RAP | Energy solutions for a changing world

Line Losses and Reserves: Often Undervalued Benefits of Energy Efficiency Investments

Jim Lazar, RAP Senior Advisor

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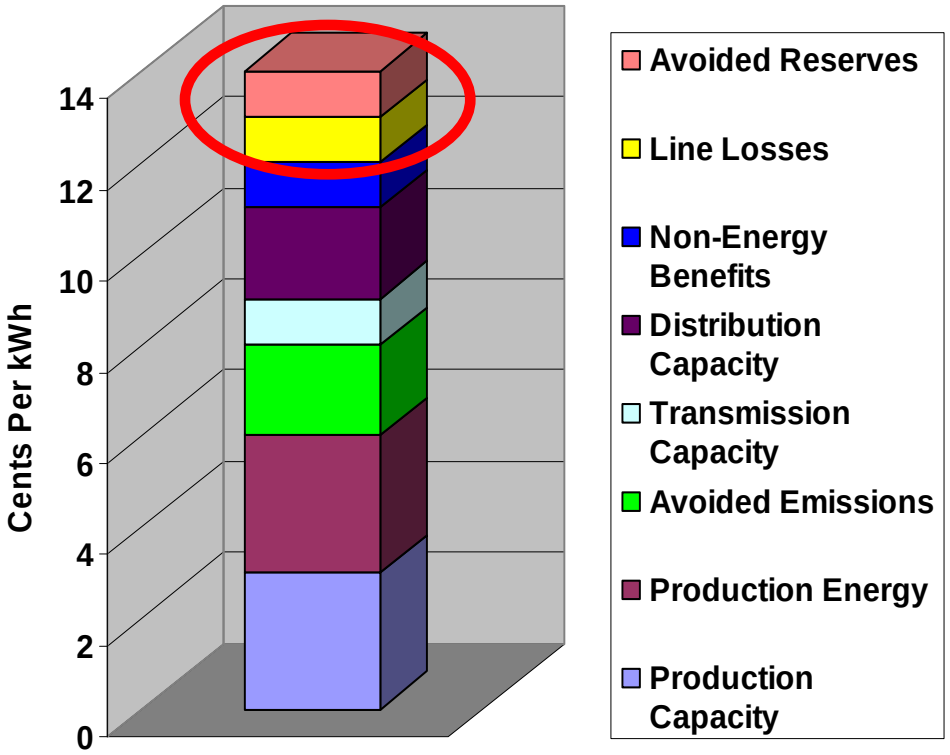
The Regulatory Assistance Project
50 State Street, Suite 3
Montpelier, VT 05602
Phone: 802-223-8199
web: www.raponline.org

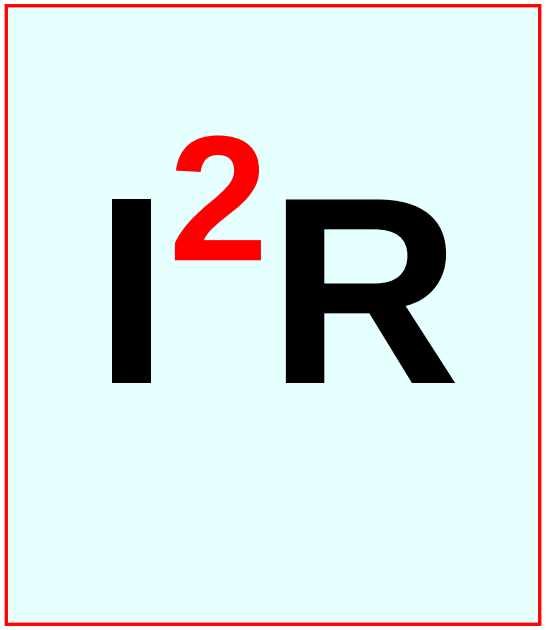
Energy Efficiency Has Many Benefits

- Production Capacity
- Production Energy
- Avoided Emissions
- Transmission Capacity
- Distribution Capacity
- Non-Energy Benefits
- **Line Loss Reduction**
- **Avoided Reserves**



These Benefits Are Often Undervalued

- **The formula for resistive line losses is I^2R --- Current (amps) squared X resistance of the lines.**
- **Losses rise exponentially as the system approaches it's peak.**
- **The line loss reductions from energy efficiency (or DR) grow exponentially as the system approaches it's peak.**
- **That exponent is your friend.**



Losses On A Distribution System

- **No-Load Losses (not subject to I^2R)**
  - The losses incurred to energize the system.
  - Mostly occur in transformers
  - Typically about 25% of total system losses
  - These are constant, even at minimum load.
- **Resistive losses (subject to I^2R)**
  - The losses incurred due to congestion (heat) in the lines and transformers
  - Typically about 75% of total system losses
  - These rise exponentially with load.
  - The calculus is pretty simple: marginal resistive losses are always 2 times the average resistive losses (*first derivative of I^2R is $2IR$*)
- **But you need to know how much of each type exist.**

The Concept of "Marginal" Losses

- If the system load goes up, the resistive losses go up exponentially. That is, the "marginal" losses are a much higher percentage of the marginal load than the total losses are a percentage of the total load.

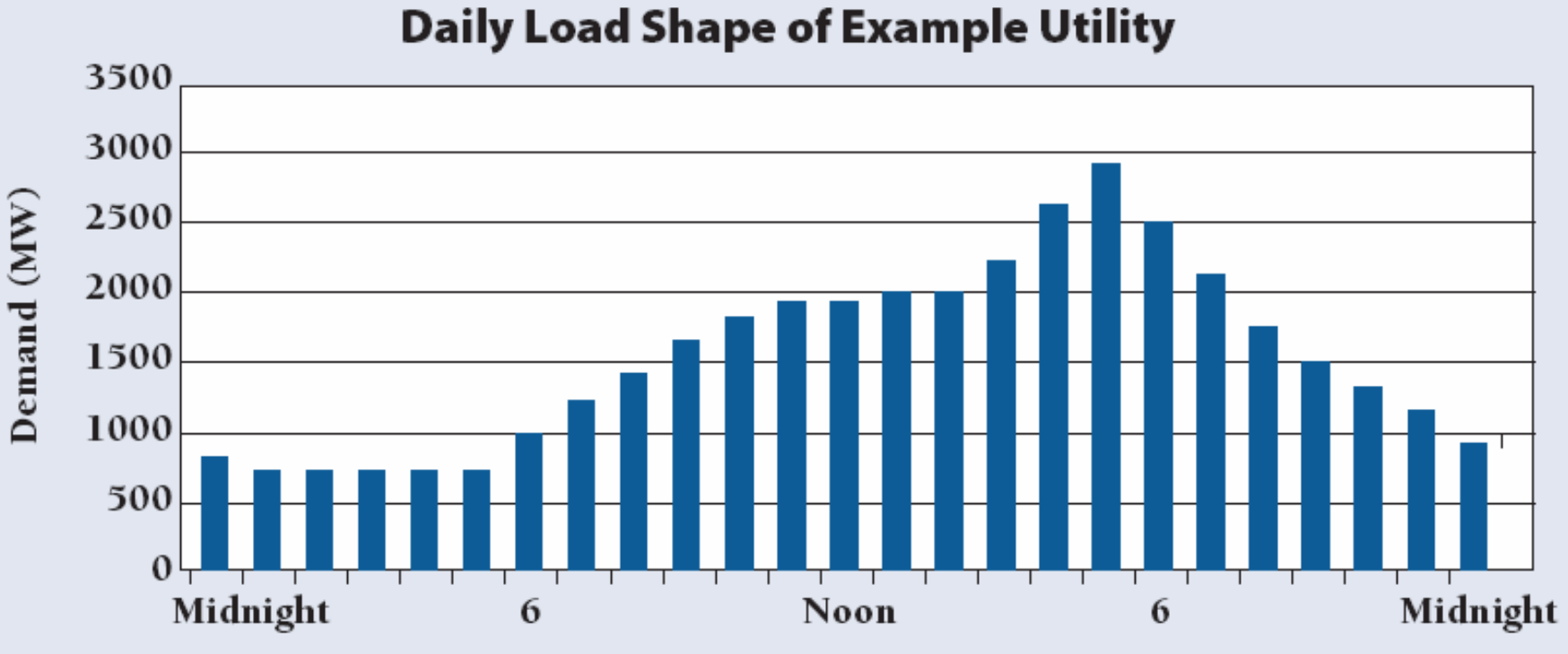
- The same thing happens in reverse when loads go down (i.e., energy efficiency or demand response). EE and DR avoid **marginal** losses.

- For every hour, the **marginal** losses are higher than the **average** losses at that hour.

One Utility's Loss Study

Ontario Hydro Line Loss Study (2005) *Loss as % of Total Load*				
Component		**No-Load**	**Load**	**Total**
Subtransmission			**2.33**	**2.33**
Substation Transformer		**0.21**	**0.12**	**0.33**
Primary Distribution Lines			**1.18**	**1.18**
Distribution Transformers		**0.78**	**0.19**	**0.97**
Secondary Lines			**0.24**	**0.24**
		0.99	**4.06**	**5.05**
% of Total		**20%**	**80%**	
Ratio of Marginal to Average Losses:			**1.6**	
Marginal Energy Losses				**8.12**

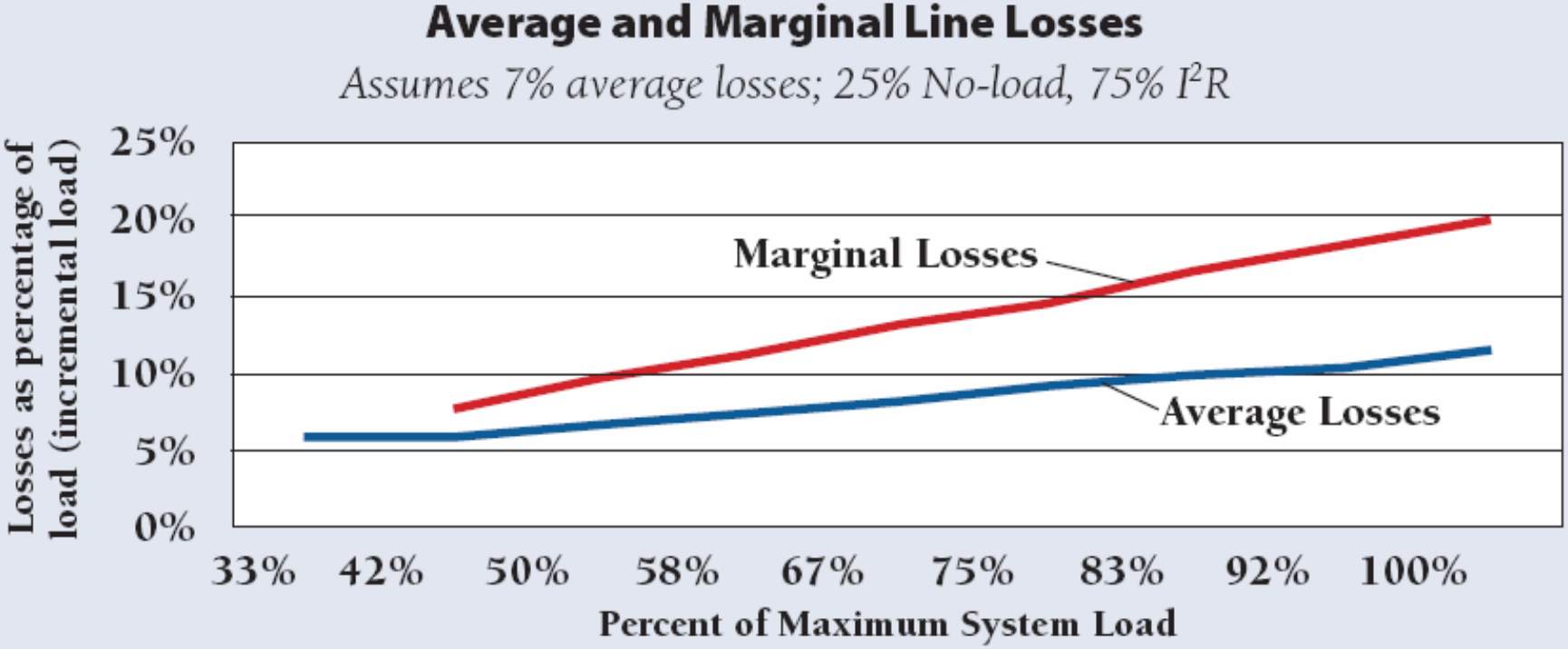
Loads Are Dramatically Higher During Peak Periods



If Loads Are 4X as high on-peak as off-peak,

how much greater are losses then?

Here's Where That Exponent Can Make a Big Difference



If Average System Losses Are About 7%,

Marginal Losses On-Peak Are About 20% THREE TIMES AS HIGH

But Wait! There's More

- **Reserves**
  - Utility grids must carry "reserves" above their actual load, in case something breaks.
  - These are generation (and associated transmission facilities) that are idle, but ready.
  - On most systems, required reserves are a percentage (5% - 20%) of the load.
  - If you reduce the load at the meter, you reduce the load at the generator by a much larger amount.
  - Reducing the load at the generator may reduce the required reserves the utility grid must carry.

10 kW Saved At the *Meter* May Be Worth 14.7 kW at the Generator

Installed Generation (kW)		14.7
Reserve Requirement (15%)		-2.2
Available to Serve Load		12.5
Marginal Line Losses on-Peak (20%)		-2.5
Load At The Meter At System Peak		10.0

47% Capacity Value Bonus for EE/DR

Quantifying These Values To Estimate the Energy Value of EE

- **Capacity**
  - Marginal losses on-peak are about 3 X average losses.
  - Add in reserves, at the required level for your control area, RTO, or ISO.
  - **Total is 35% - 50% premium for EE (and DR)**
- **Energy**
  - Much more complicated. The (20%) marginal on-peak energy losses are only experienced for a few hours. But at EVERY hour, a marginal reduction in load at that hour will avoid marginal losses at that hour (which, in turn, are 2 times the average resistive losses).
  - **Rule of thumb:** About 25% of losses are no-load losses; the rest are resistive losses. Avoided marginal energy losses are therefore about **1.5 times** the system average line losses.

About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

Jim Lazar: jlazar@raponline.org

Global
US
China
EU

The Regulatory Assistance Project
50 State Street, Suite 3
Montpelier, Vermont 05602
phone: 802-223-8199
fax: 802-223-8172
www.raponline.org