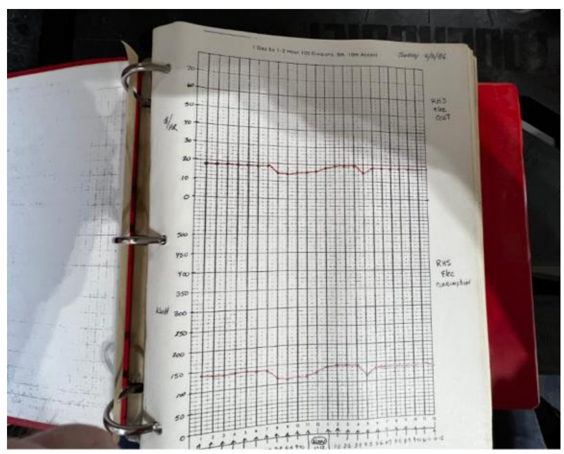
The Energy Cycle By Edward H. Brzezowski, PE, May 2, 2025 **Sandbox 12**

The "Energy Cycle," discovered by Ed Brzezowski in the mid-1980s, reveals hidden cyclic patterns in energy use, initially observed through detailed, manual plotting of boiler energy data in schools. This innovative insight draws a compelling parallel to the well-known "Otto Cycle" in internal combustion engines, underscoring its significance as a universal metaphor for cyclic processes.

Otto Cycle	**Energy Cycle**
Intake	Night to Day mode
Compression	Day
Power	Day to Night mode
Exhaust	Night

Early in my engineering career, I uncovered a critical insight that profoundly shaped my professional trajectory. While reviewing my archives recently, I came across hand-drawn energy curves stored in three-ring binders from the early to mid-1980s. These reminded me of how crucial the discovery of the Energy Cycle was, laying the foundation for numerous successful and award-winning projects, inventions, and patents that followed.

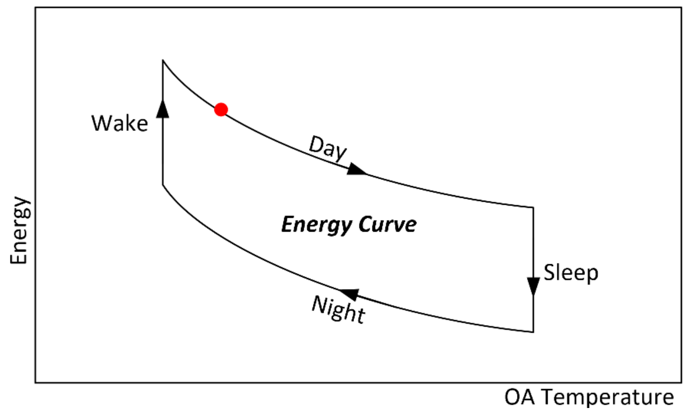


In the early days of computers, outputting charts and graphs was challenging. Consequently, I manually plotted data from my energy projects. This process brought me exceptionally close to the data and its variations over time—something I still value deeply. My fascination with understanding the mechanics of systems led me to discover hidden insights, particularly when analyzing detailed data down to the minute or even faster.

Initially, my goal was to quantify actual energy savings from various operations and maintenance improvement projects. This is necessary to get support for projects and build communication with various stakeholders as you improve building operations and reduce energy usage. Often, the impact of these projects wasn't immediately obvious. Many times, I found equipment running continuously because no one noticed, particularly during after-hours periods when facilities were typically unoccupied.

Upon examining HVAC systems closely, particularly their operational patterns with distinct day and night (occupied/unoccupied) cycles, I identified what I now call the Energy Cycle. This pattern is typical for building energy usage, closely tied to weather conditions. Although data plots often appeared scattered, deeper analysis revealed distinct cyclic patterns associated with proper system operation.

In **Sandbox 12**, this Energy Cycle is represented through an animation where a red dot tracks energy consumption throughout different daily phases. The Energy Cycle clearly shows four distinct phases during the heating season analogous to the Otto Cycle as mentioned earlier:

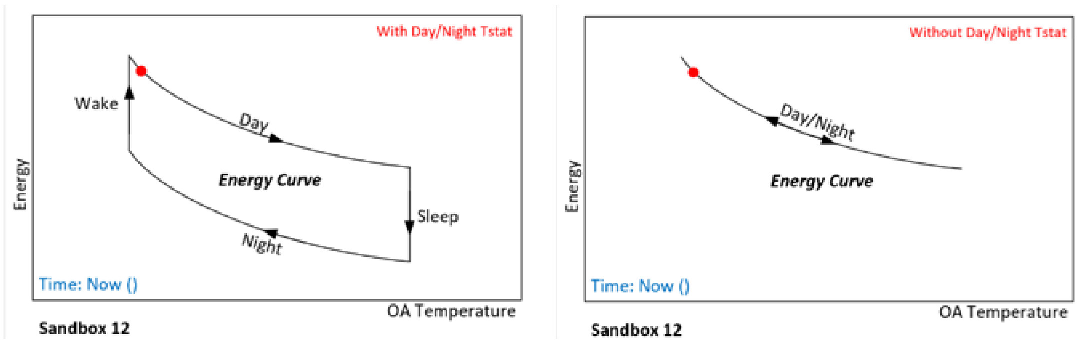


The Energy Cycle

- Unoccupied to Occupied (morning startup)
- Occupied (daytime use)
- Occupied to Unoccupied (evening setback)
- Unoccupied (nighttime economy)

These transitions not only save energy but also reduce wear and tear on equipment, extending useful life and lowering maintenance costs. Buildings operating efficiently follow this cyclic energy pattern, as shown in the "normal operation" animation.

Conversely, the "abnormal operation" animation depicts buildings or systems running continuously or cycling frequently to maintain a constant setting without taking advantage of lower energy use during unoccupied times. The difference between these two operational patterns represents measurable and cumulative energy savings.

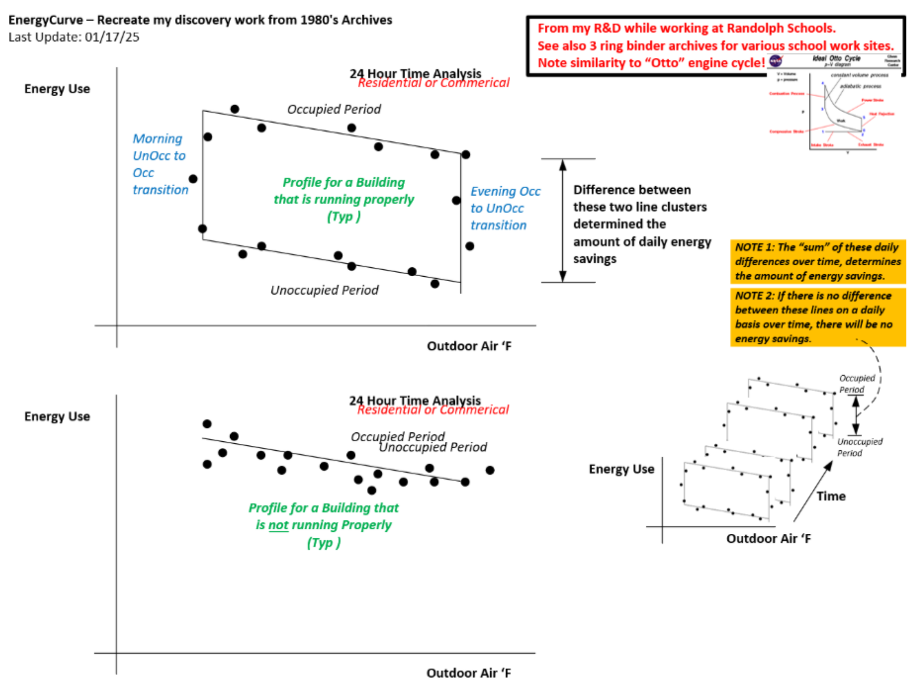


Energy Cycle Examples

Beyond building systems, my lifelong interest in cars and trucks allowed me to see clear parallels with the Otto Cycle's four defined phases: intake, compression, power, and exhaust. The Energy Cycle similarly underscores the cyclic nature of all physical systems, offering profound implications for understanding efficiency across various domains.

Key applications and benefits stemming from this discovery include:

- Identifying hidden operational inefficiencies
- Optimizing equipment selection and sizing
- Developing adaptive and predictive energy control systems
- Reducing maintenance costs and downtime
- Achieving persistent, measurable energy savings
- Expansion of concepts to all “physical” and “virtual” systems



Updated Technote from Personal Archives

This foundational insight opened doors to numerous opportunities, such as tracking and projecting impacts, ensuring persistence of energy savings, determining part-load efficiencies, optimizing equipment operation, and pioneering adaptive self-learning control systems. It also ignited an ongoing journey of exploring hidden cyclic patterns within time series data, now enhanced by advancements in AI.

I'm excited to share this discovery more broadly via **EnergyLab-Timeseries.com**. I invite you to join me on this continuing journey of exploration and innovation, uncovering deeper insights and applications in energy management and beyond.

Explore the diverse "Sandboxes" on EnergyLab-Timeseries.com, each of which is a self-contained, WordPress-based interactive module designed for real-time exploration, visualization, and analysis of time-series data." Discover how real-time data insights can transform system operations including energy understanding and management.

Sandbox 5 looks at PV system connected to a Power Station that runs one of my desktop workstations, **Sandbox 6** looks at a three zone hot water boiler, **Sandbox 8** looks at potential impact of the suns x-ray flux activity on PV output, **Sandbox 9** looks at data from the Energy Information Administration.

Sandbox 10 and Sandbox 11 are my first "Digital Twin" simulations, one calculates heating and cooling requires based on live minute-by-minute data from the EnergyLab weather station and shares this load data information with a digital twin of a geothermal water source heat pump system.

All of these Sandbox units were build using **Programming by Word**, i.e. Vibe Computing with ChatGPT (aka Jarvis), a important member of Team EnergyLab.