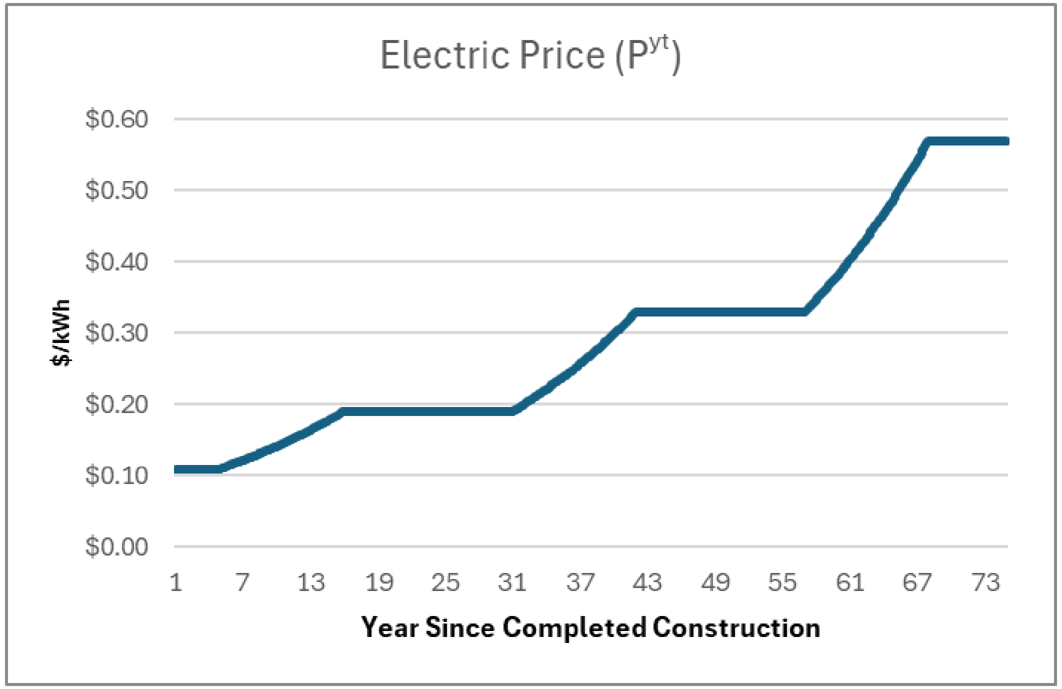
The <u>GOAL</u> of the Financial Evaluation project phase is not to "vilify financial analysis" but to

"liberate it from bad heuristics"

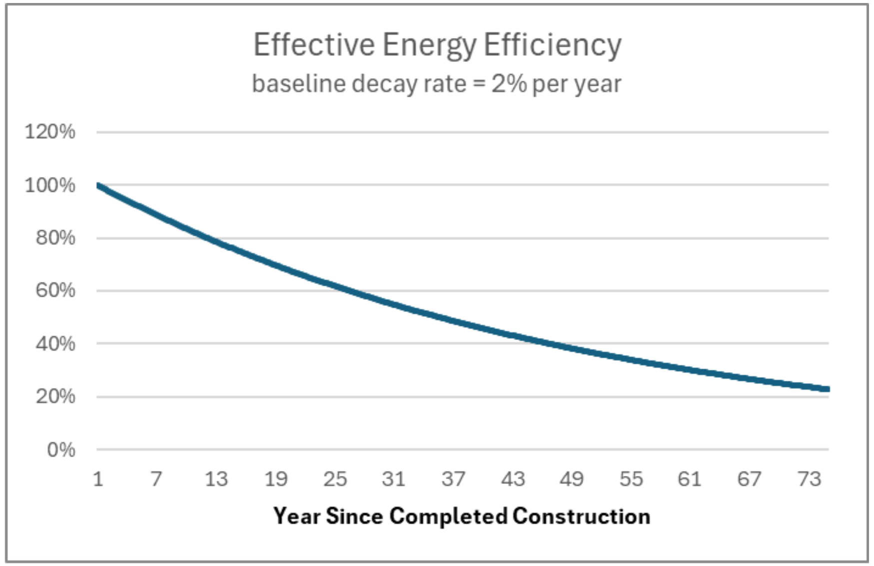


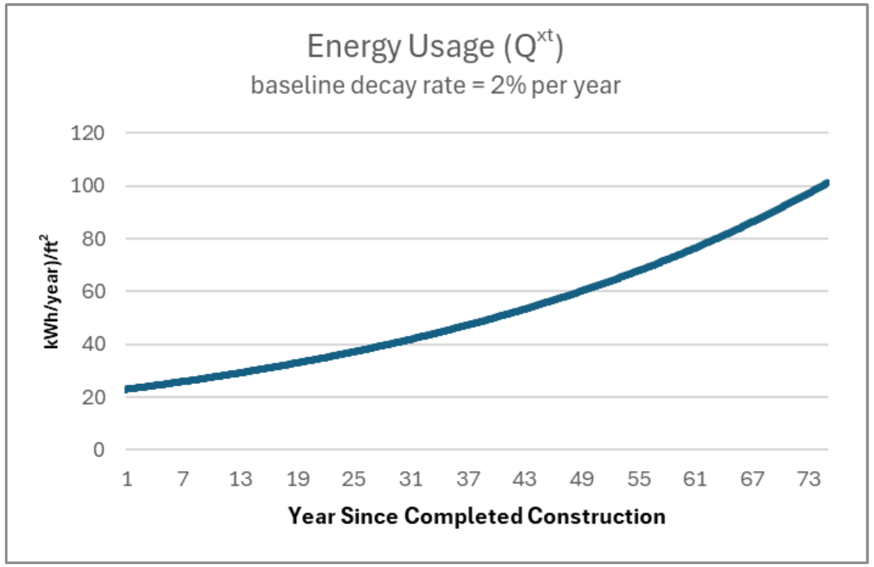
And finally, the financial model to evaluate the financial dimension (one of many) of the design

- **Start with the forecasted electric prices**
  - Assumptions: **punctuated periods** of rapid price increases followed by periods of stable prices.
    - Model specifics:
      - Using the current price, integrate a 5% annual growth for 11 years, followed by 15 years of stable prices.
      - You can include a contingency scenario for a possible carbon tax (I didn't in this example).
  - This produces the forward **price curve** (P^{yt}).



the financial model, continued



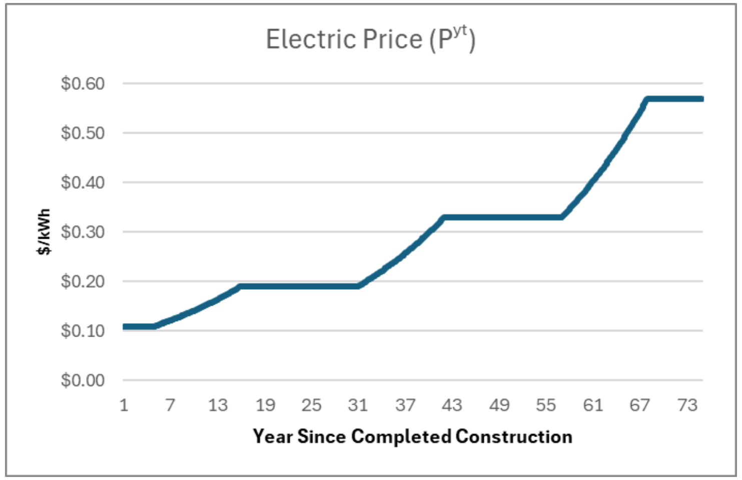


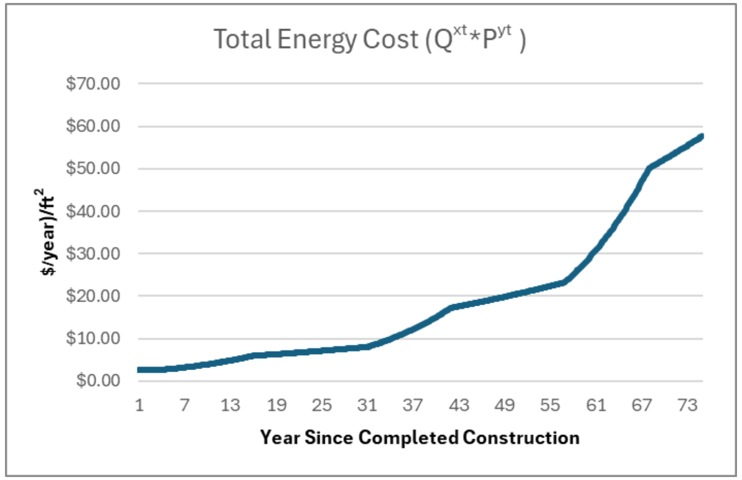
- **Use the baseline building that meets code and forecast the energy usage (baseline Q^{xt})**
  - Model Specifics: use first-order delay to apply a **2% annual decay rate** to the baseline building's initial year effective energy efficiency.
  - This produces the forward **quantity use curve** (Q^{xt})

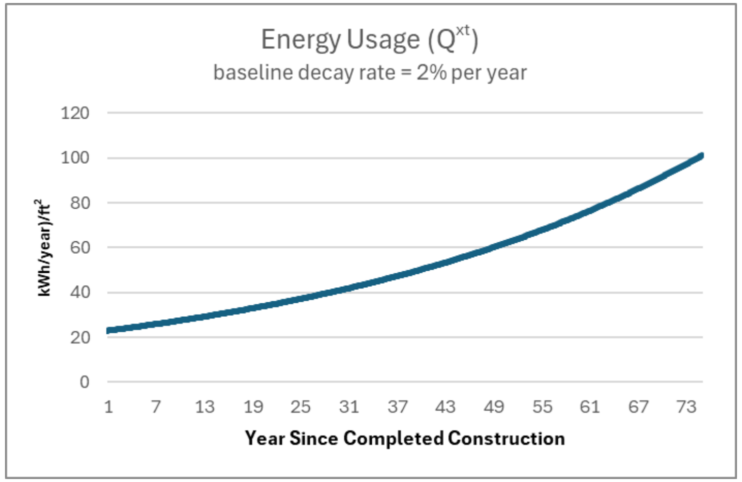
credit human

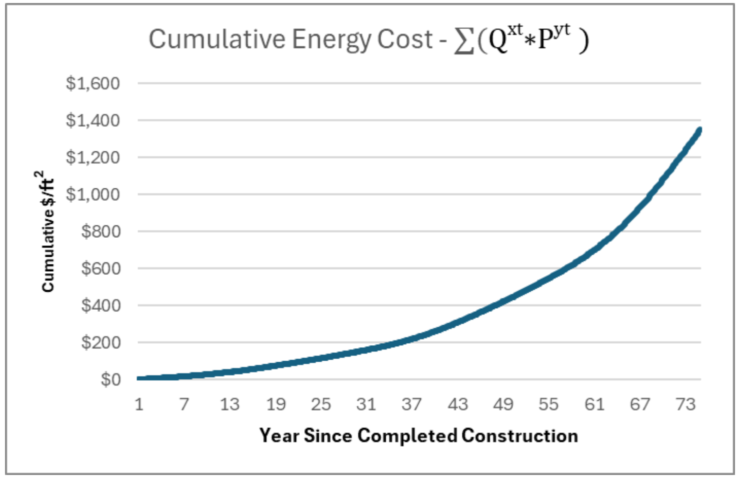
the financial model, continued

- Then calculate the predicted total energy cost over the baseline building's life-time (baseline $Q^{xt} * P^{yt}$)





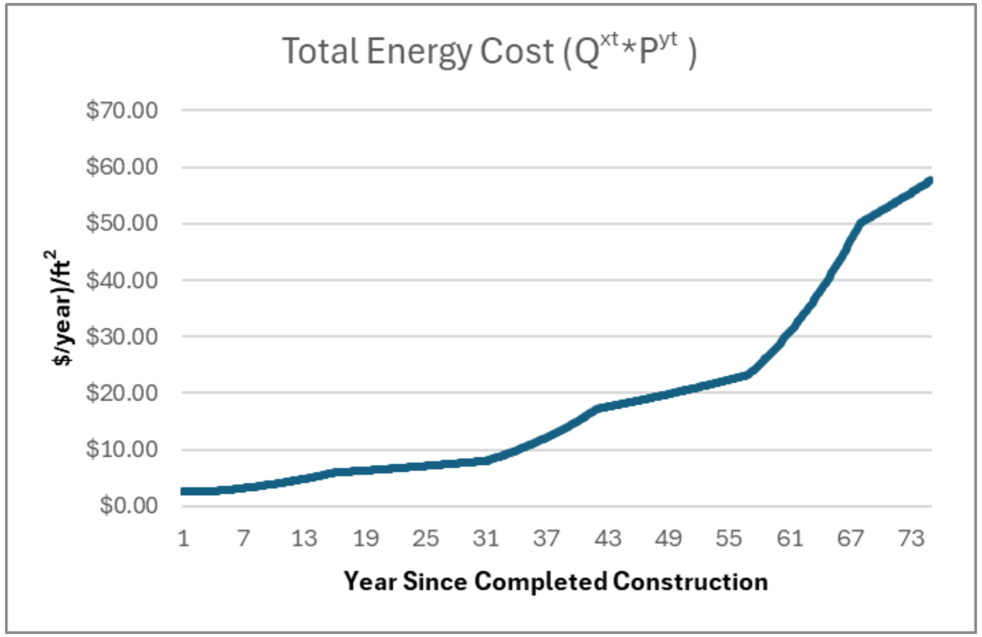


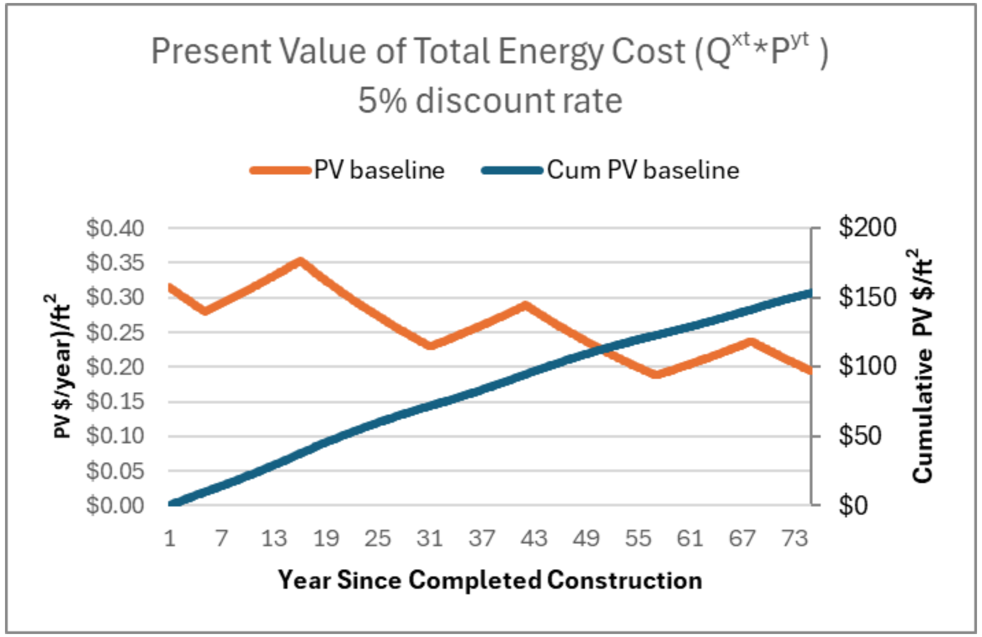


credit human

the financial model, it's complete!

- **Calculate the Present Value of the total energy cost curve time series (baseline $Q^{xt} * P^{yt}$).**
  - This provides the value in today's dollars of the electricity cost that can be used to design a building to achieve net zero energy.
  - In this case, the financial value for zero energy pursuits is **$153/ft^2** (chart below on right side, 2nd y-axis) for all energy demand-side or supply-side design elements. Notice the year in which the **discounted cash flow peak occurs…beyond 10 years — where Simple Payback stops looking!**
  - There is **nothing more to do** of any value or further effort because this is the estimated value of all energy savings theoretically possible.





Final points

- When investing in **your retirement savings, y**ou benefit immensely from the **compounding effects of time**. (In fact, **no one would tell you to use a ten-year time horizon**.)

- **Energy usage** is an integral **permanent component** of the structure of a building's **behavior and performance.**

- **Buildings** by their very nature are long-term and **will use energy over the same time horizon** that building structures will be in use. The pattern of behavior of energy **prices and building decay is NOT in your favor in the long term.**

- Make **compounding growth** over time **your design partner** (instead of some arbitrary variable to make some recovery as short as possible).

- Doesn't it just make good sense (**a rule of thumb**) to **recover energy costs continuously** over time through **design choices proportional to the countervailing forces at work** at the beginning of a construction project, just like building your retirement savings?

credit human