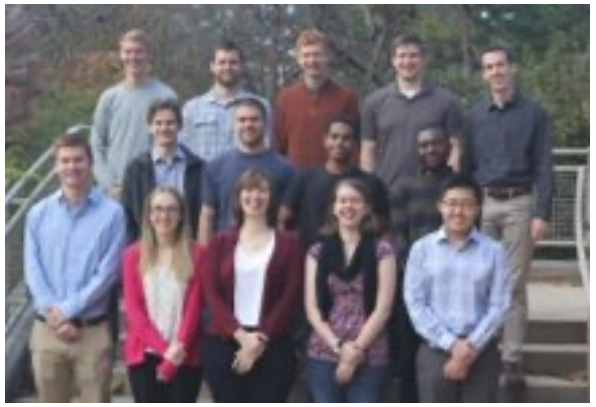
Energy Rebound Research

ENGR 333 - A



ENGR 333 - B

Calvin UNIVERSITY 1876

12/04/2019

Engineering 333 Fall 2019

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Adam Marquardt, Lillie Spackman

Source: United Methodist Church. www.vaumc.org/Caretakers

Research Question

How much energy does energy efficiency save?

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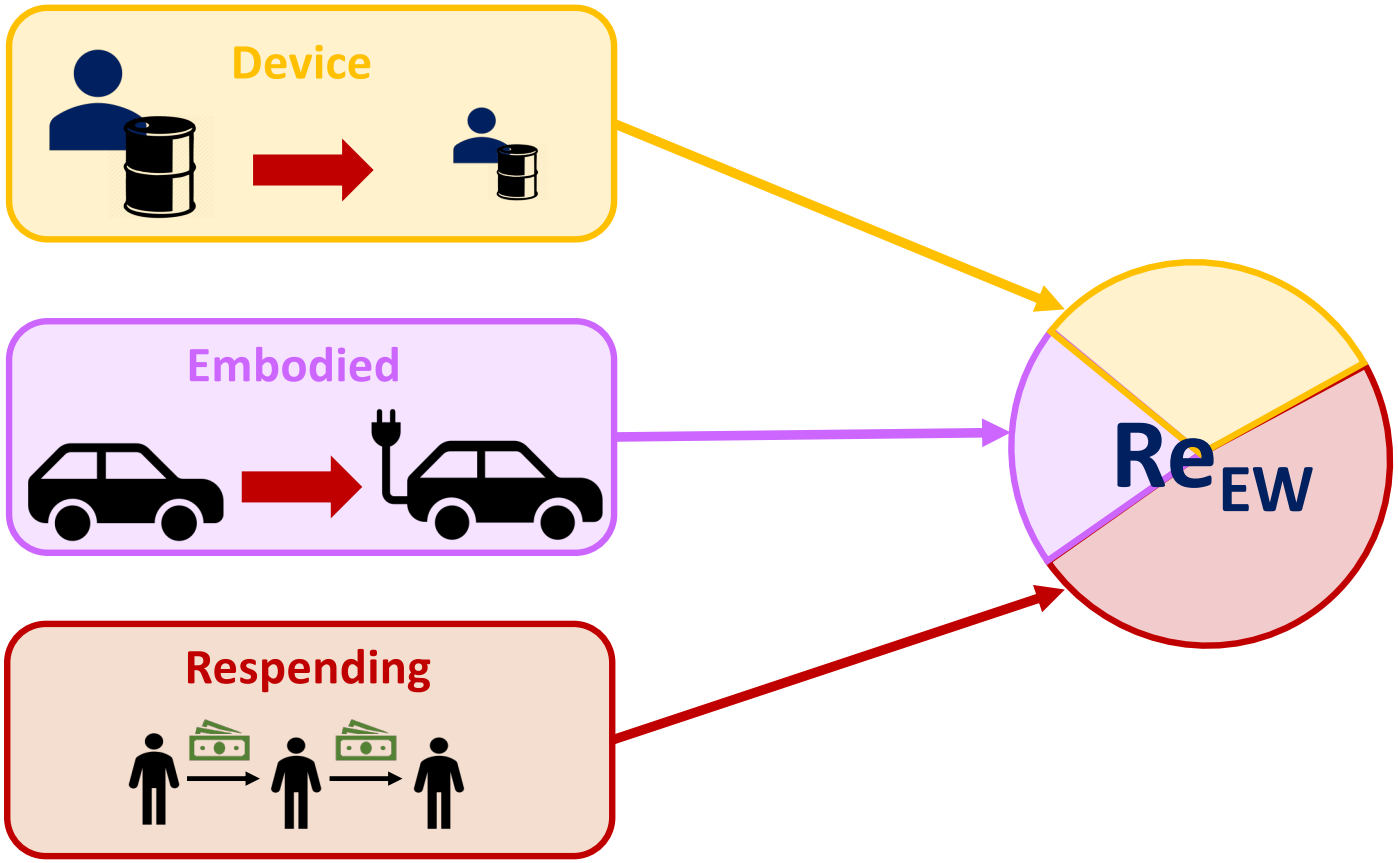
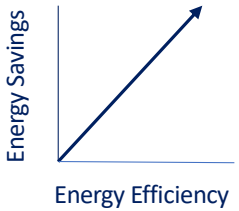
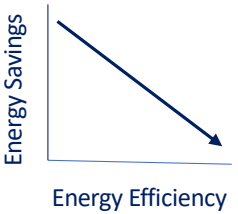
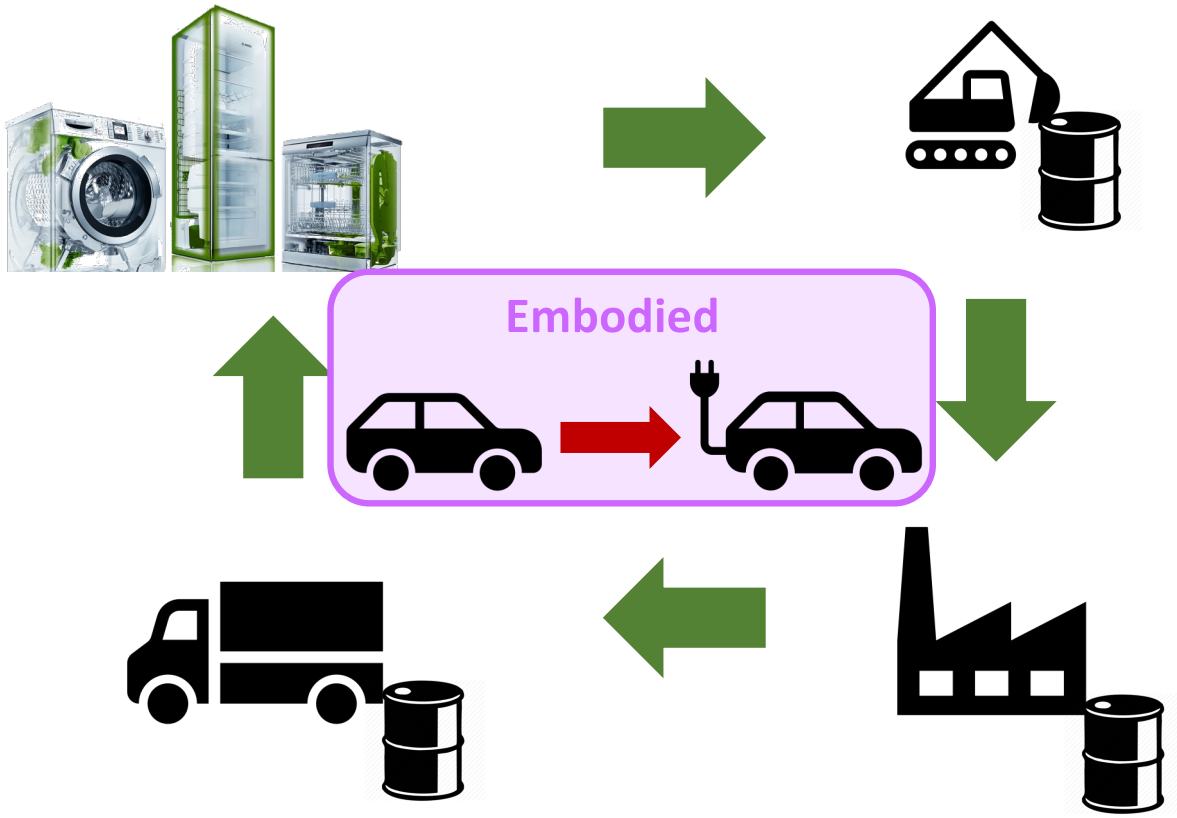
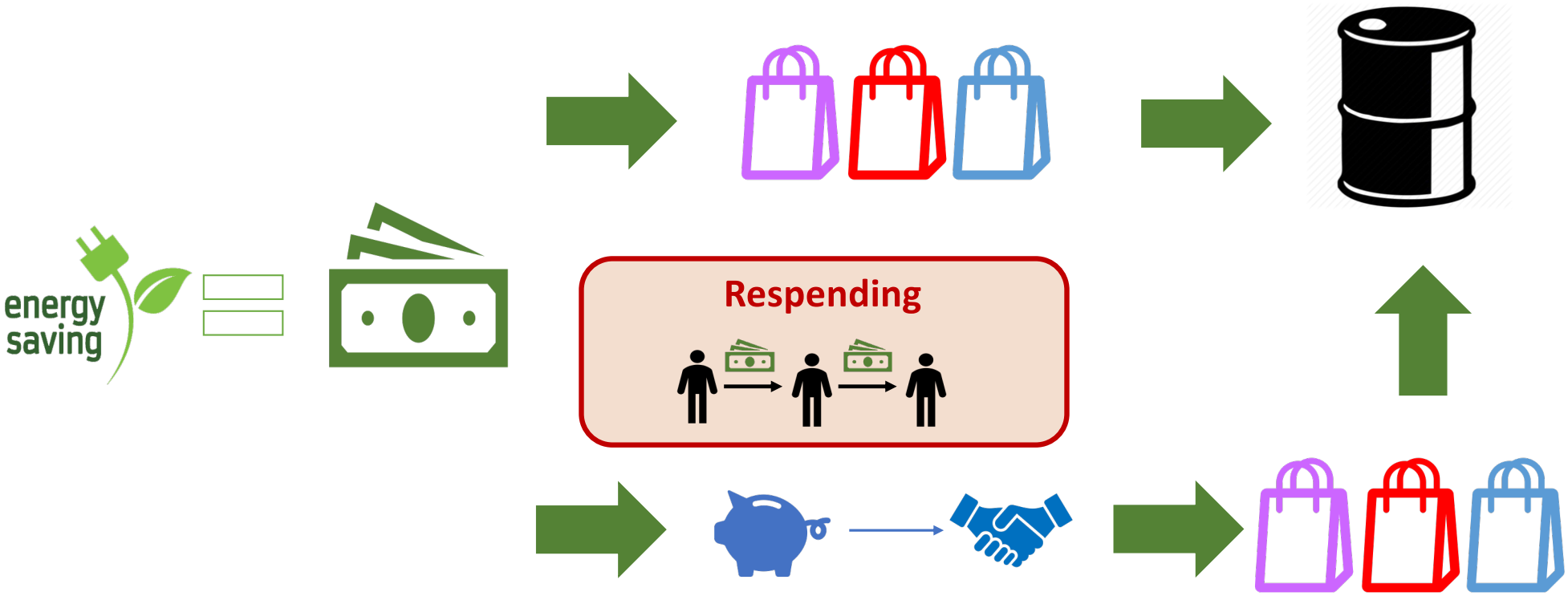



Energy Savings
Energy Efficiency

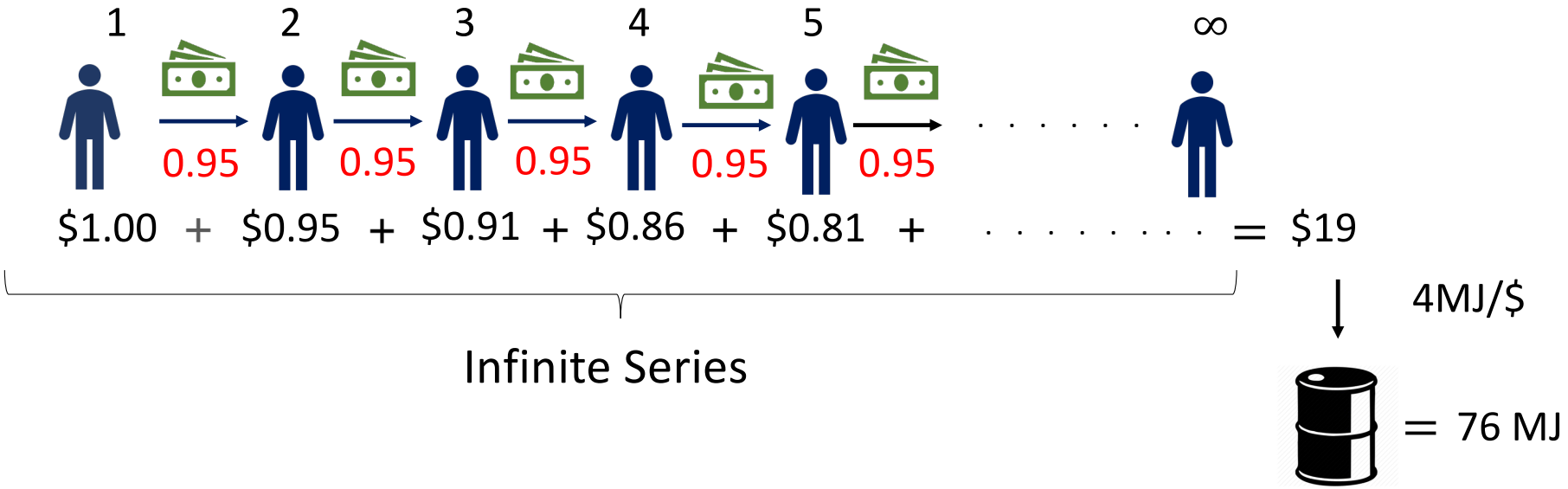

Behavior
Change


Energy Savings
Energy Efficiency

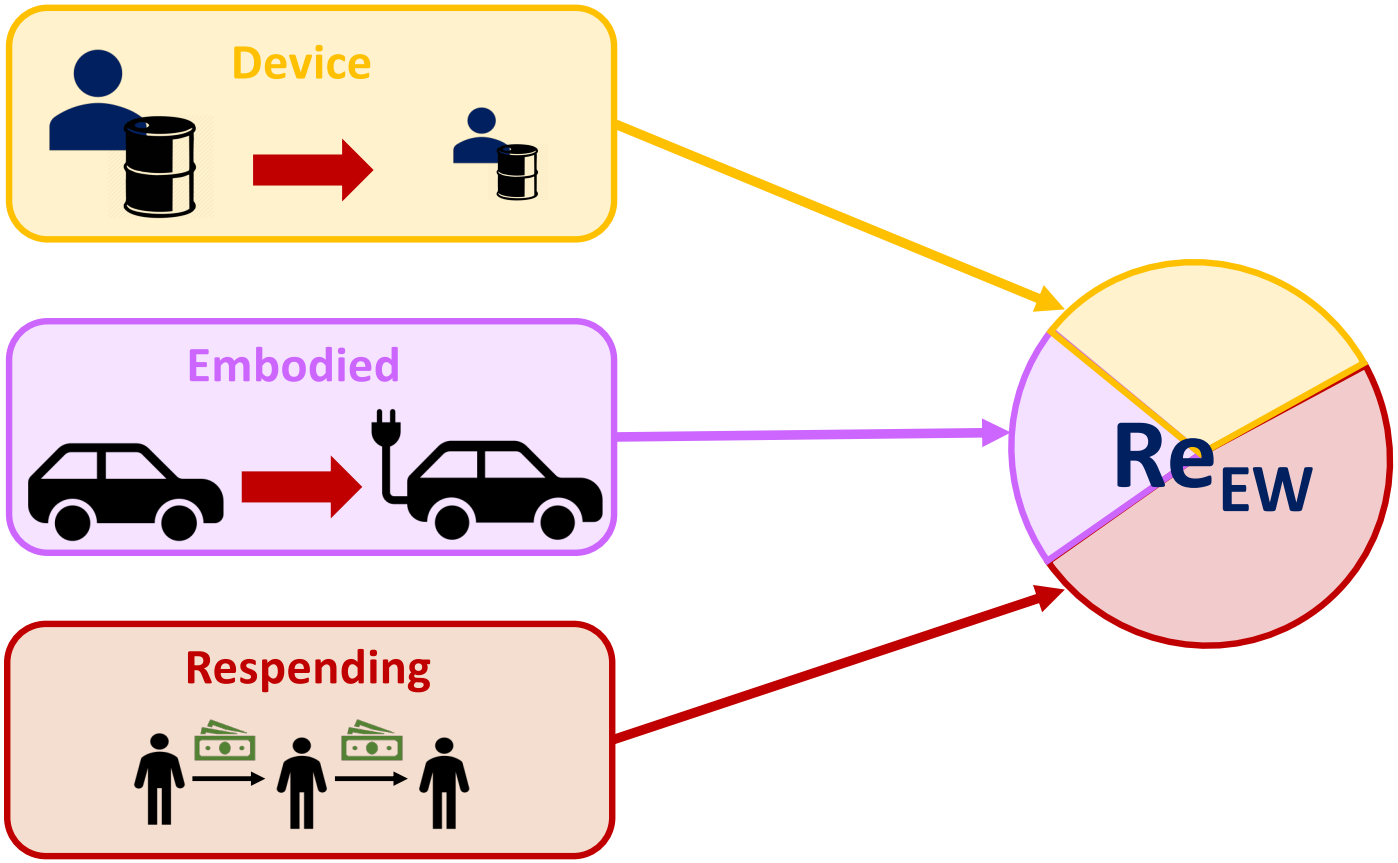

Embodied


energy saving
Respending

Marginal Propensity to Consume



How much energy does energy efficiency save?



Base Case vs Energy Efficient Case

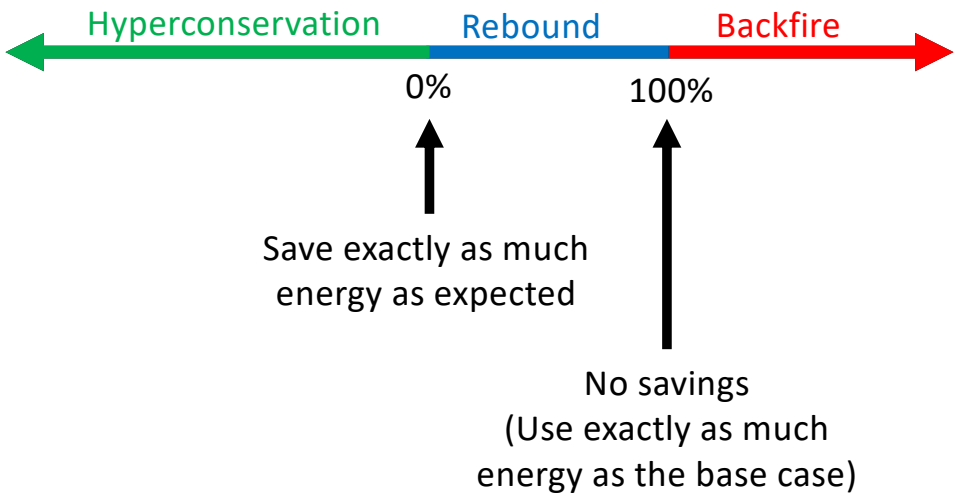
Equation for Rebound

$$Re_{EconomyWide} = 1 - \frac{\dot{E}_{savings,economy\ wide,net}}{\dot{E}_{savings,device,direct,expected}}$$

$$Re_{EconomyWide} = 1 - \frac{0}{\dot{E}} = 1 \quad Re_{EconomyWide} = 1 - \frac{large\ E}{\dot{E}} < 0 \quad Re_{EconomyWide} = 1 - \frac{\dot{E}}{\dot{E}} = 0$$

$$Re_{EconomyWide} = Re_{dev} + Re_{emb} + Reres_{pend}$$

How much energy does energy efficiency save?



$$Re_{EconomyWide} = 1 - \frac{\dot{E}_{savings,economy\ wide,net}}{\dot{E}_{savings,device,direct,expected}}$$

Devices Studied

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Devices Studied

Calvin UNIVERSITY 1876

Case Study: Tennis and Track Lighting Control System

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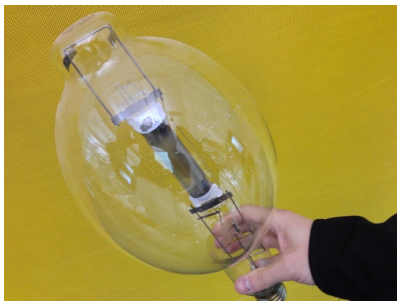
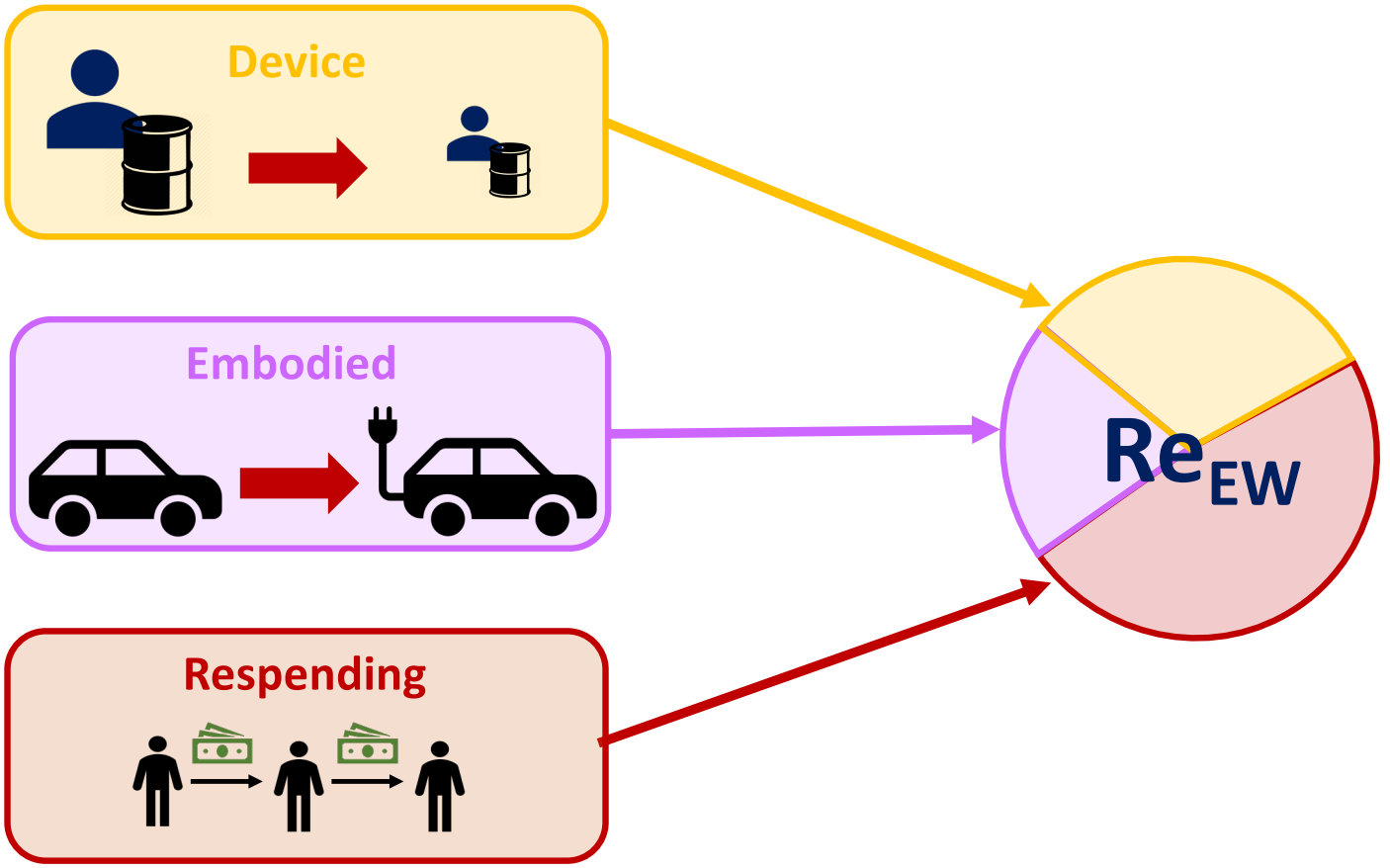
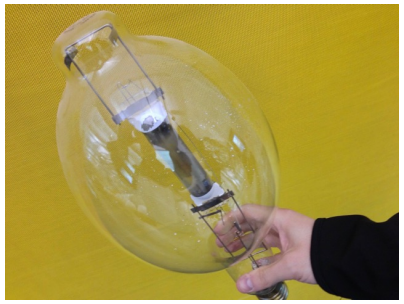


How much energy does energy efficiency save?

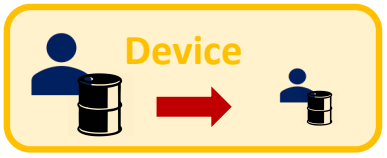


Case Study: Tennis and Track Lighting Control System



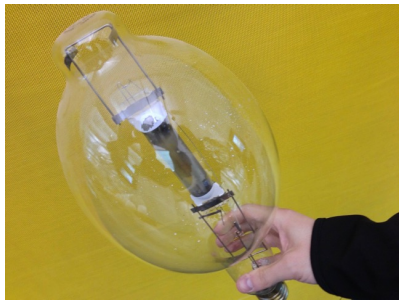
2,740 hr/yr

3,169 hr/yr



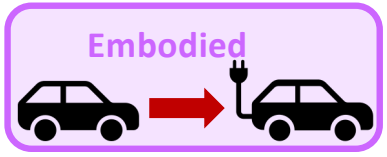
15%

Case Study: Tennis and Track Lighting Control System



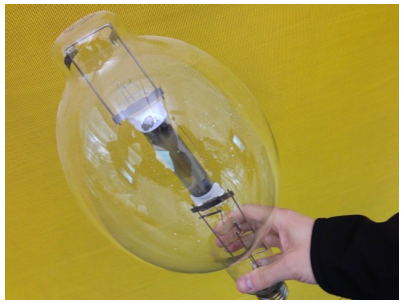
Embodied Energy 9x
Larger

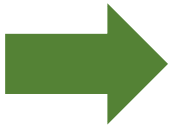
Usable Life 5x Longer



1%

Case Study: Tennis and Track Lighting Control System

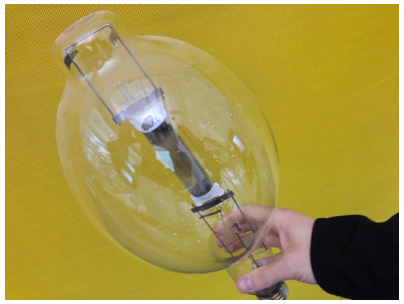




$9,504 [$/yr]

$8,721 [$/yr]

Case Study: Tennis and Track Lighting Control System



1,519,747 [MJ/yr]

$30,598 [$/yr]

374,043 [MJ/yr]

$7,531 [$/yr]

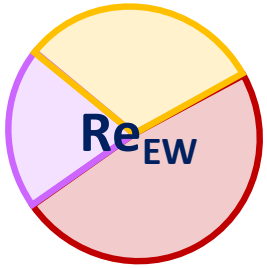
148%

Equation for Rebound

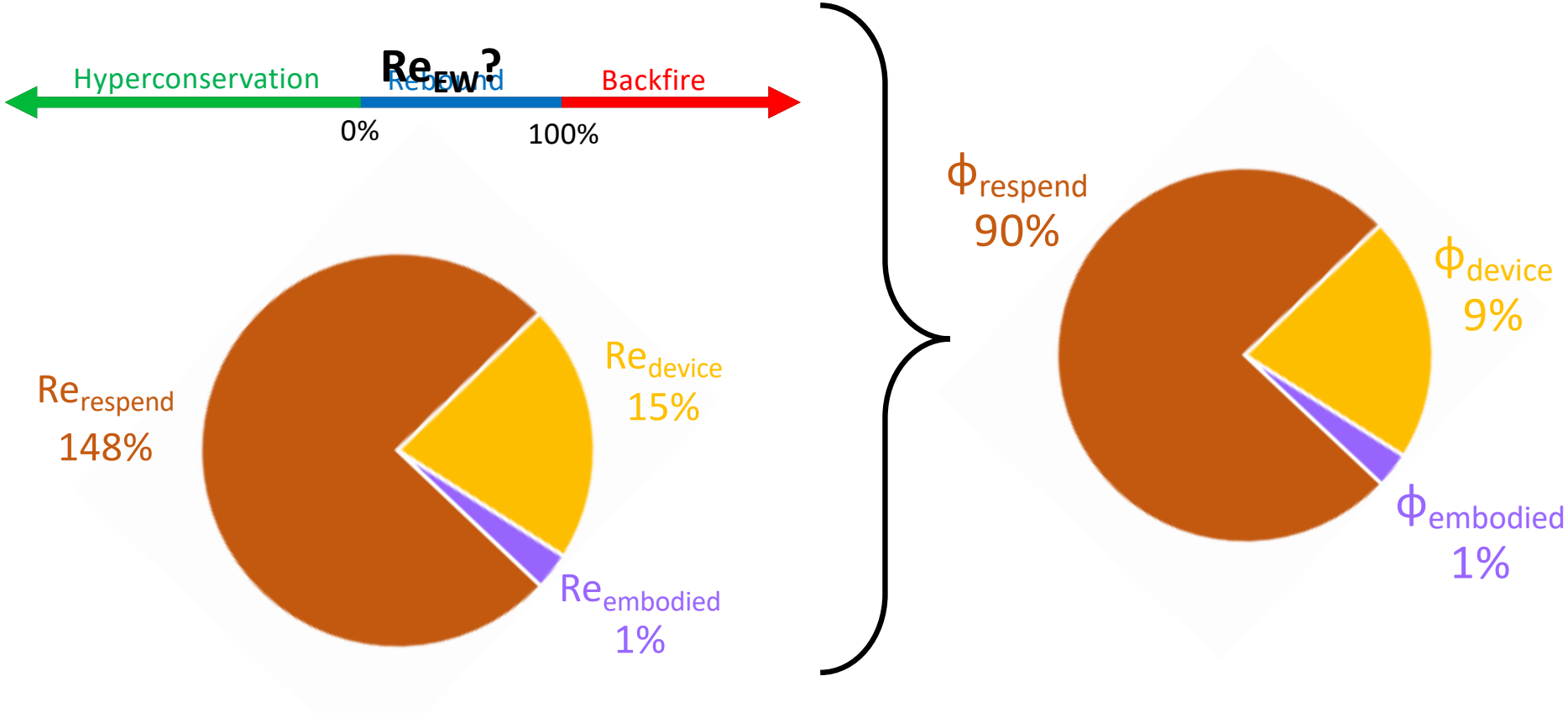
$$Re_{EconomyWide} = Re_{dev} + Re_{emb} + Rerespend$$

$$164\% = 15\% + 1\% + 148\%$$

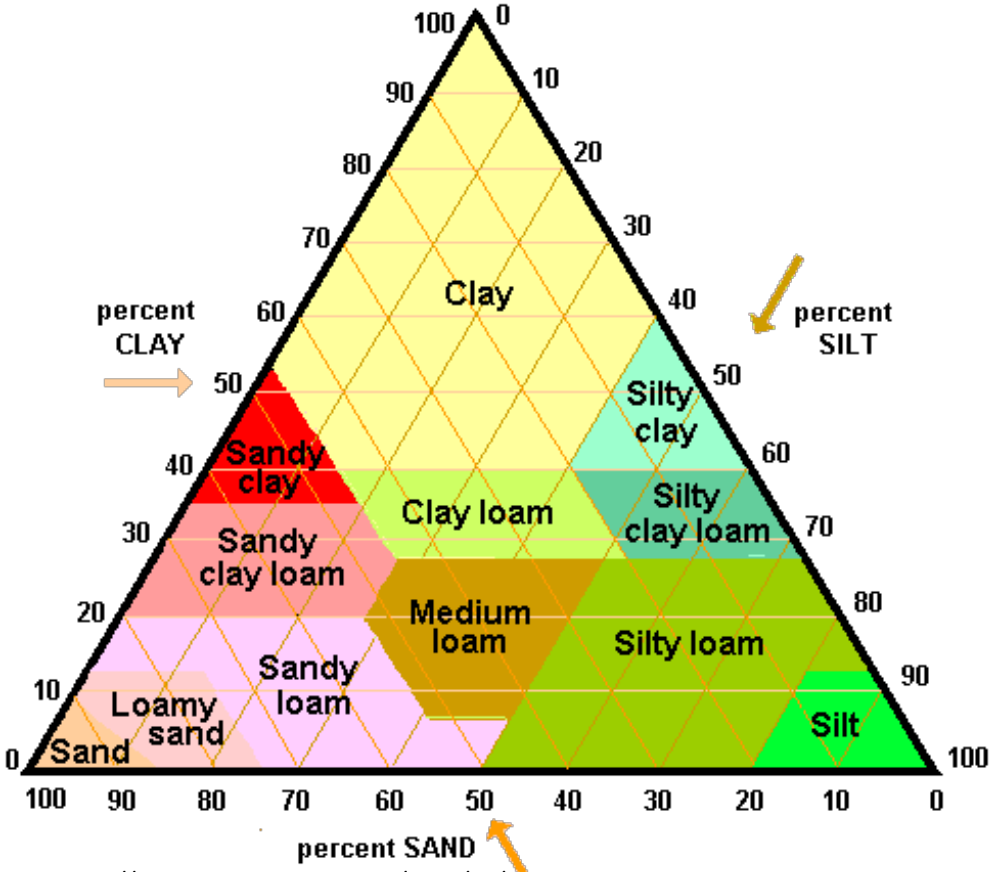
Case Study: Tennis and Track Lighting Control System



How much energy does energy efficiency save?

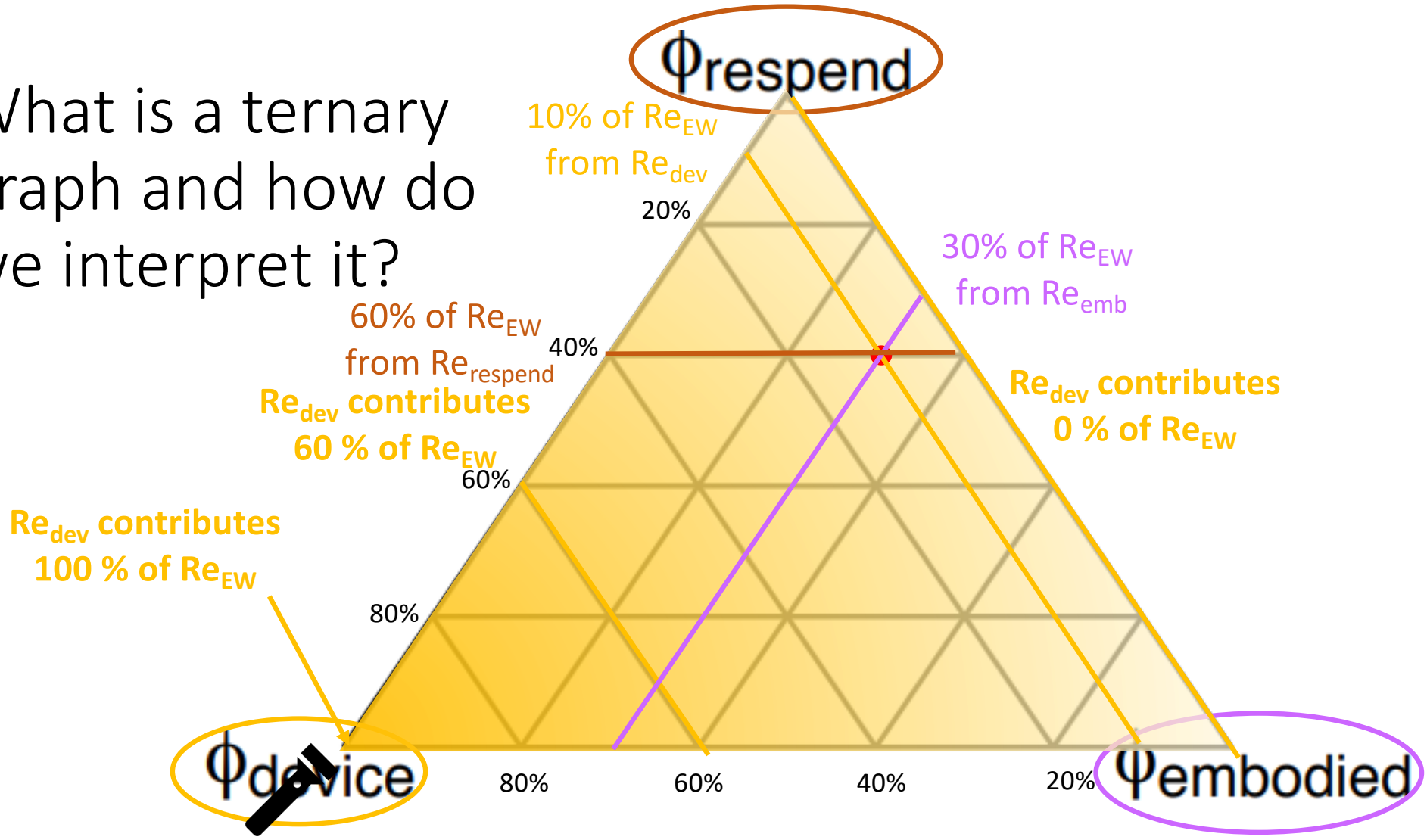


Ternary Graph

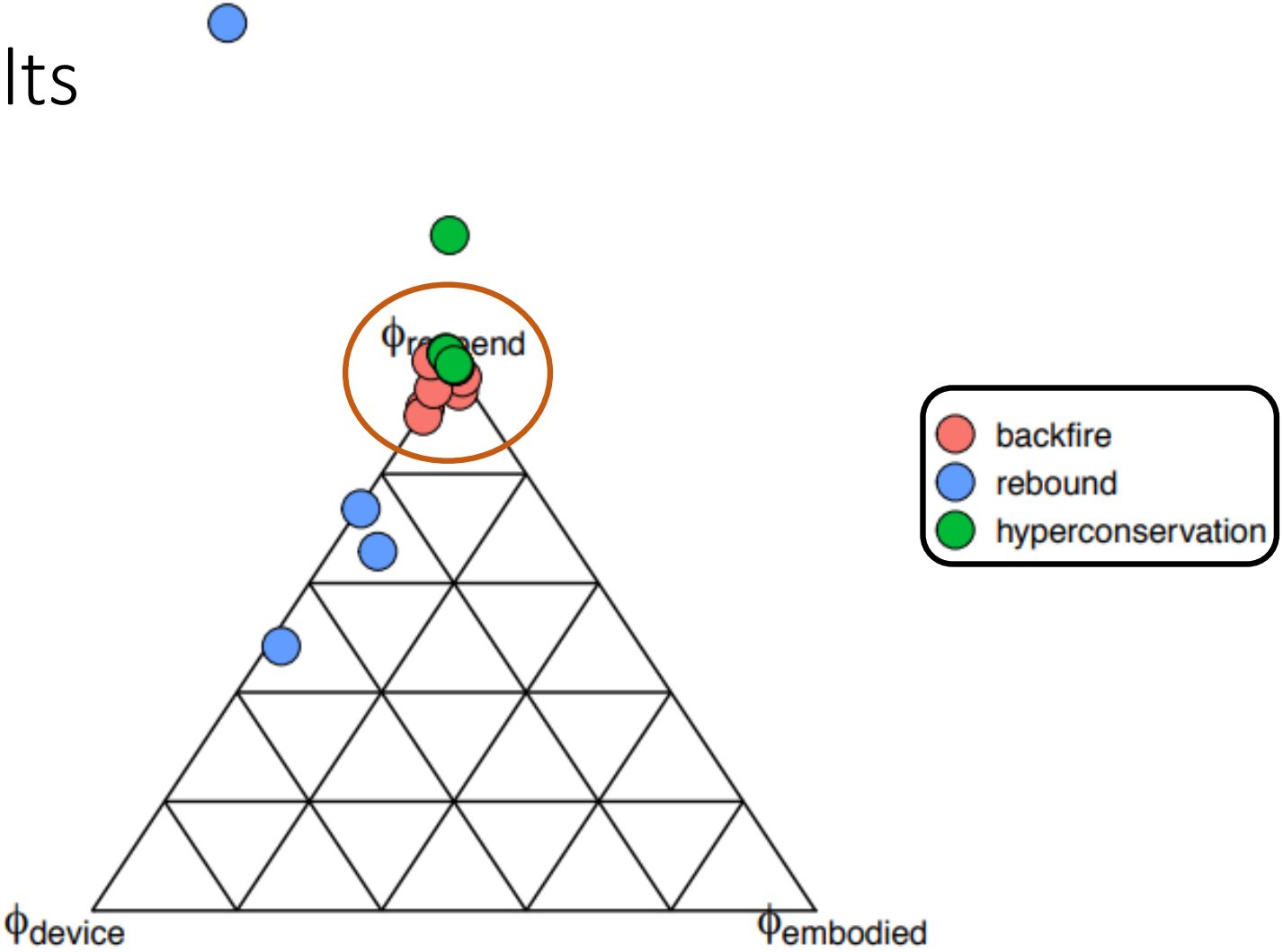


http://perezmaps.blogspot.com/2011/03/triangular-plot.html

What is a ternary graph and how do we interpret it?



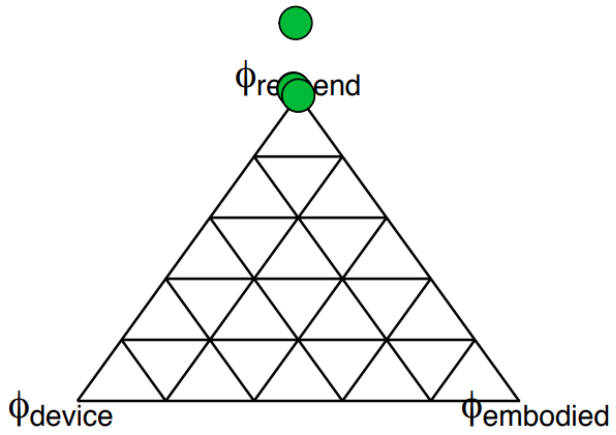
Overall Results



Economy-Wide Impacts

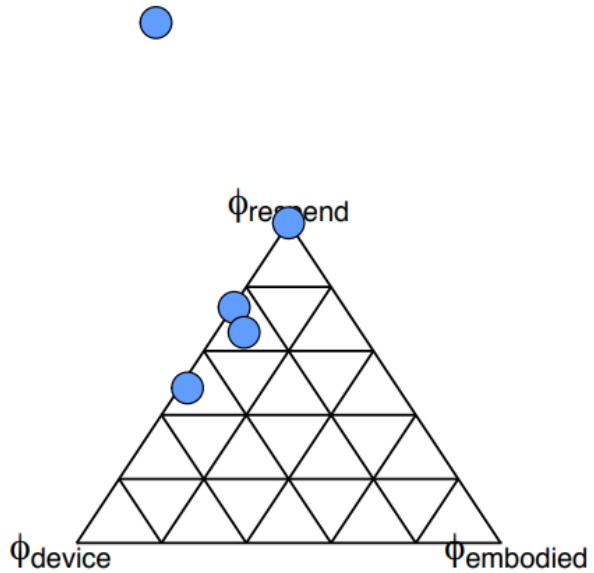
Hyperconservation:

Saves more energy than expected



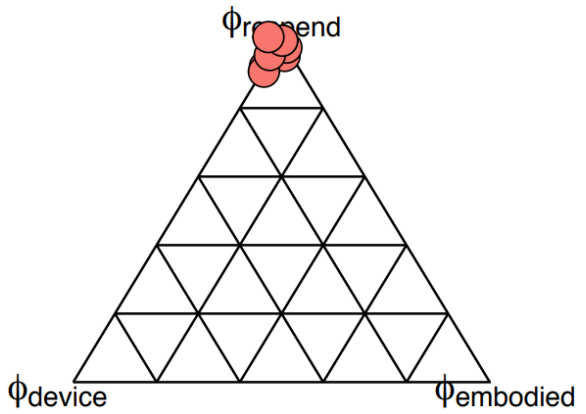
Rebound:

Saves energy, but less than expected

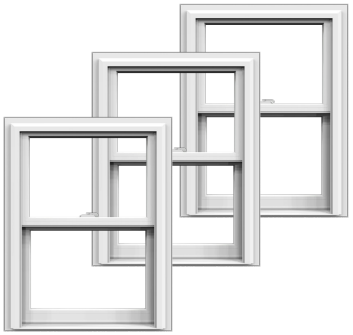


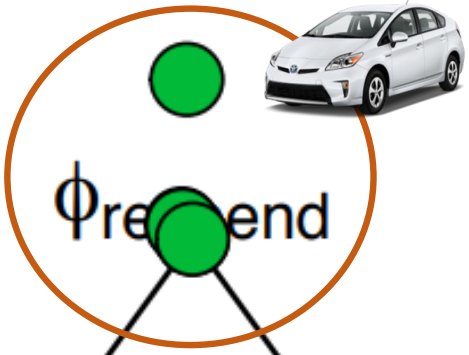
Backfire:

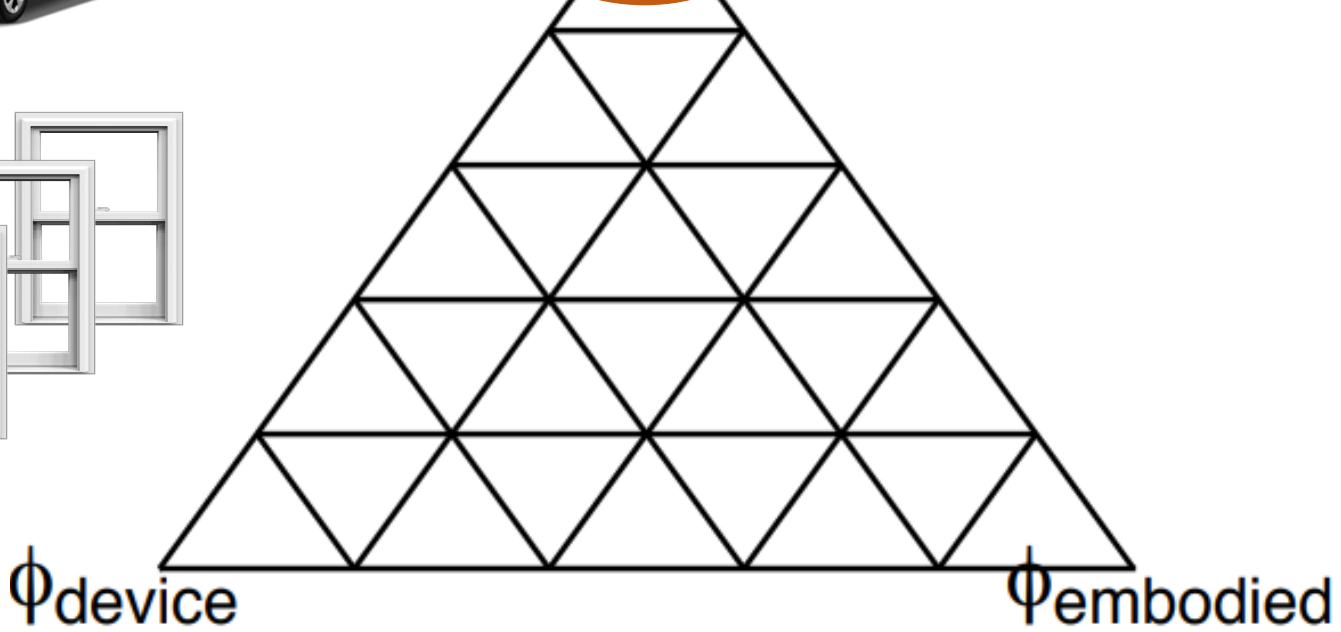
Uses more energy than before



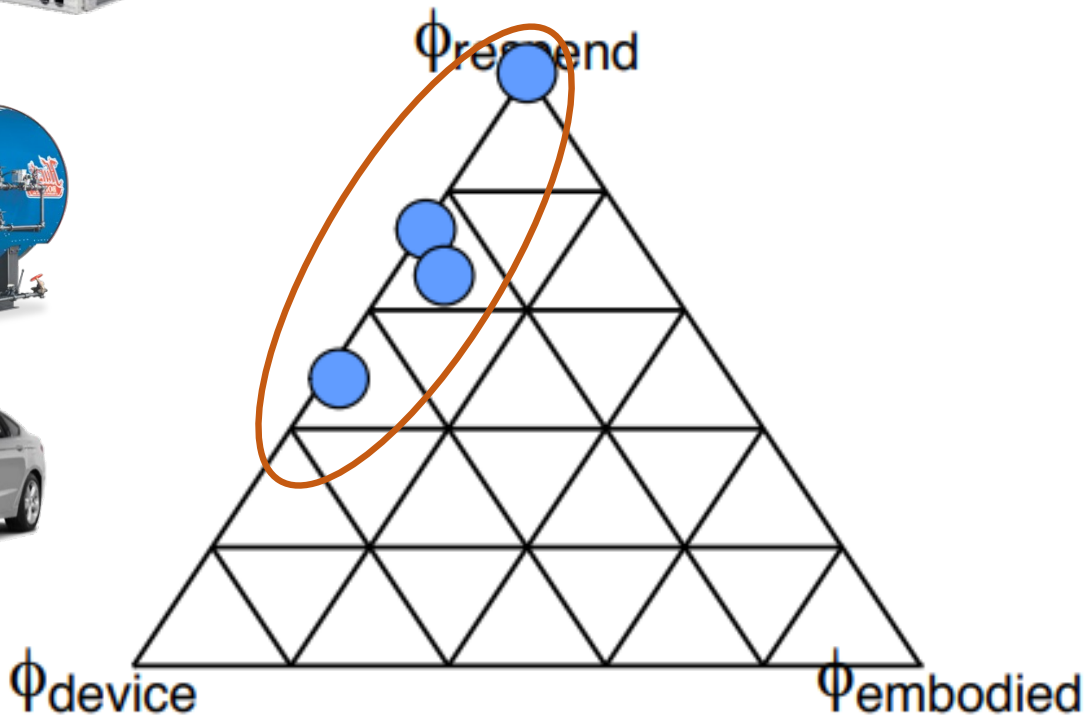
Hyperconservation



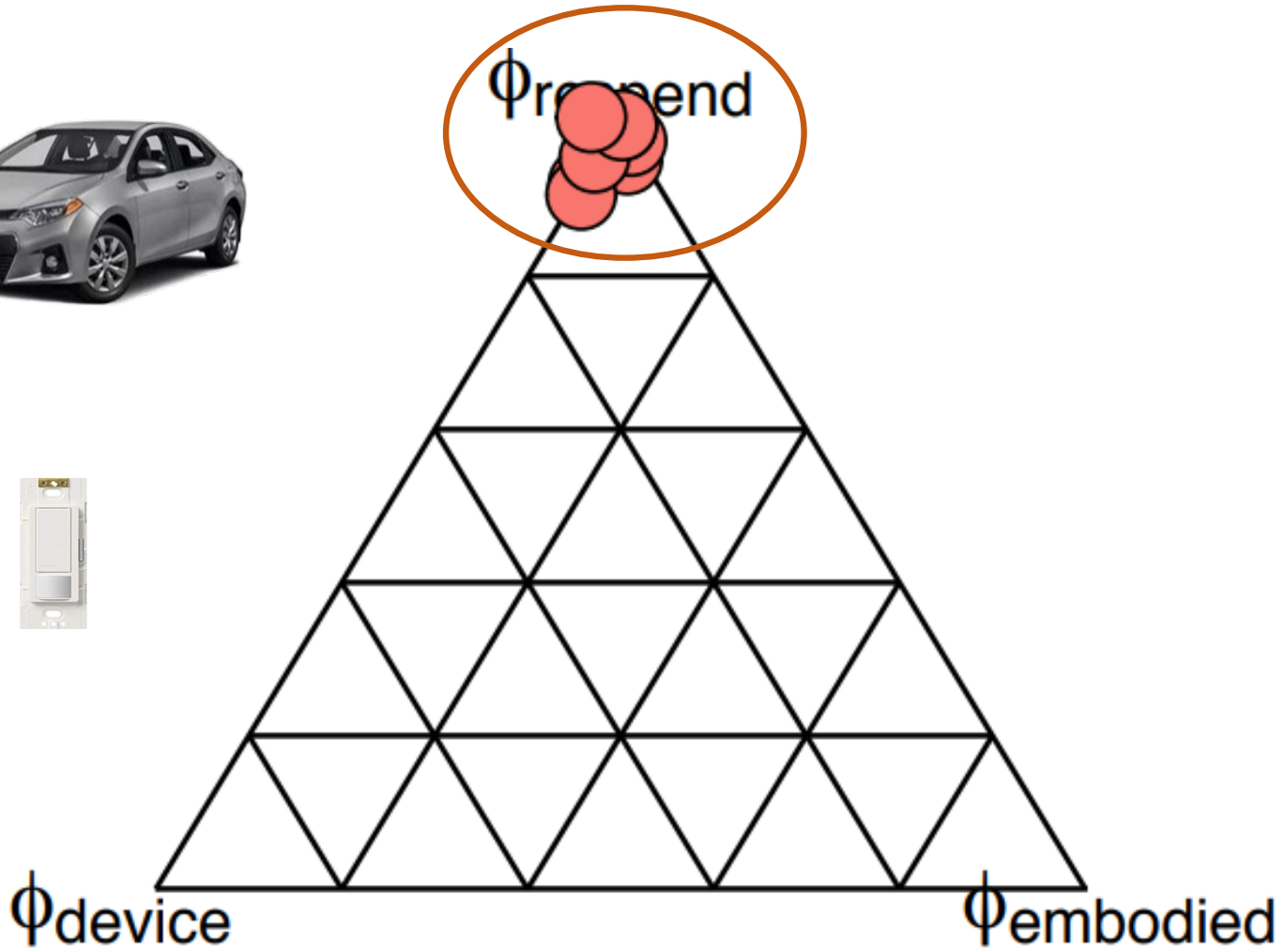




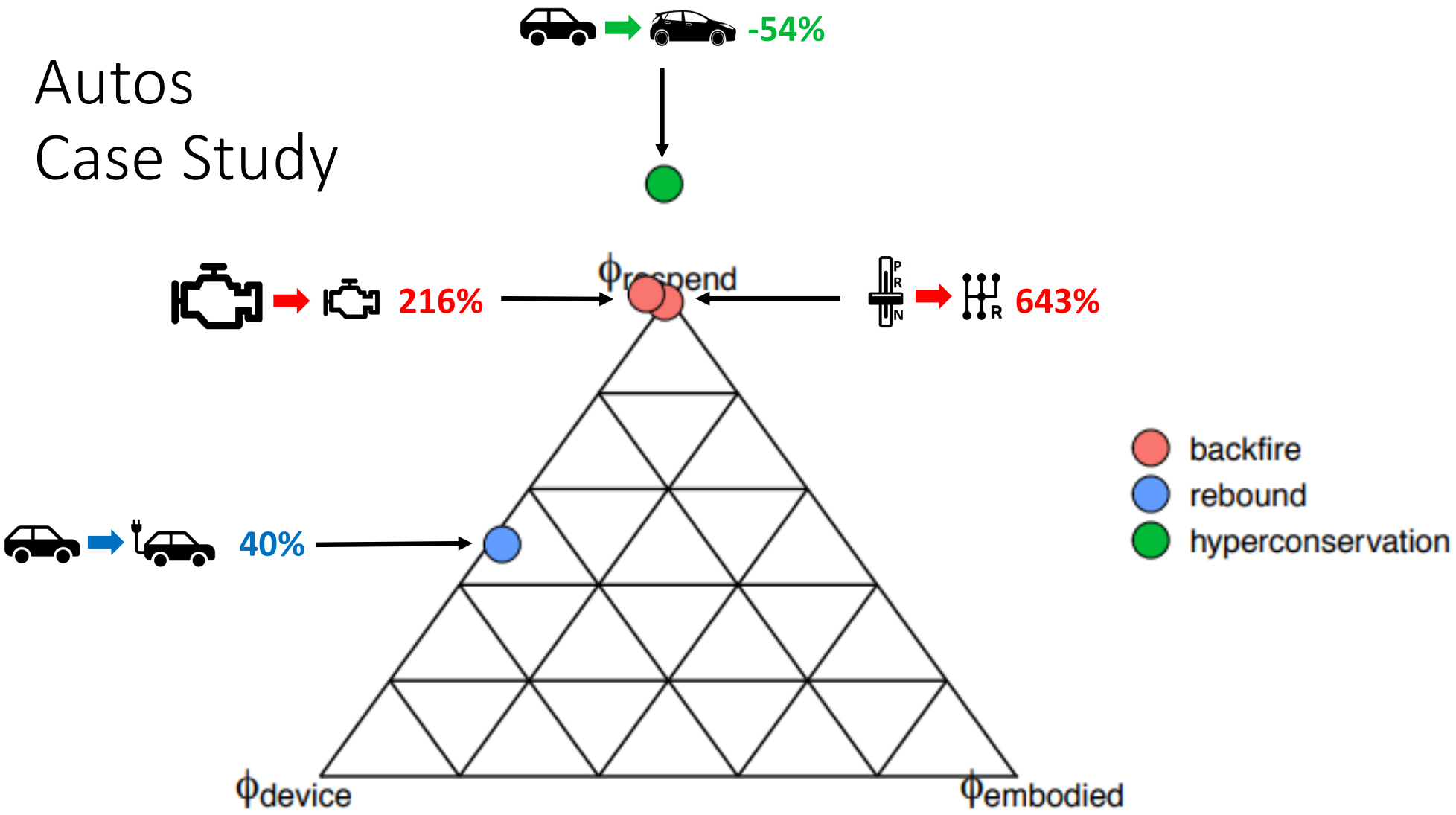
Rebound



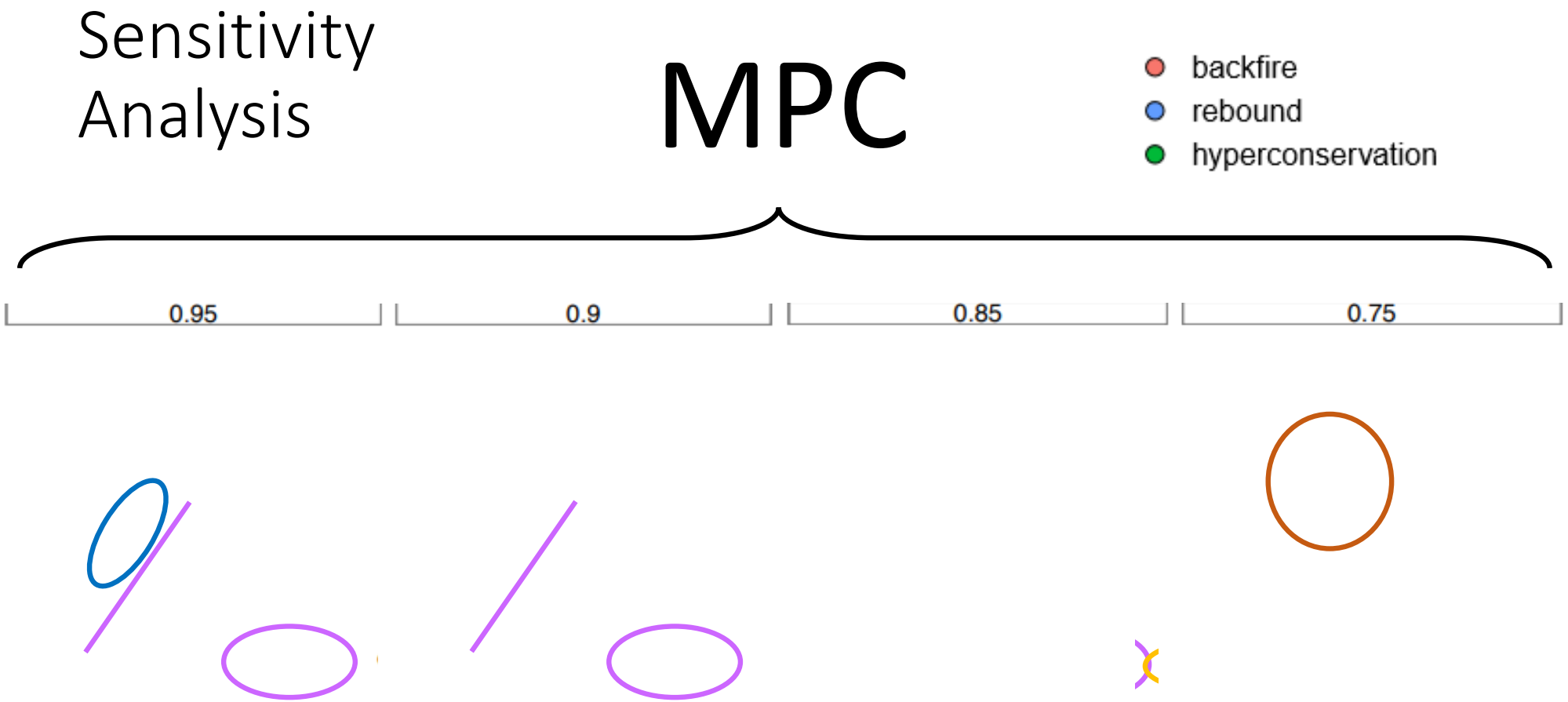
Backfire



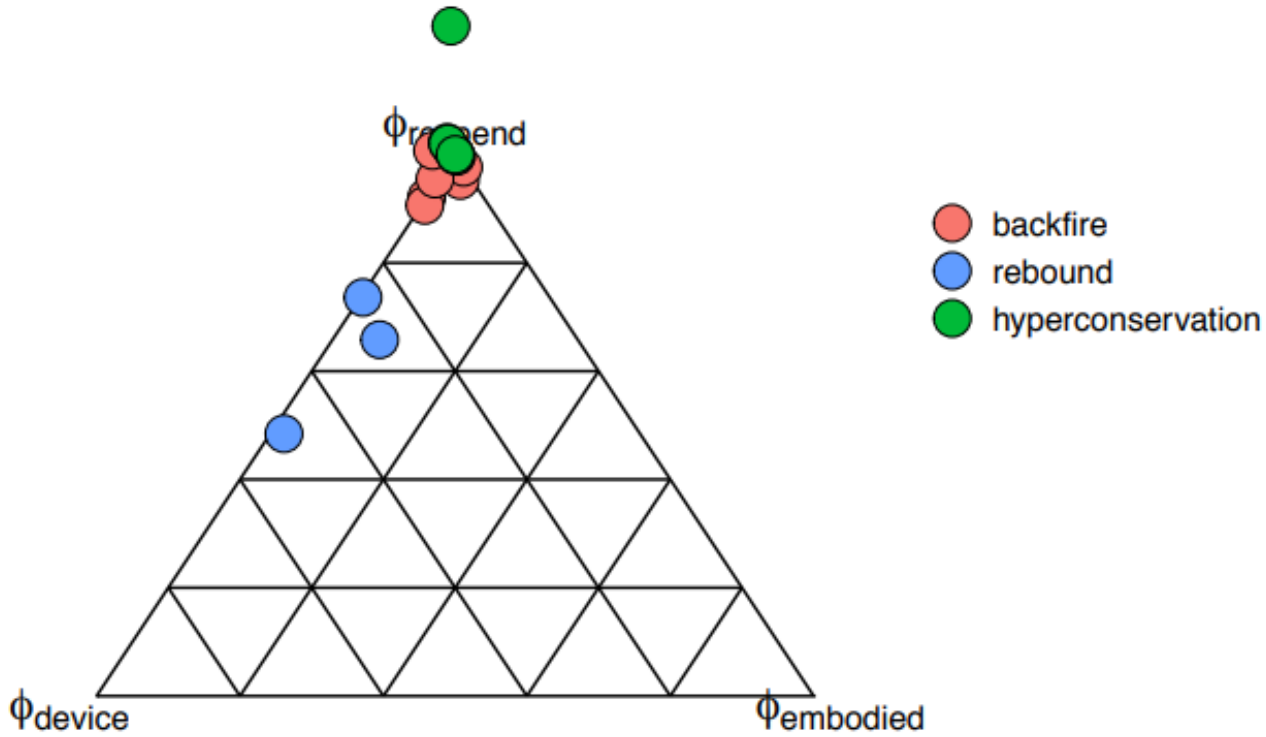
Autos
Case Study



Sensitivity Analysis



How much energy does energy efficiency save?



Mitigating Rebound

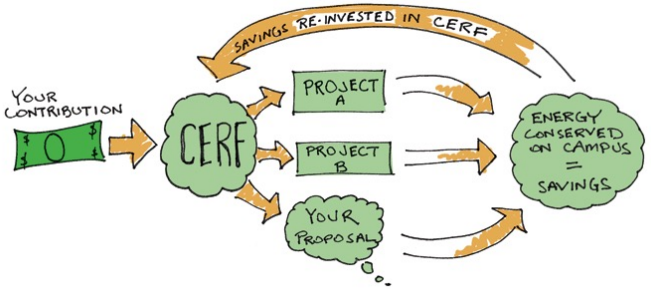
Device Level Rebound

https://www.adazing.com/book-clipart/

Embodied Energy Rebound

http://www.solidworks.com/sustainability/sustainable-design-guide.htm

Respending Rebound



https://calvin.edu/support/energy/

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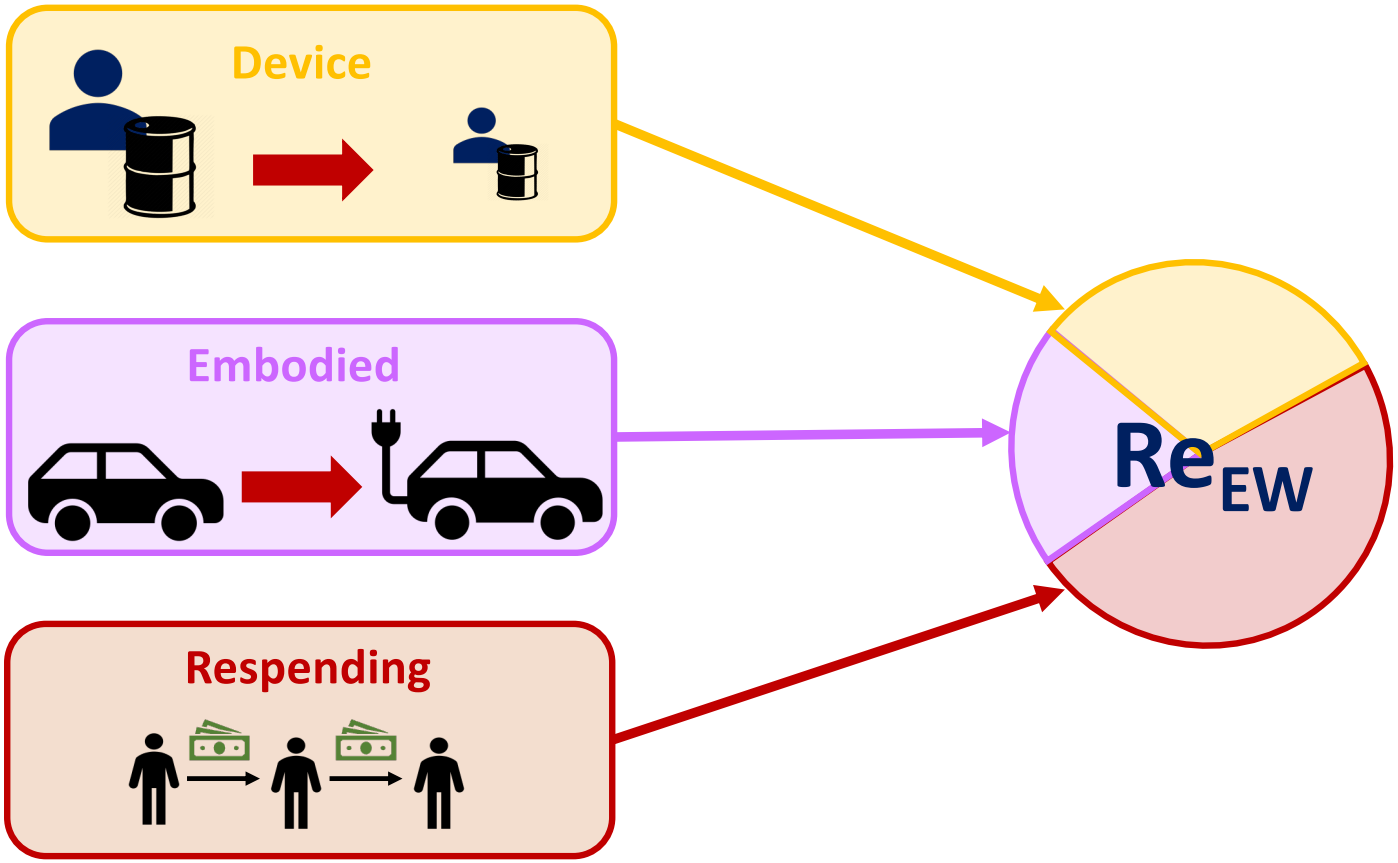

Further Questions

- Does education *actually* have an impact on device level rebound?
- Are there ways to design products that reduce device level rebound?
- How do you design products to minimize embodied energy rebound?
- How do energy revolving funds influence economy wide rebound?
- Are there ways to implement revolving funds at a community level?
- Are there policy changes that could impact economy wide rebound?
- Does the size of the economy effect rebound?

Acknowledgements

- Dr. Paul Brockway from the University of Leeds, UK
- Calvin Energy Recovery Fund (CERF)
- Kyle Bratt from the Window Center in Holland, MI
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- Keith Van Kooten and Larry VanHoe from Calvin Facilities
- Travis Vander Kolk from Hurst Boiler and Welding Co.
- Gary Rutman from Burnham Commercial Boilers
- Mike Troupos from Foresight Energy Management

Questions