Energy Efficiency Potential

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Stanford University

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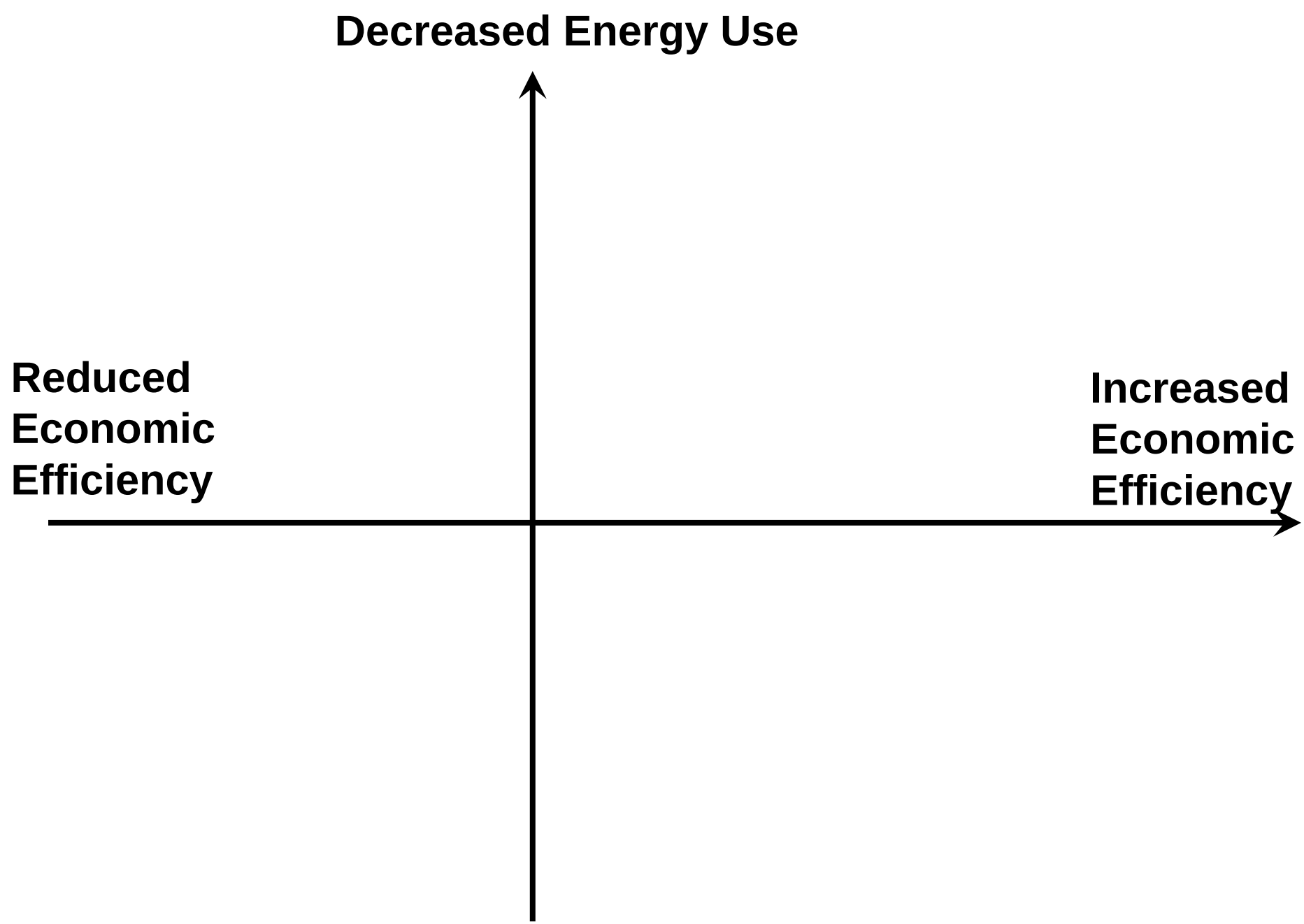
Energy Efficiency:

Economically Efficient Reductions in Energy Use Intensity



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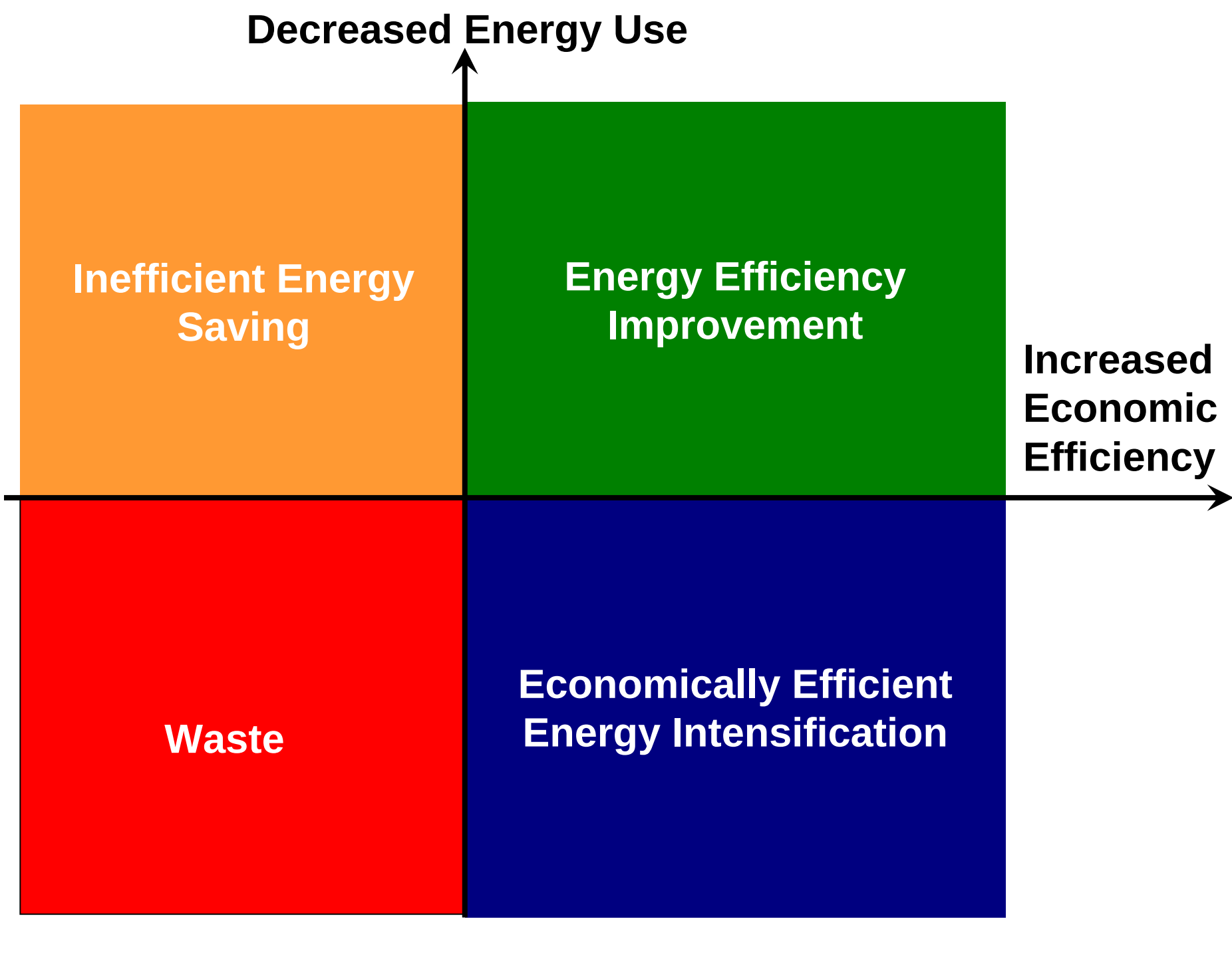
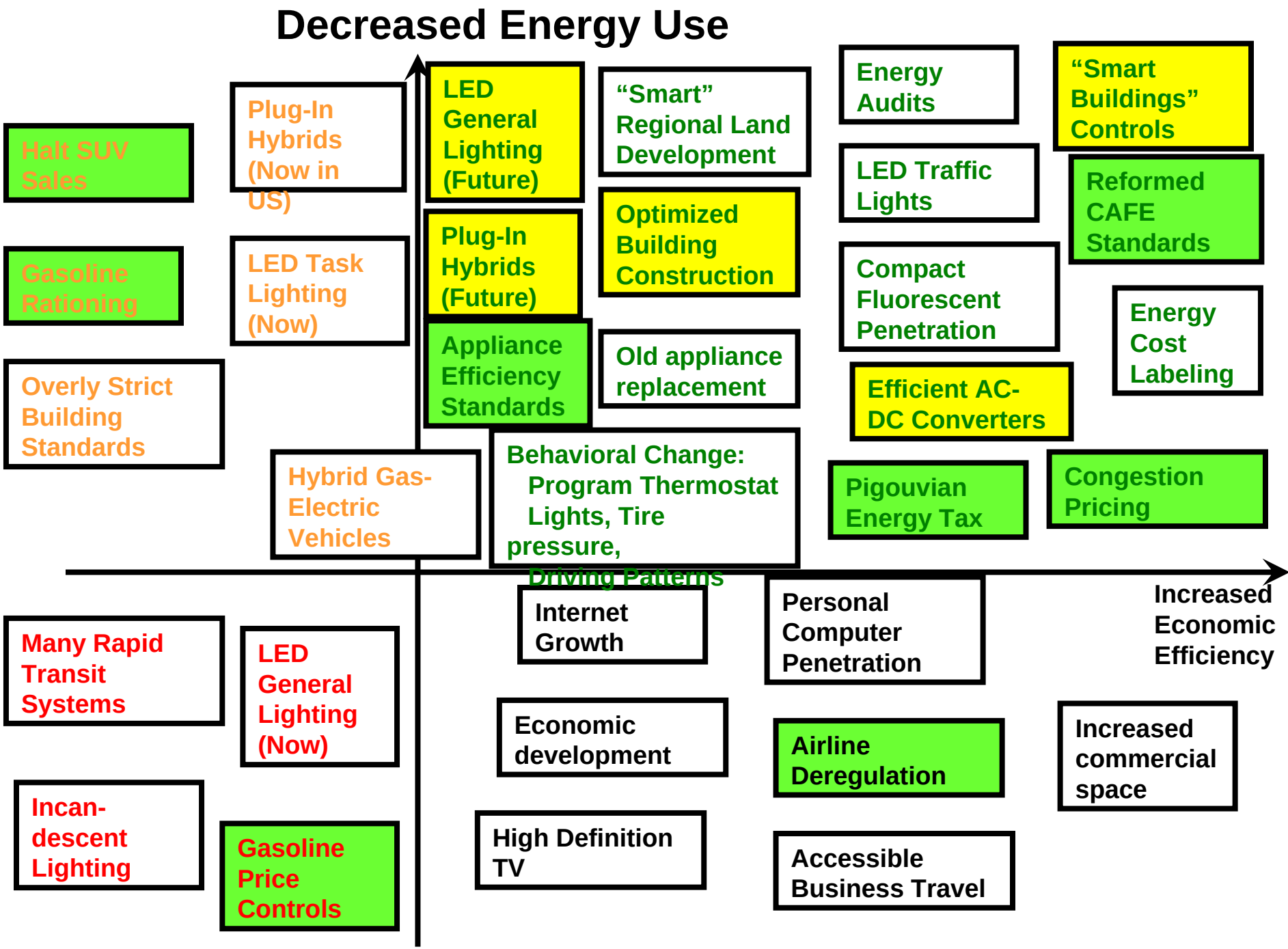
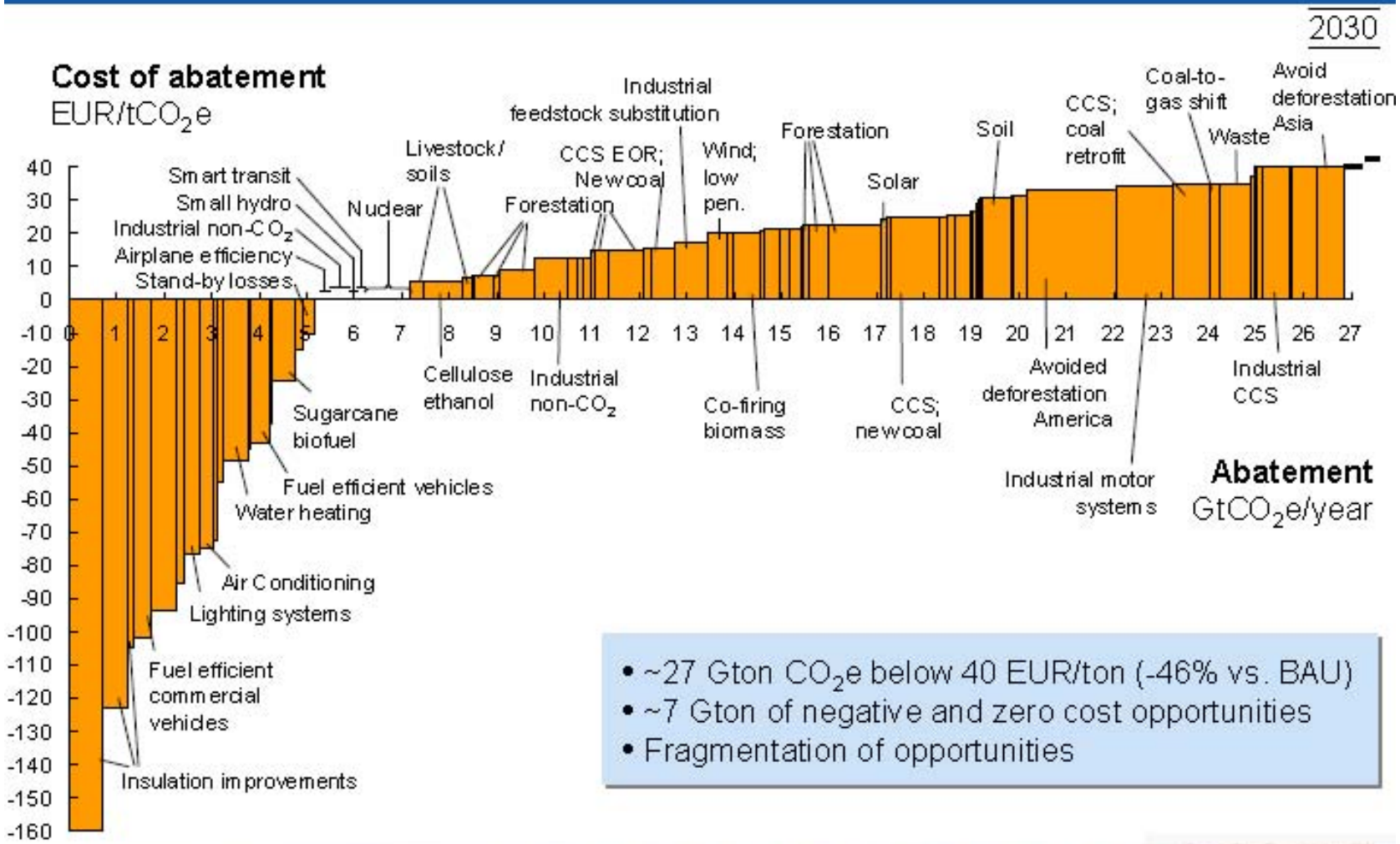

Decreased Energy Use
Inefficient Energy Saving
Energy Efficiency Improvement
Increased Economic Efficiency
Waste
Economically Efficient Energy Intensification


Decreased Energy Use
Halt SUV Sales
Plug-In Hybrids (Now in US)
LED General Lighting (Future)
"Smart" Regional Land Development
Energy Audits
"Smart Buildings" Controls
Gasoline Rationing
LED Task Lighting (Now)
Plug-In Hybrids (Future)
Optimized Building Construction
LED Traffic Lights
Reformed CAFE Standards
Overly Strict Building Standards
Appliance Efficiency Standards
Old appliance replacement
Compact Fluorescent Penetration
Energy Cost Labeling
Efficient AC-DC Converters
Hybrid Gas-Electric Vehicles
Behavioral Change: Program Thermostat Lights, Tire pressure, Driving Patterns
Pigouvian Energy Tax
Congestion Pricing
Increased Economic Efficiency
Many Rapid Transit Systems
LED General Lighting (Now)
Internet Growth
Personal Computer Penetration
Economic development
Airline Deregulation
Increased commercial space
Incan-descent Lighting
Gasoline Price Controls
High Definition TV
Accessible Business Travel

Global cost curve of GHG abatement opportunities beyond business as usual



- ~27 Gton CO_2e below 40 EUR/ton (-46% vs. BAU)
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities

VATTENFALL

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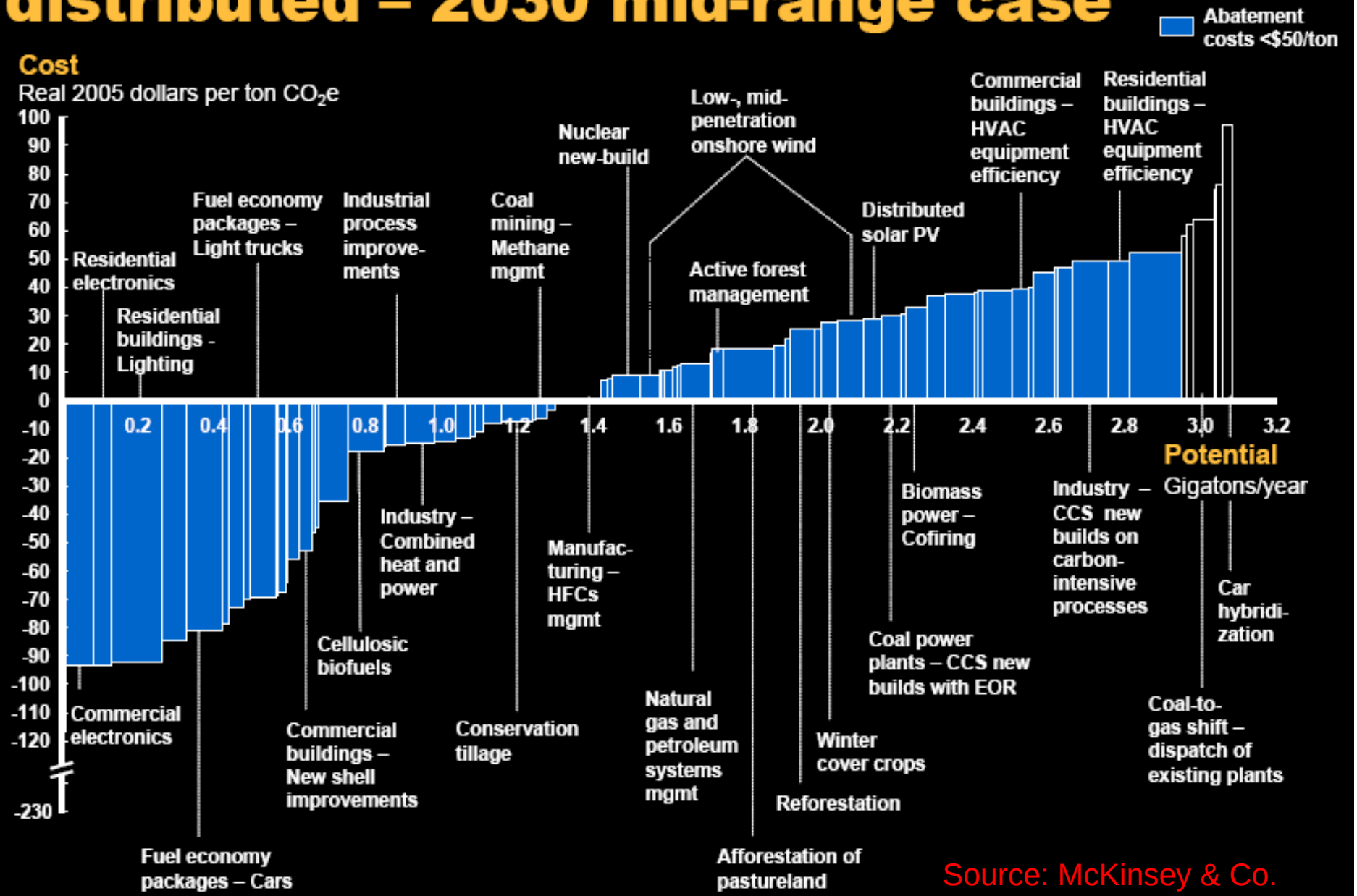
GHG reduction opportunities widely distributed – 2030 mid-range case

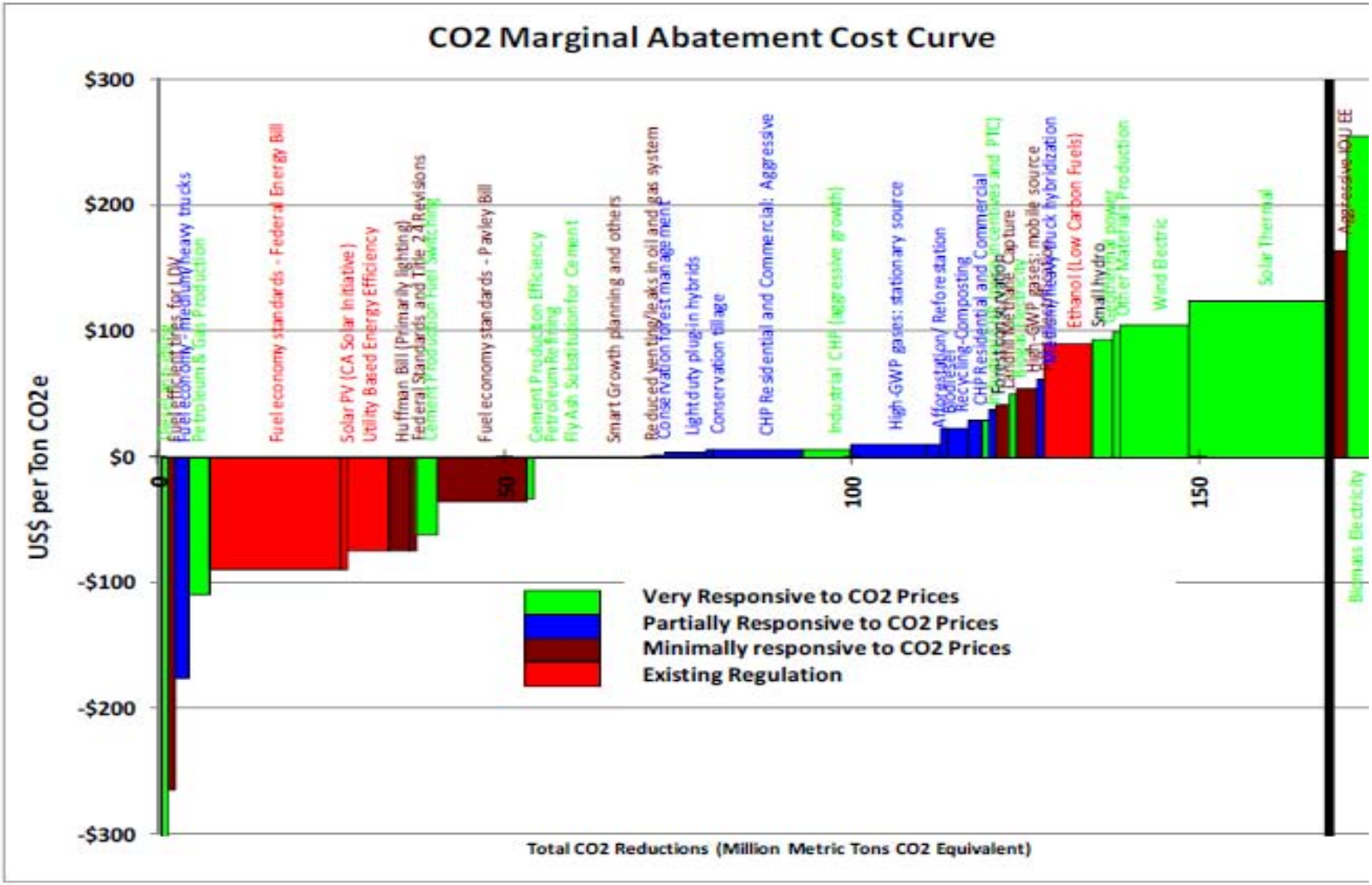


Source: McKinsey & Co.

Issues With MAC Curves for EE

- **Dependence on Baseline Projection of GHGs**
- **Insuring Consistency of Assumptions Across Individual Measures**
- **Can't Look at General Equilibrium Effects**
- **Challenge of Identifying Policies to Achieve GHG Reductions**
- **Many of The Negative Cost Options Have Been Around for Awhile, But Not Implemented**

PEEC California MAC Curve



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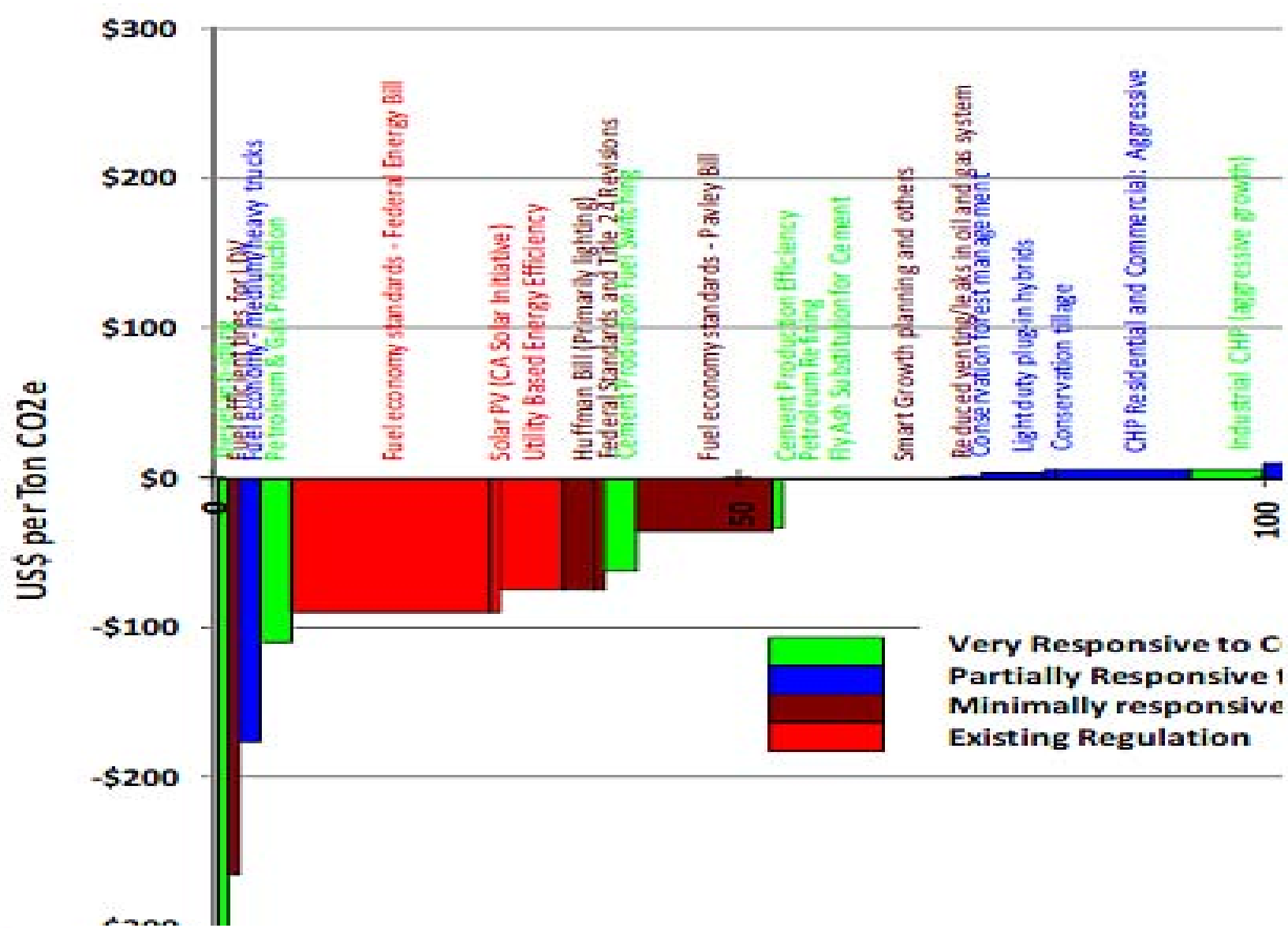
A Lot of Low Cost Potential



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Value of MACs for EE

- **Identify Easy Options to Focus On**
- **Understand Where Barriers or Market Barriers Might Exist**
- **Springboard for Better Empirical Models**
- **Get Insights for Building Better Hybrid Models**
- **But Recognize EE May Be a Largely Non-Renewable Resource**

Why Do Negative Cost Options Continue ?

Traditional View: Market Failures and Market Barriers

Market failures	Market barriers
Unpriced costs and benefits	Low priority of energy issues
Distortionary regulatory and fiscal policies	Incomplete markets for energy efficiency
Misplaced incentives	Capital market barriers
Insufficient and inaccurate information	(Cognitive Skills)

Source: Brown, Marilyn. 2001. “Market failures and barriers as a basis for clean energy policies.” *Energy Policy*

Externalities

- **Externalities of Energy Use (“Unpriced costs and benefits”)**
  - **Global Climate Change**
  - **Risks of Energy Price Shocks**
  - **Limitations on our Foreign Policy Options**
  - **Terms of Trade Impacts (Pecuniary “Externalities”)**
  - **Automobile risk shifting by purchase of heavy vehicles**

- **Jurisdictional Differentiations**
  - **Oil Strategic**
  - **Fossil Fuel Greenhouse Gases**

- **R&D Externalities**
  - **Individual firm may not be able to capture all benefits (especially significant for environmental benefits)**

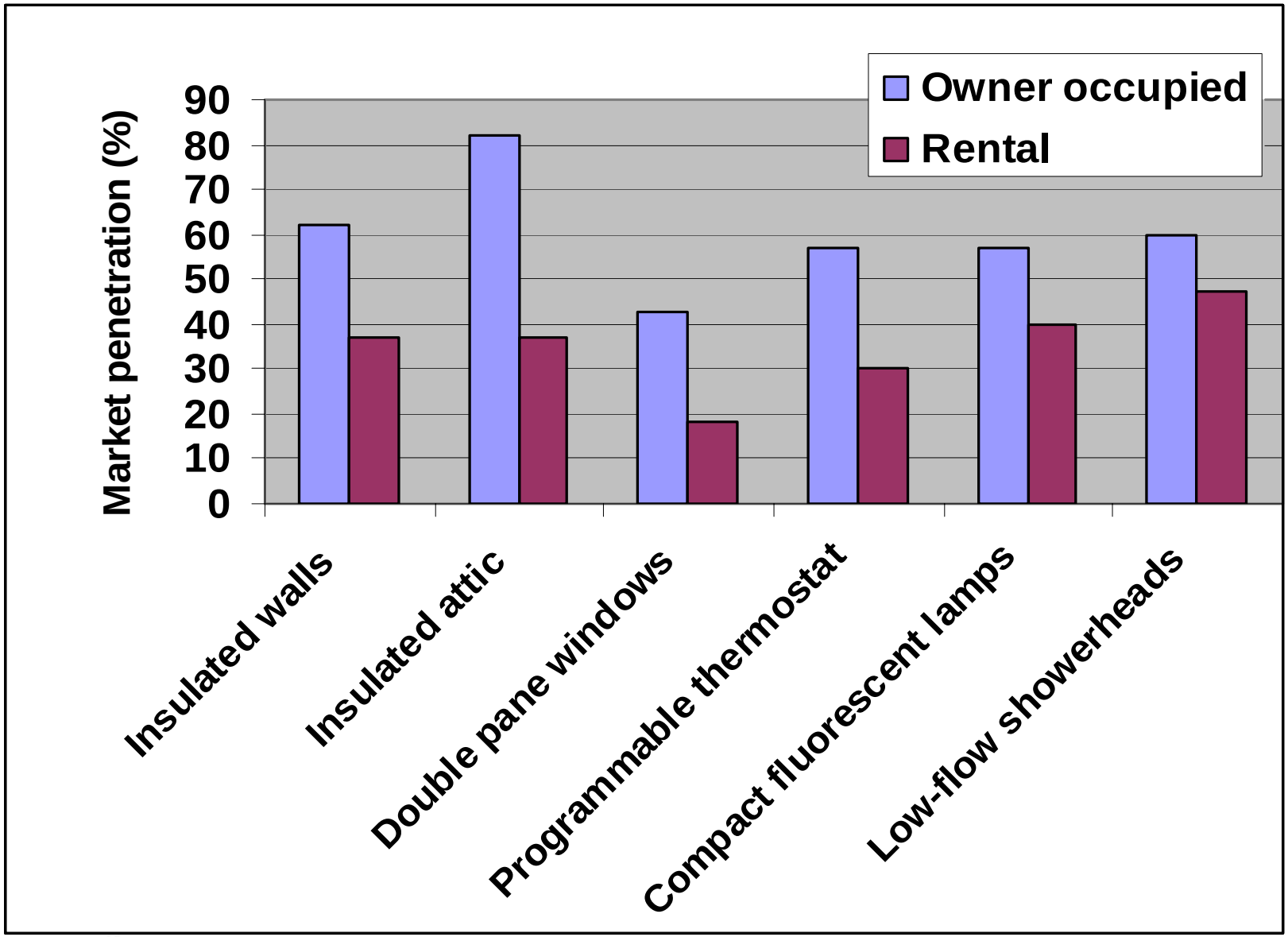
Agency Problems

- **Where is problem?**
  - **New Building Construction**
  - **Rental vs Owner-Occupied buildings**
  - **Consumer Product Design**
  - **Consumer Product Marketing**

- **Information/cognitive limitations generally central to agency problems**
  - **Automobile Design**
  - **Electricity Use by TVs, Passive chargers**

- **Incomplete markets for energy efficiency**
  - **Discrete nature of commodities Offered for Sale**
  - **Information Problems When Offering Energy Efficiency Services**

Agency Problem: Market Penetration of Energy Efficiency Measures in Owner-Occupied and Rental Housing in California (CEC 2004)



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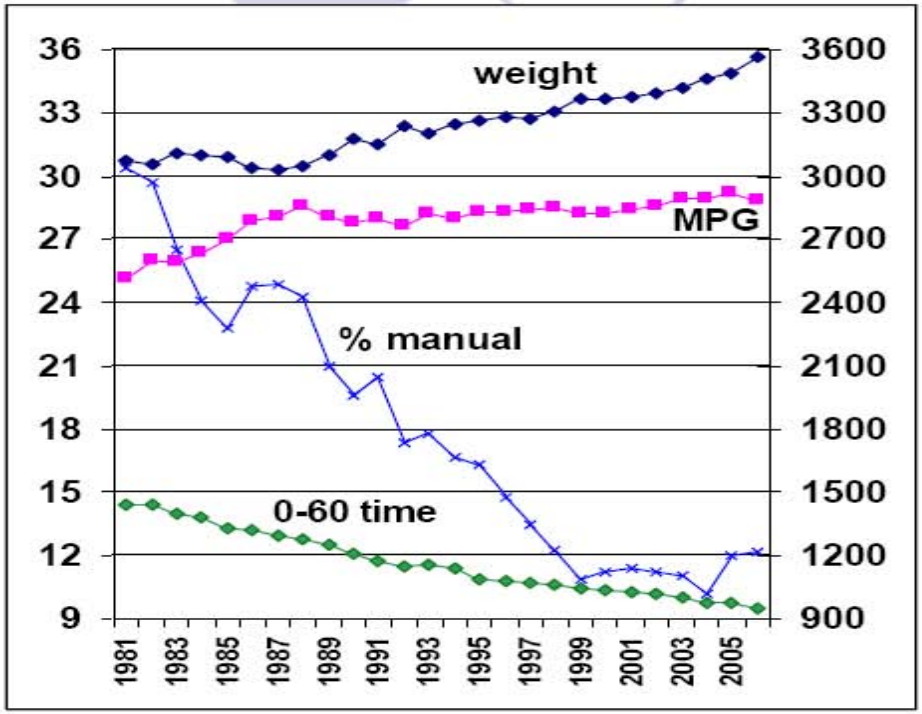
Market Barriers: Agency/Cognitive

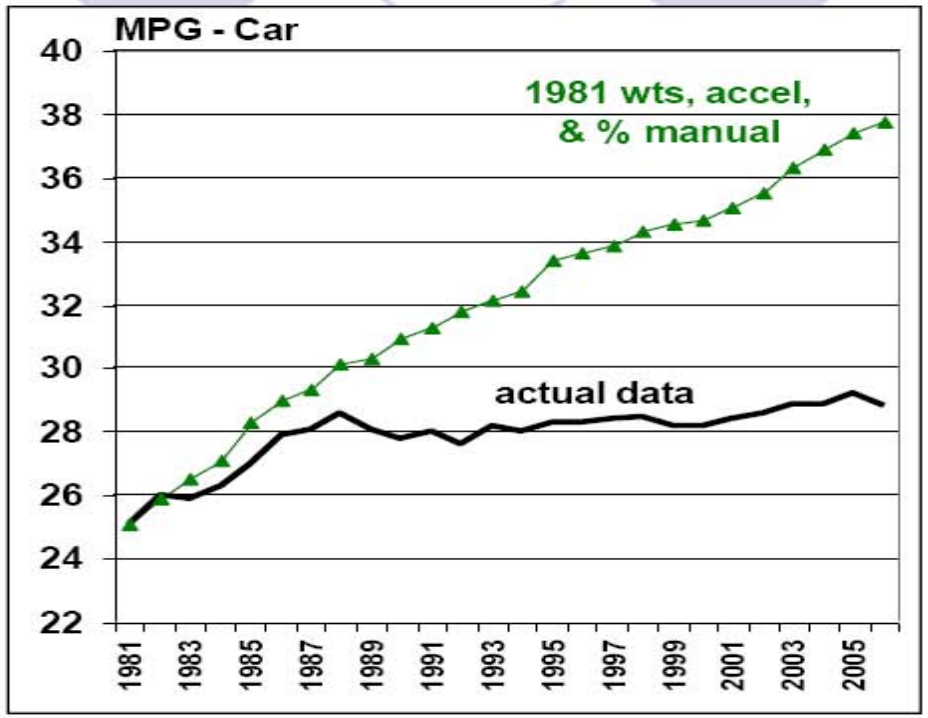
- Automobile purchase
  - Automobile purchase decisions
    - First cost bias
      - Failure to calculate operating costs
      - Belief that resale value will be independent of fuel economy
  - Automobile design decisions
    - Understand first cost bias
    - Don't design optimally efficient cars
  - Consumers don't have option to choose optimally efficient cars because they are not offered for sale
  - Market stays in equilibrium
  - Concept that consumers learn randomly is not applicable if there are no available options from which to learn randomly.

Example: Light Duty Vehicles

Since 1987 (CAFE standards constant since 1985) technological advances have been used to improve attributes other than fuel economy.

Car Data from EPA's 2006 FE Trends Report



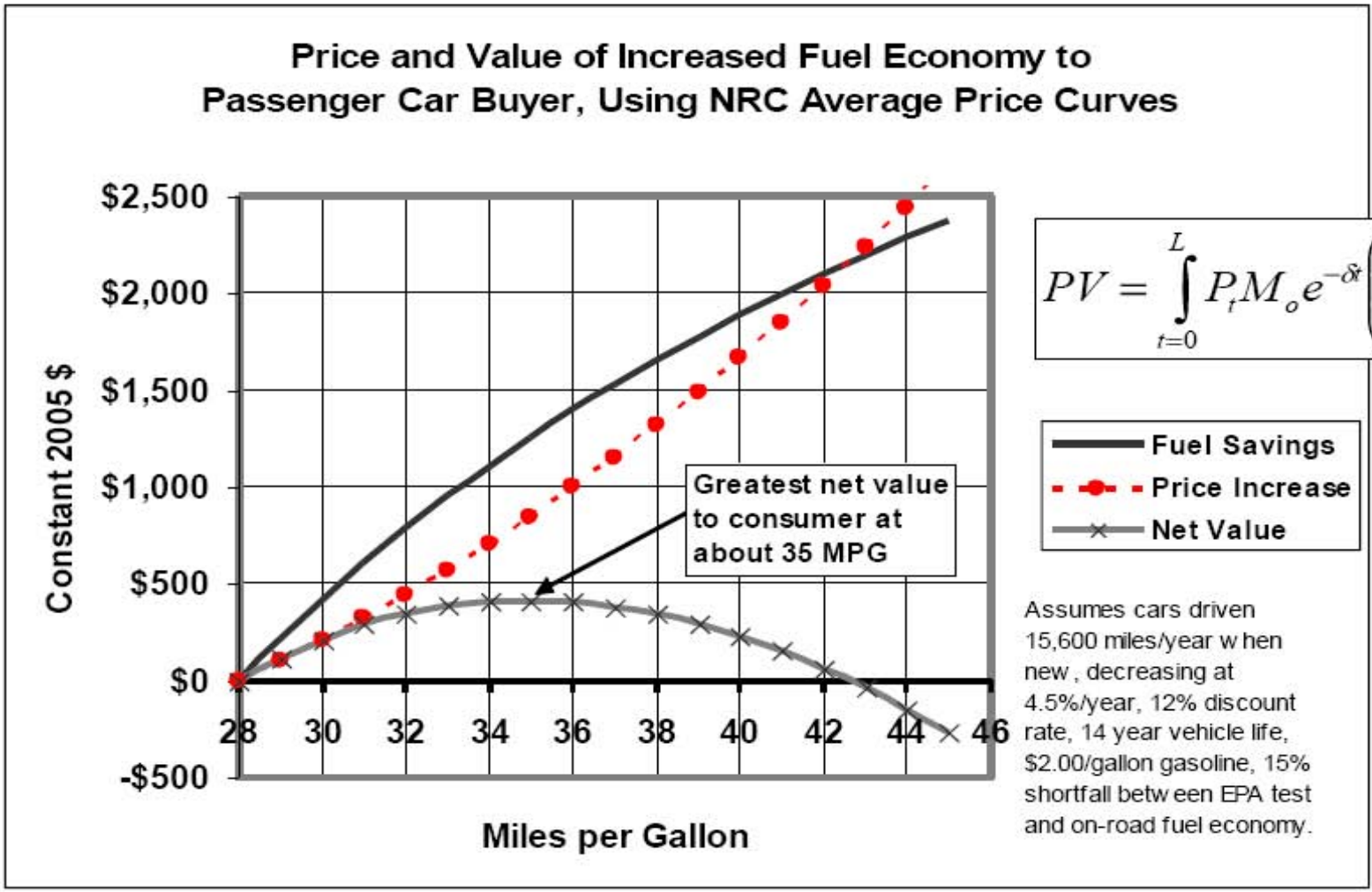


Fuel efficiency has increased by about 1.3% per year since 1987

However, this has all been used to increase other attributes more highly valued by the customer, such as performance, comfort, utility, and safety

Source: David Greene – Oak Ridge National Laboratory

Automobiles (Continued)



$$PV = \int_{t=0}^{L} P_t M_o e^{-\delta t} \left(\frac{1}{E_o} - \frac{1}{E_1} \right) e^{-rt} dt$$

Source: David Greene – Oak Ridge National Laboratory

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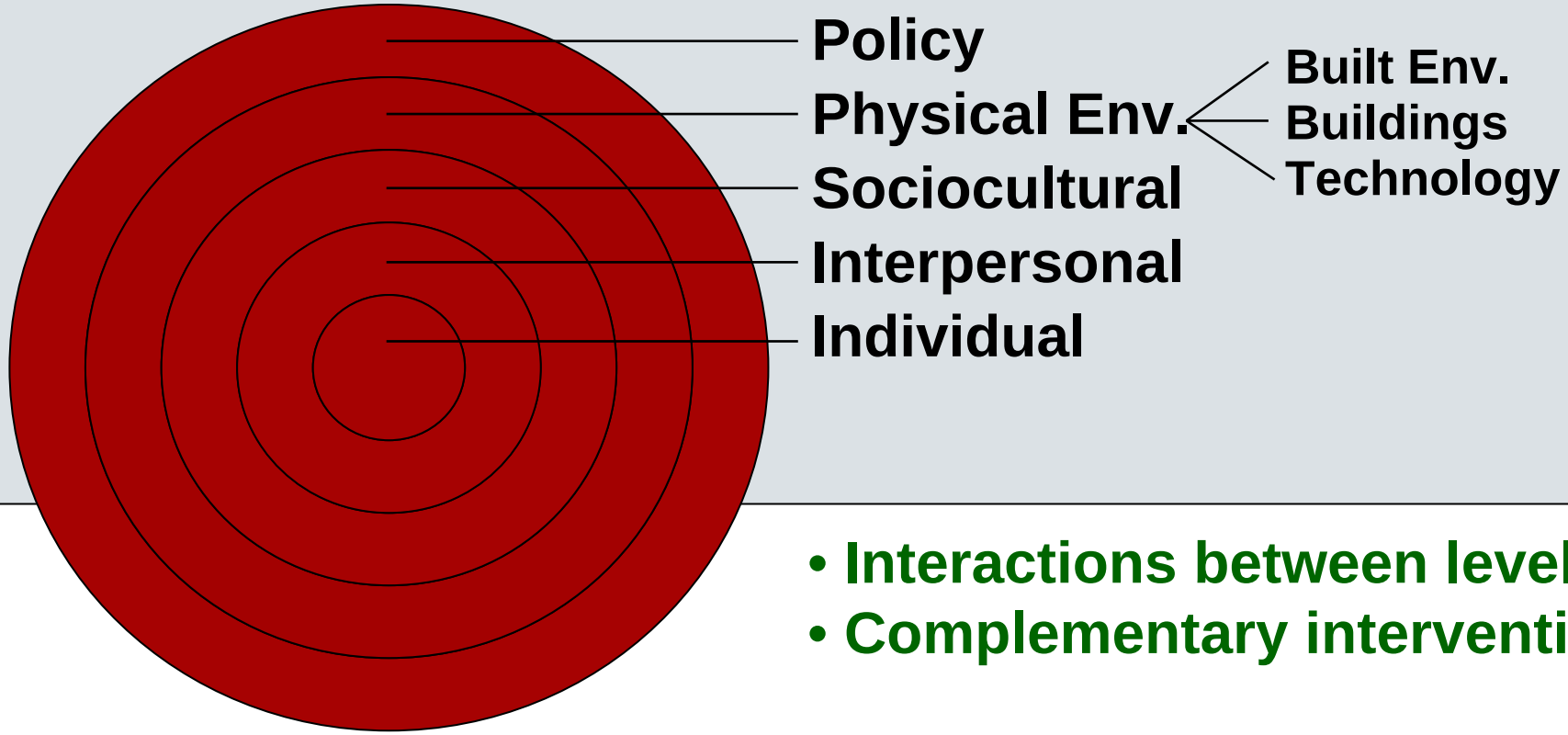
Market Barriers

- **Low Priority of Energy Issues**
  - **Generally means that energy costs are so small that it is not worth the effort to try to optimize**
- **Cognitive Issues**
  - **Probably very important for residential, small commercial, and individual transportation decisions**
- **Cognitive issues: programmable thermostats**
  - **2004 study. Only 20% of Americans own programmable thermostats. Of those, 70% don't use programmable features because they're too complicated.**
- **Vehicle Purchase**
  - **Limited horizon of purchaser in calculating operating cost.**

Systems Issues

- Learning by doing
  - Relevant particularly in unconcentrated industries
  - Individual decision making does not account for benefits of learning
- Chicken and egg problems
  - Non-convexity of problem
  - Individual competitive equilibrium does not get to global optimal
- Regional development
  - Local tax higher than cost for commercial development
  - Cost higher than tax for residential development
  - Incentives for communities to compete for commercial development and hope other communities have residential development (at least at margin)
  - May lead to more commuting

Levels of Interventions



- **Interactions between levels**
- **Complementary interventions**

Based on the socio-ecological model of health behavior

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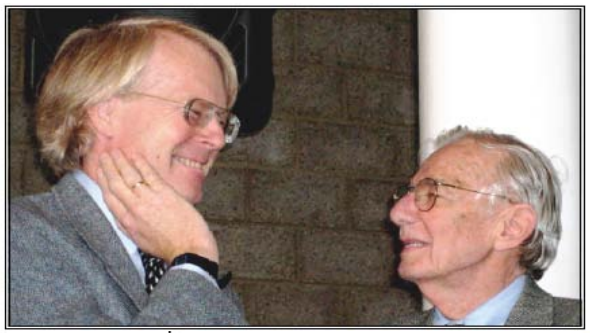
Thanks to Carrie Armel

The Rosenfeld Effect Project



NRDC

Source: California Energy Commission, 2004

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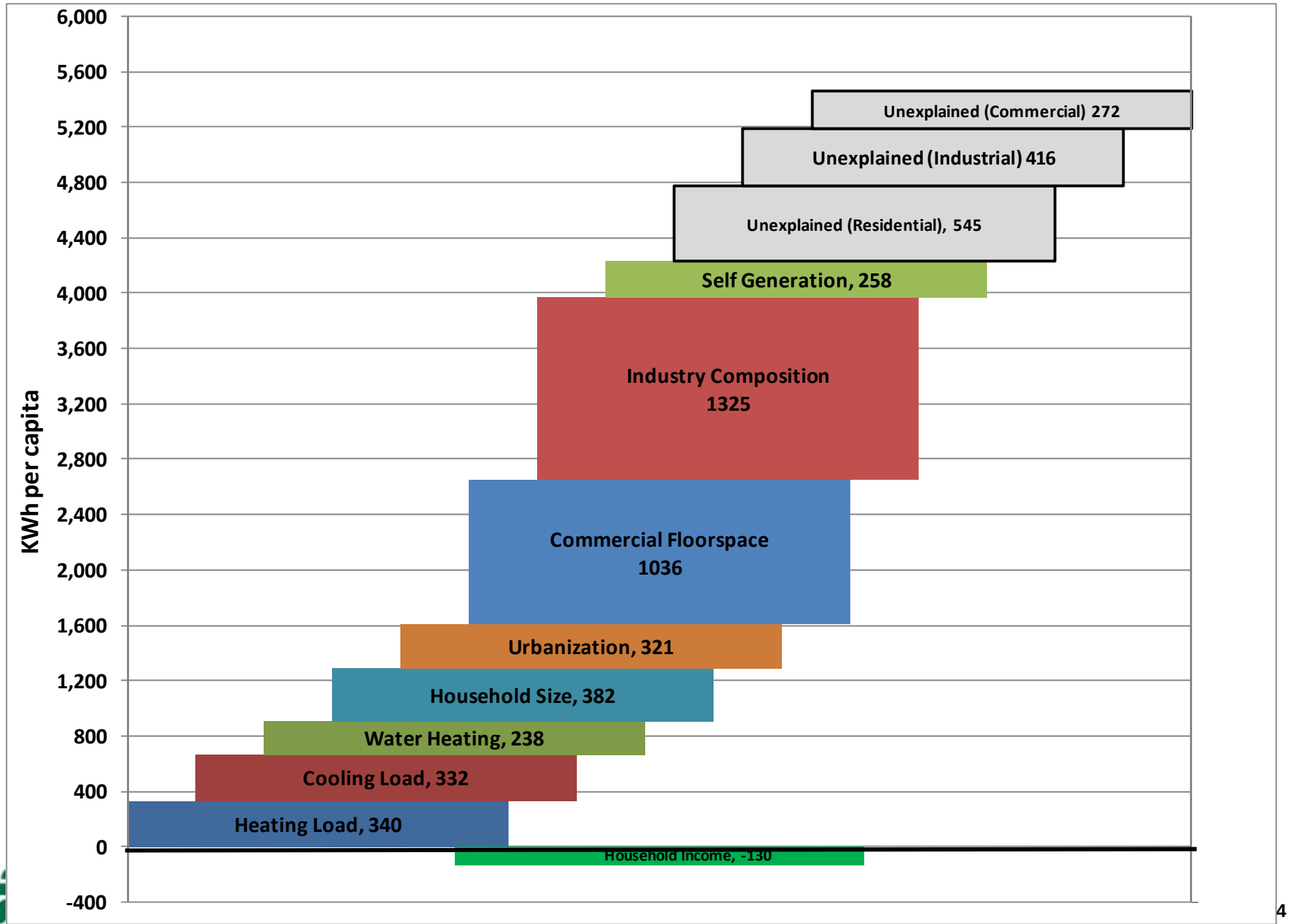
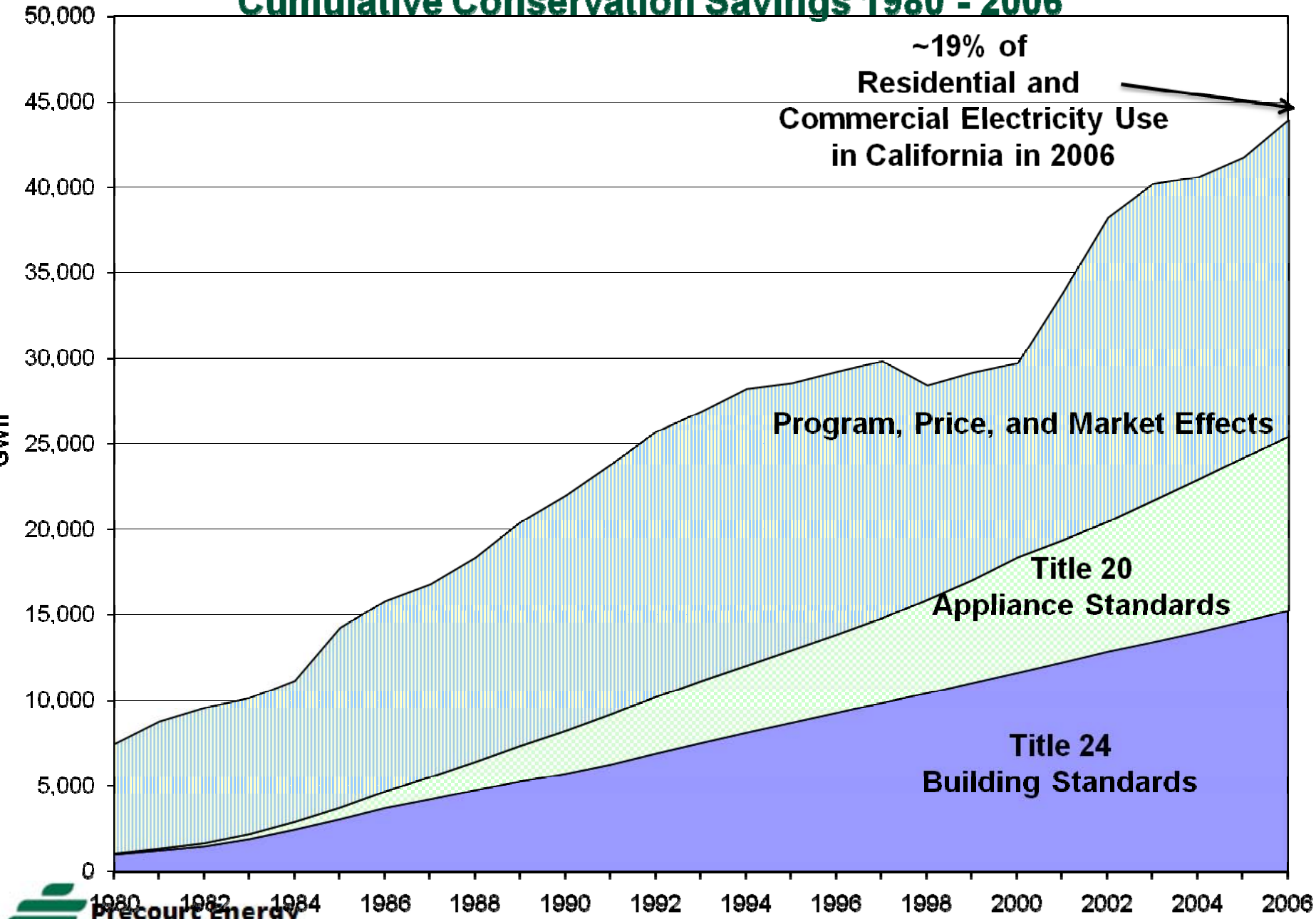
PEEC Year 2001 CA Electricty Decomposition



Residential and Commercial Cumulative Conservation Savings 1980 - 2006



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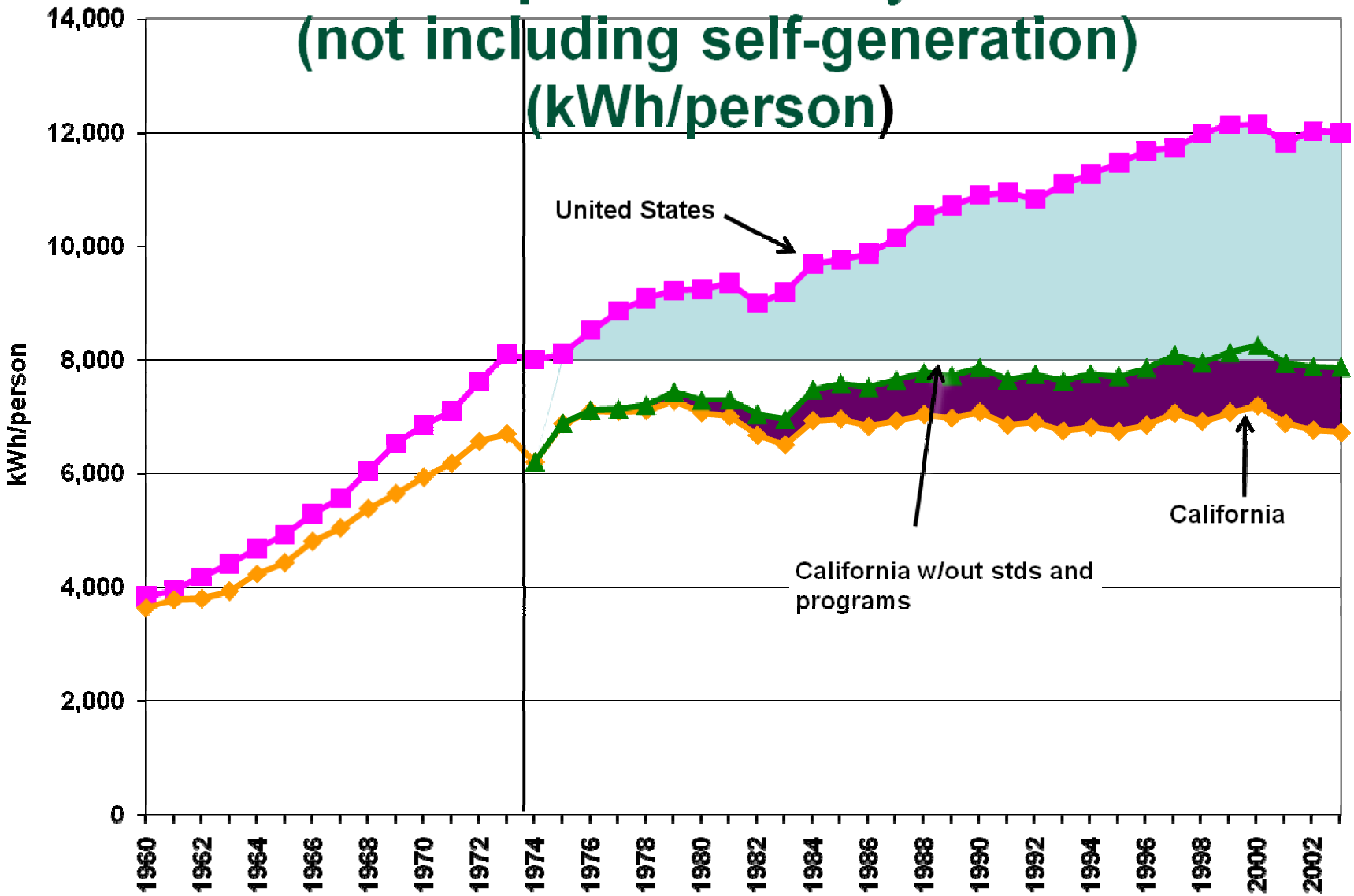
Per Capita Electricity Sales (not including self-generation) (kWh/person)



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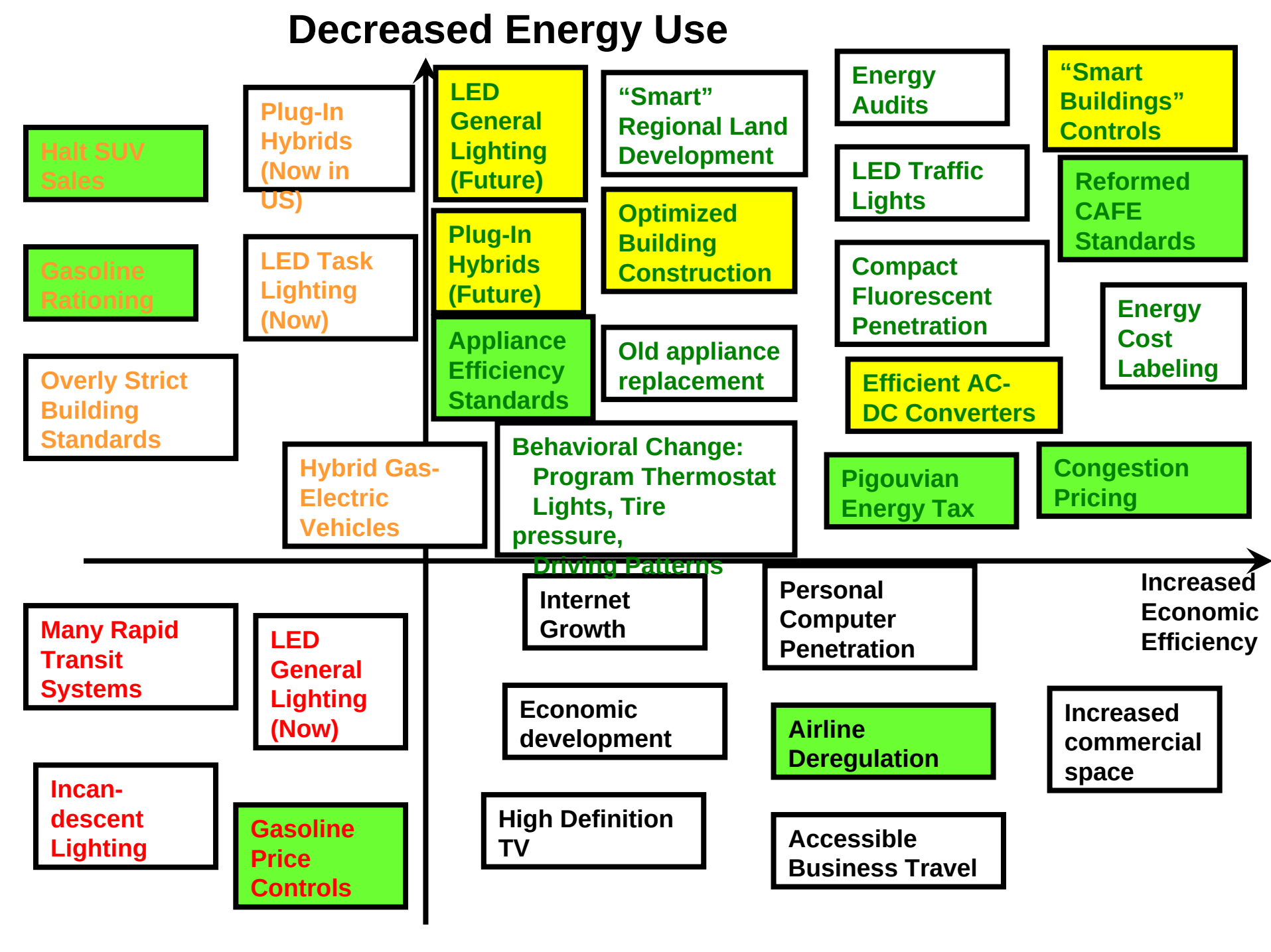
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