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CEE 173L/273L: Advanced Energy End-Use Efficiency

Public Lectures in Advanced Energy Efficiency:
4. Implementation

"To be truly radical is to make hope possible, not despair convincing."

— Raymond Williams



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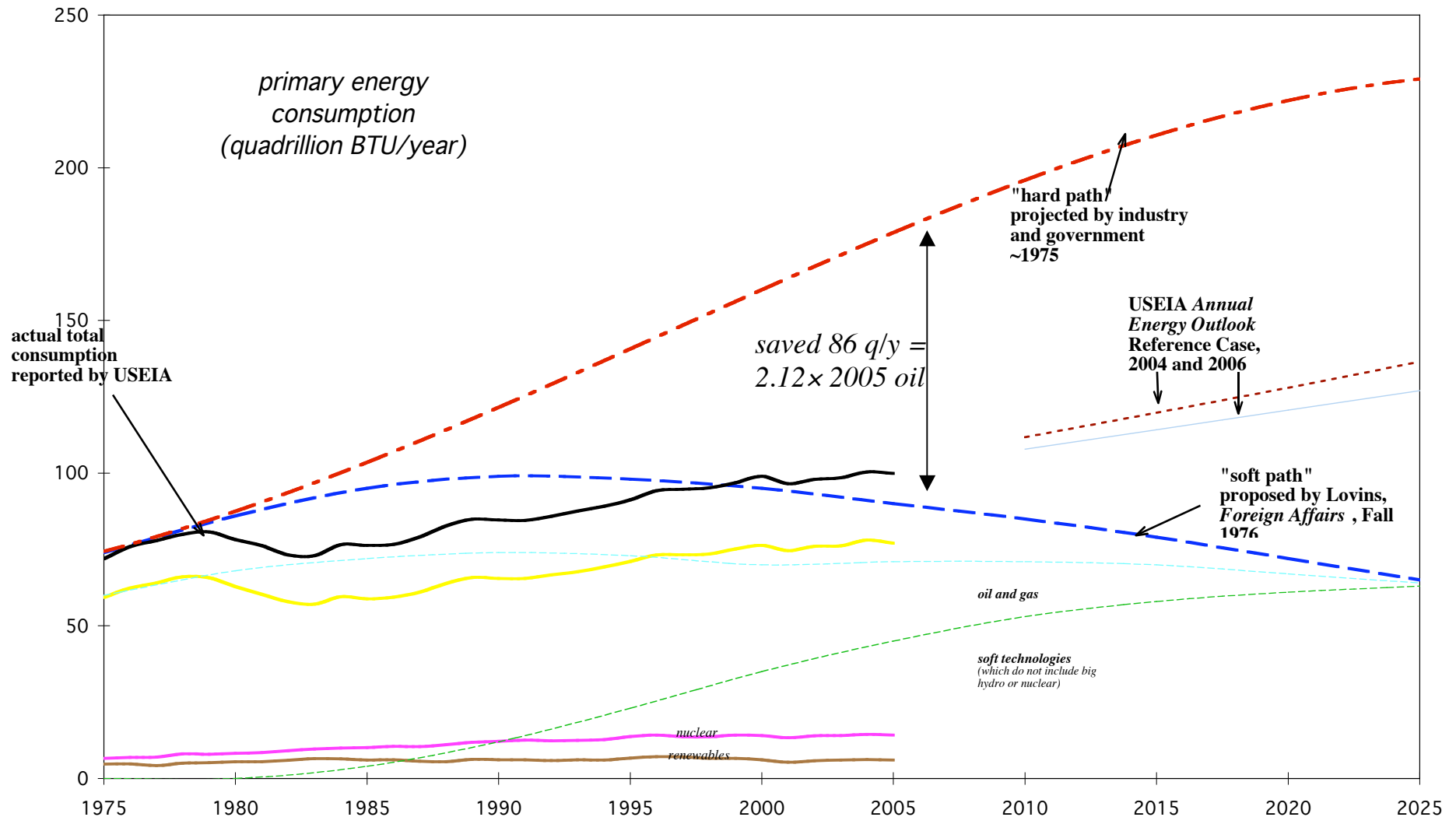


Osage (Iowa) municipal utilities

- ◇ 11 employees serving ~3,800 population
- ◇ A decade of demand-side management advice to homes and small businesses:
 - Prepaid all the debt and built a \$2.5M emergency fund
 - Cut the rates 5 times in 5 y (by 1/3 real, to 1/2 IA av.)
 - Kept existing factories competitive & attracted two more
 - Kept >\$1,000/household-y in town, supporting local jobs and multipliers
 - Made Osage noticeably more prosperous than comparable neighboring towns
- ◇ If you can't keep the bathtub full because the water keeps running out...do you need a bigger water-heater, or do you need a plug?



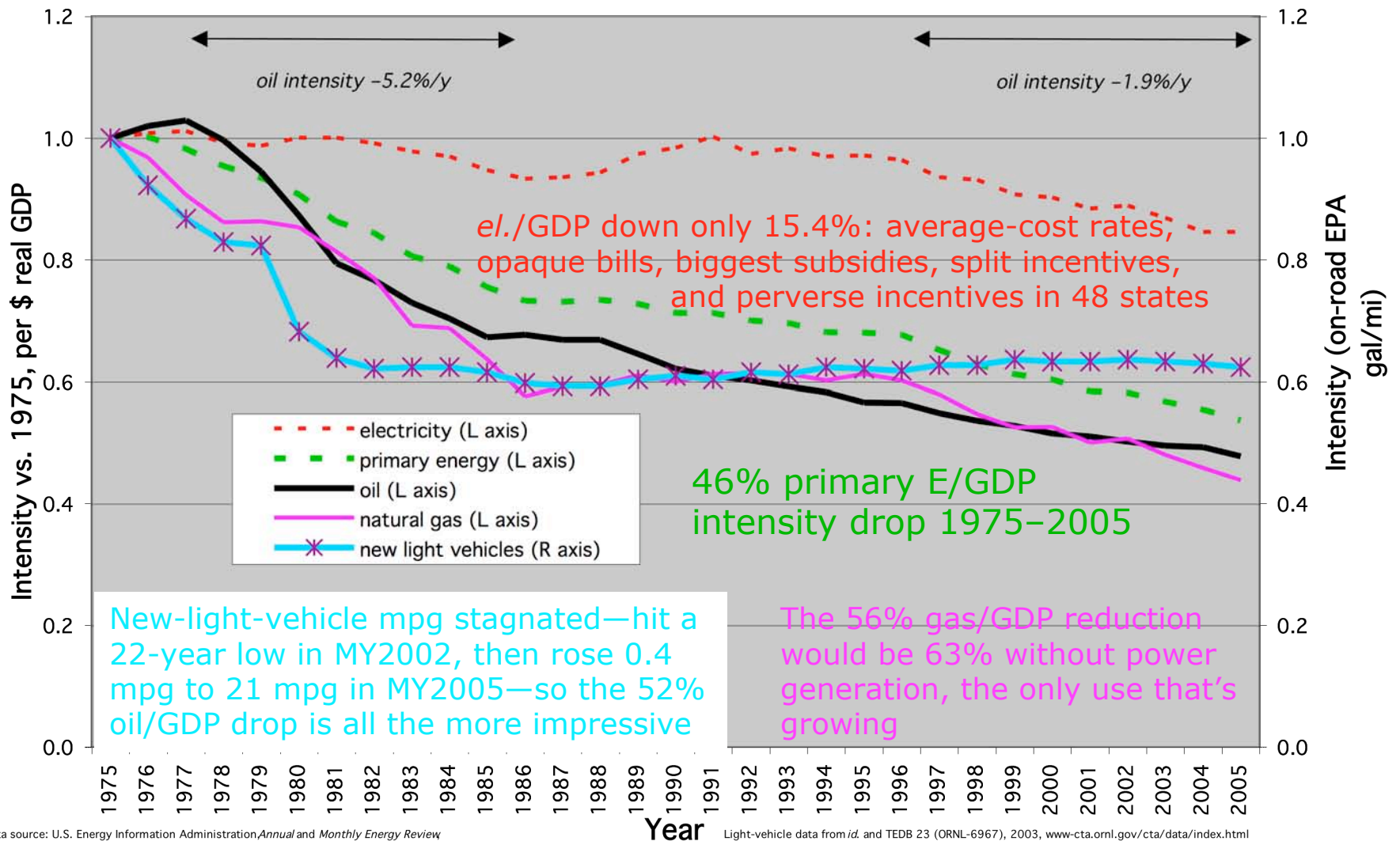
U.S. energy/GDP already cut 46%, to very nearly the 1976 "soft path"



but that just scratches the surface (eI/GDP down only 15%)



U.S. energy intensity since 1975



Data source: U.S. Energy Information Administration, Annual and Monthly Energy Review

Light-vehicle data from *id.* and TEDB 23 (ORNL-6967), 2003, www.cta.ornl.gov/cta/data/index.html



Progress in implementation has been as radical as in technology and design

Oil

General barrier-busting

Marketing efficiency

Electricity: public policy

Electricity: business strategy

Electricity: making negawatt markets



Higher energy prices are helpful and theoretically correct, but...

- ◇ Politically the most *difficult* policy instrument; worse:
- ◇ Not *necessary* (efficiency is profitable at low prices)
 - 1996–2001 US E/GDP fell 3%/y despite record-low & falling prices
 - Seattle residents in 1990–96, paying half the price/kWh of Chicagoans, saved 12× %kW_p and 3640× %kWh/y of Chicago: it's faster to respond well to weak price signal than badly to strong one
- ◇ Not *sufficient* (no “barrier-busting” → little effect)
 - DuPont's EU chemical plants were as inefficient as U.S. ones
 - Dow/Louisiana saved \$110M/y @ >200%/y ROI; Dow/Texas didn't
- ◇ Often not the most *effective* policy instrument
 - *E.g.*, new-car feebates would work far better than fuel taxes
 - People are complex, influenced by many factors besides price
- ◇ *Weaker* than improving *ability to respond* to price
 - 60–80 market failures dominate use and require close attention
 - Each barrier is a business opportunity, as we'll see in a moment



By the way, we've just been trying the high-price approach

- ◇ Energy market prices have been testing historic highs
 - Most U.S. policymakers fear costly energy even though our strongest competitors have long had it, and thus became more efficient than us
 - Congress wouldn't raise oil taxes, so OPEC captured the rent instead
 - White House rejected Kyoto from claimed fear of \$50/TC carbon taxes
 - Other White House policies soon helped raise world market prices by the equivalent of \$80–160/TC*, to levels predicted to wreck the economy
 - *I.e., increases by ~\$0.65–1.30/gal for wholesale gasoline and by ~\$4–8/million BTU for natural gas
 - So we paid the "carbon tax" to others, but missed the carbon reduction
- ◇ Markets now preparing for carbon trading (the right price isn't zero—it's better to be roughly right than precisely wrong)
 - Vital not to indulge in ancestor worship—no grandfather clauses!
- ◇ Wider context: some EU nations' shifts of taxation from jobs and income to consumption and depletion correctly signal new relative scarcities and increase total factor productivity
- ◇ Ideally, get correct prices *and* trimtabs to evade the barriers
- ◇ What are the market failures whose repair lets prices work?



Saving oil: basic market failures

- ◇ Oil is priced well below its societal cost
 - Externalities include military/security ($\sim \$10-25+/bbl$), diplomatic/geopolitical/instability ($\$?/bbl$), climate ($\sim \$2-5/bbl$), other environmental ($\sim \$1-15/bbl$), net subsidies ($\sim (\$1-3/bbl + ?\$16/bbl$ to oil-using systems), or price volatility ($\$3.5/bbl$ in spring 2004)—though our analysis assumes externalities are all worth *zero*
- ◇ Most customers, even sophisticated ones, lack good information on alternatives, especially in end-use efficiency
- ◇ Most customers have very high implicit discount rates ($\geq 60\%/y$) when buying energy efficiency
- ◇ Many other market failures and cultural / institutional obstacles also slow implementation



Five ways government can help

- 1) Stimulate demand for very efficient vehicles**
 - **Feebates—revenue- and size-neutral, more automaker profit**
 - **Create a new million-car-a-year market through leasing to low-income customers (and scrapping clunkers)**
 - **Smart military and government fleet procurement; “Golden Carrot” and “Platinum Carrot” to speed innovation**
 - **Heavy-truck-buyer info/leadership, airline loan guarantees**
- 2) Build vibrant 21st Century industries by sharing R&D risk and deploying faster than the private market**
 - **Military S&T should finance advanced materials development**
- 3) Lower risk of investment for new manufacturing plants through loan guarantees to automakers**
- 4) Support development of domestic energy supply infrastructure (hydrocarbons → carbohydrates)**
- 5) Remove barriers to efficiency through coherent policies and purging perverse incentives**

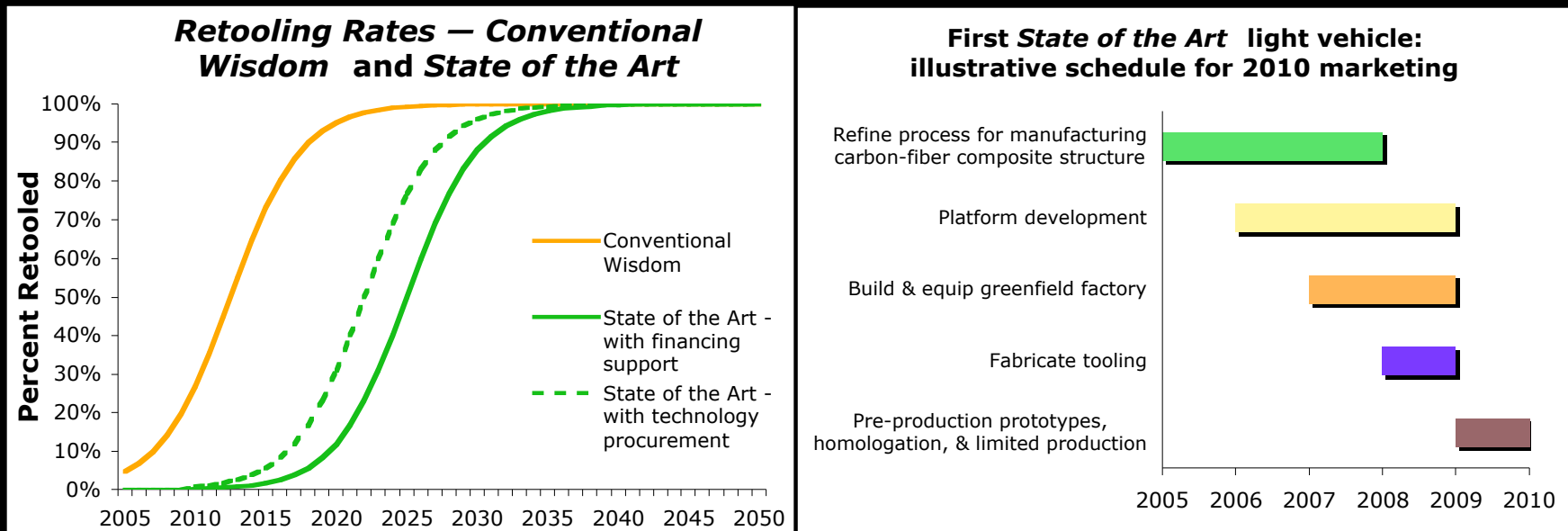


State/regional oil-saving policy opportunities besides feebates

- ◇ Reward electric & gas utilities for saving natural gas
- ◇ Light vehicles
 - Shift registration fees /excise taxes (DC); congestion charges
 - > Stockholm cut traffic 25% (-100,000 vehicles) in first month, boosted daily public-transportation ridership by 40,000; *cf.* London, Singapore, Oslo,...
 - Smart procurement aggregating all gov't levels; hybrid taxis (NYC)
 - Pay-at-the-pump insurance; shift tax from fuels to roads & driving
 - Fund initial dealer carrying charges/bonuses for superefficient cars
- ◇ Heavy trucks
 - Raise GVWR to EU norm (110klb), 14'H, 59'L, and allow extra axle, 2-/3-trailer combos
 - But improve safety via 60-mph speed limit and better brakes
 - Require fuel-economy driver's ed, improve informatics/logistics
- ◇ Biofuels (integrate with general farm/ranch reform)
 - Procurement, labeling, detaxation?, ?bonds, totalflex vehicles, CSA



Bringing affordable, ultralight, advanced-composite vehicles to market within five years

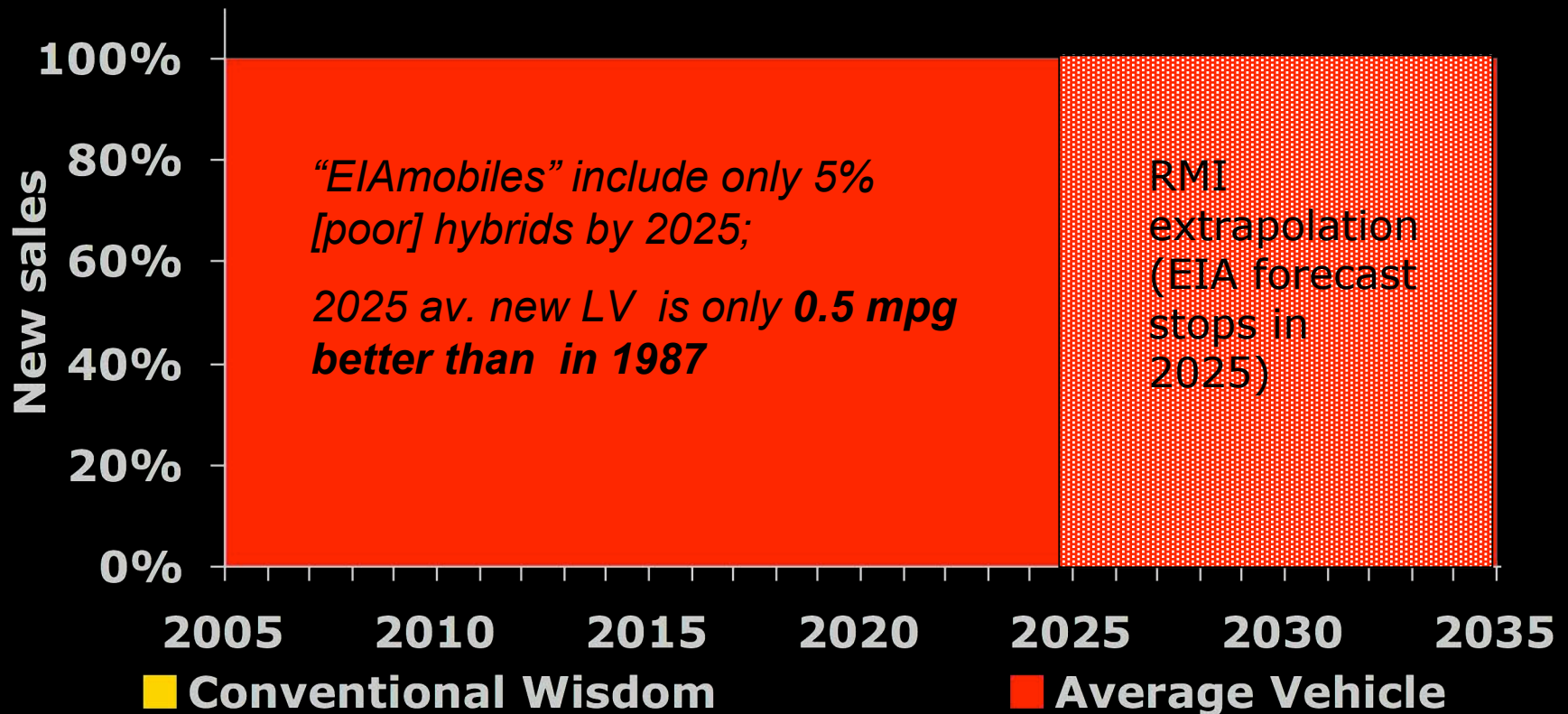


- Modeled using consumer preference theory, vetted by DOE/ORNL (and matches their model well)
- Industry intelligence on programs and state of manufacturing process development is consistent with this timeline or faster
- Strong industry interest in rapid initiatives as a key driver of competitive strategy



U.S. Energy Info. Admin. (EIA) scenario, January 2004 AEO

**Assumes no new policies nor improved vehicles (either
Conventional Wisdom or *State of the Art* technologies)**

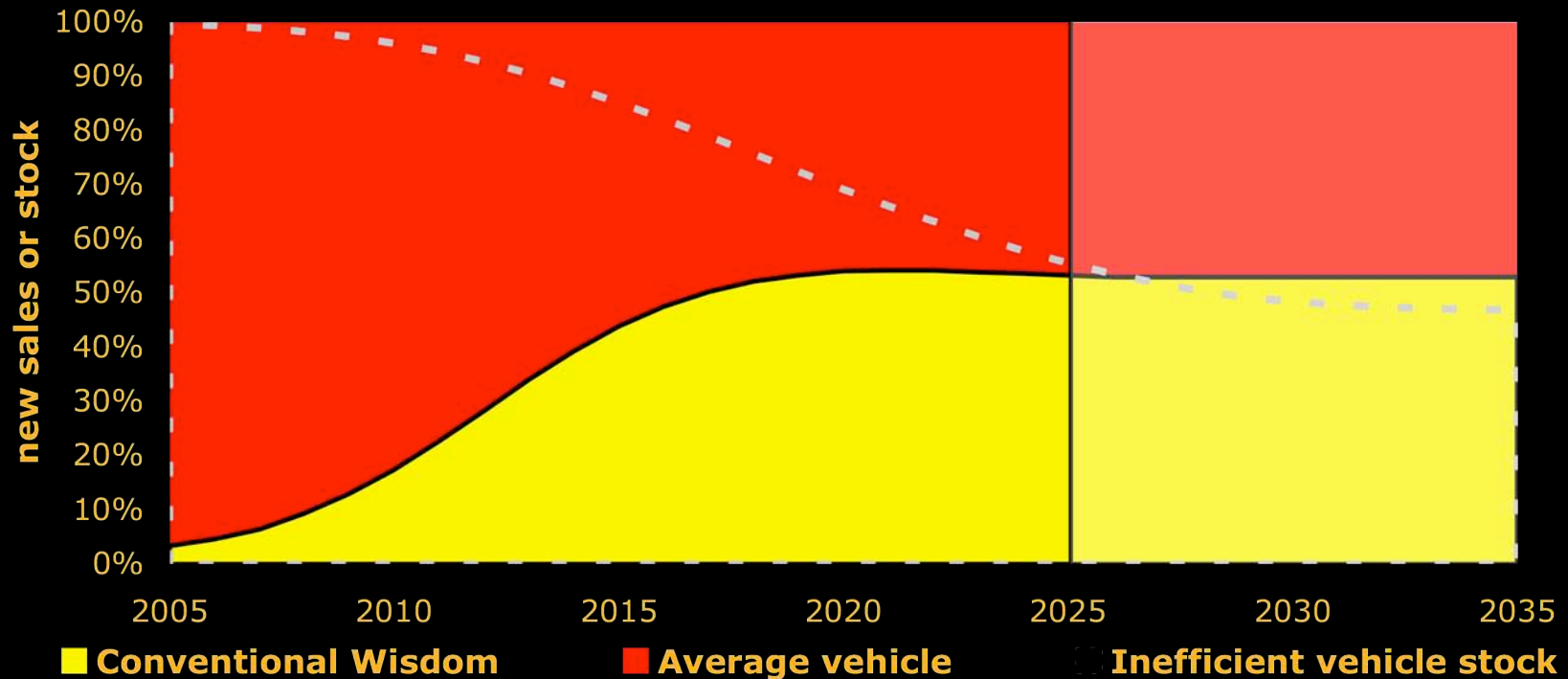


Modeling and graphics by Nathan Glasgow, RMI (www.oilendgame.com)



Drift scenario

Incrementally improved vehicles (yellow) enter the market, but no policy initiatives seek to correct market failures

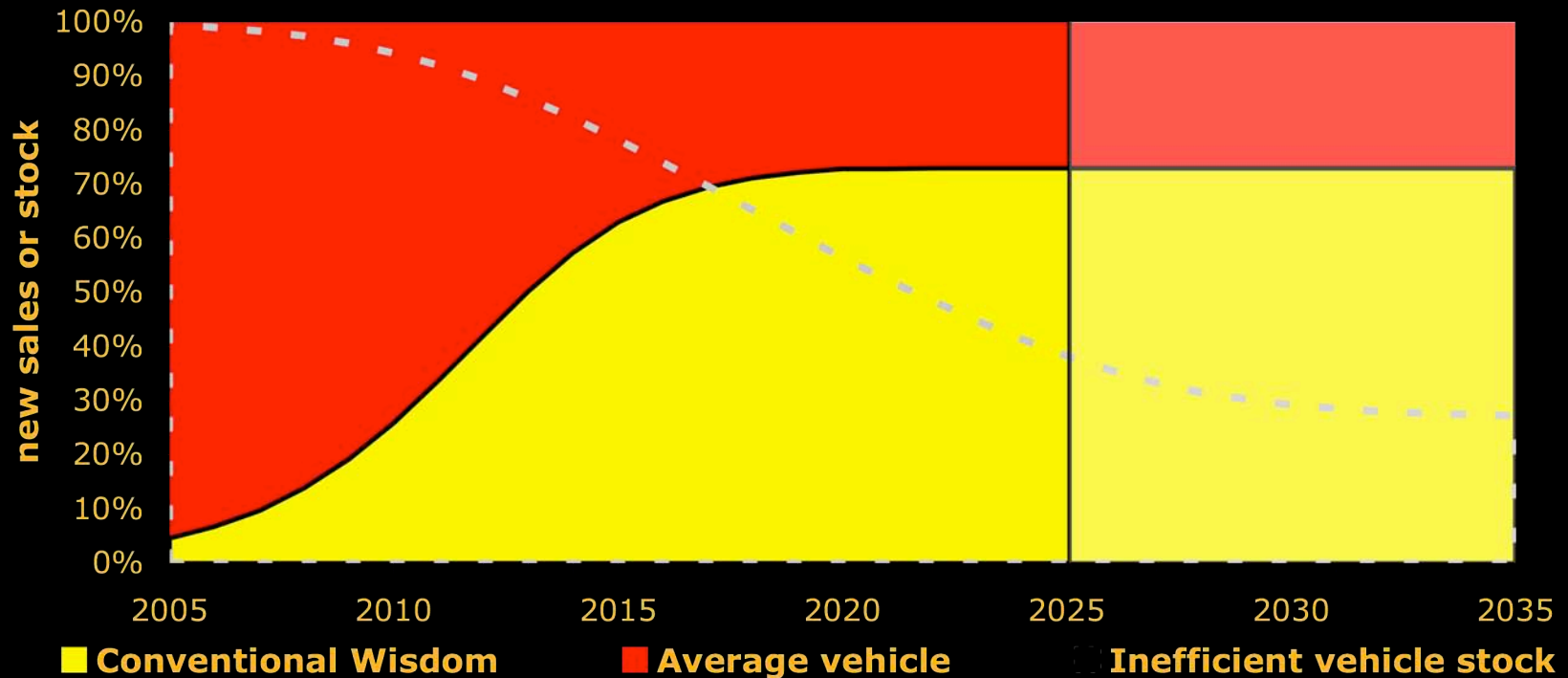


Technology	Policy	Retail fuel savings
<i>Conventional Wisdom</i>	none	\$181 billion



Let's get started scenario

Drift policy scenario + standard feebates enable CW vehicles to capture 20–30 percentage points' share

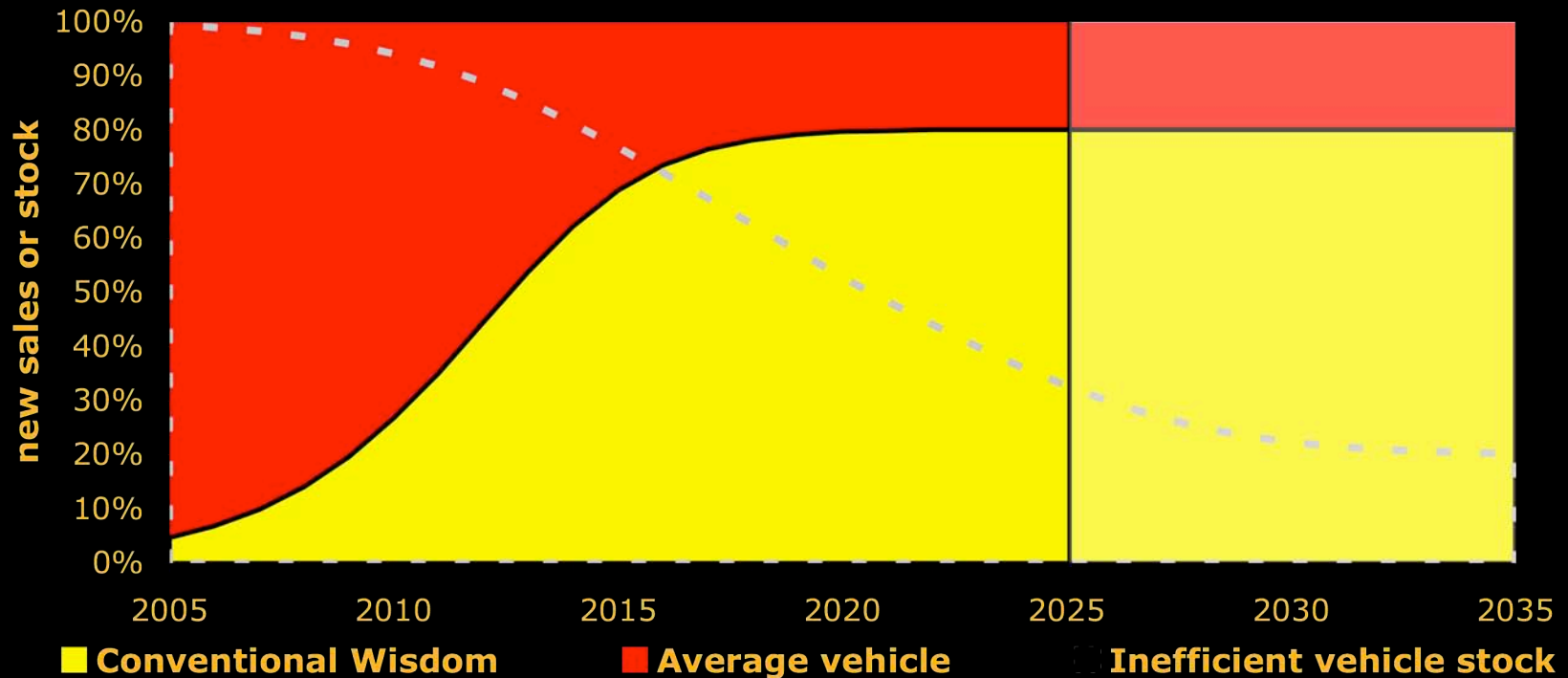


Technology	Policy	Retail fuel savings
Conventional Wisdom	Feebates at \$1,000 per 0.01 GPM	\$254 billion



Let's get started scenario

A steeper feebate slope, equivalent to a \$3.5/bbl oil externality, further increases capture

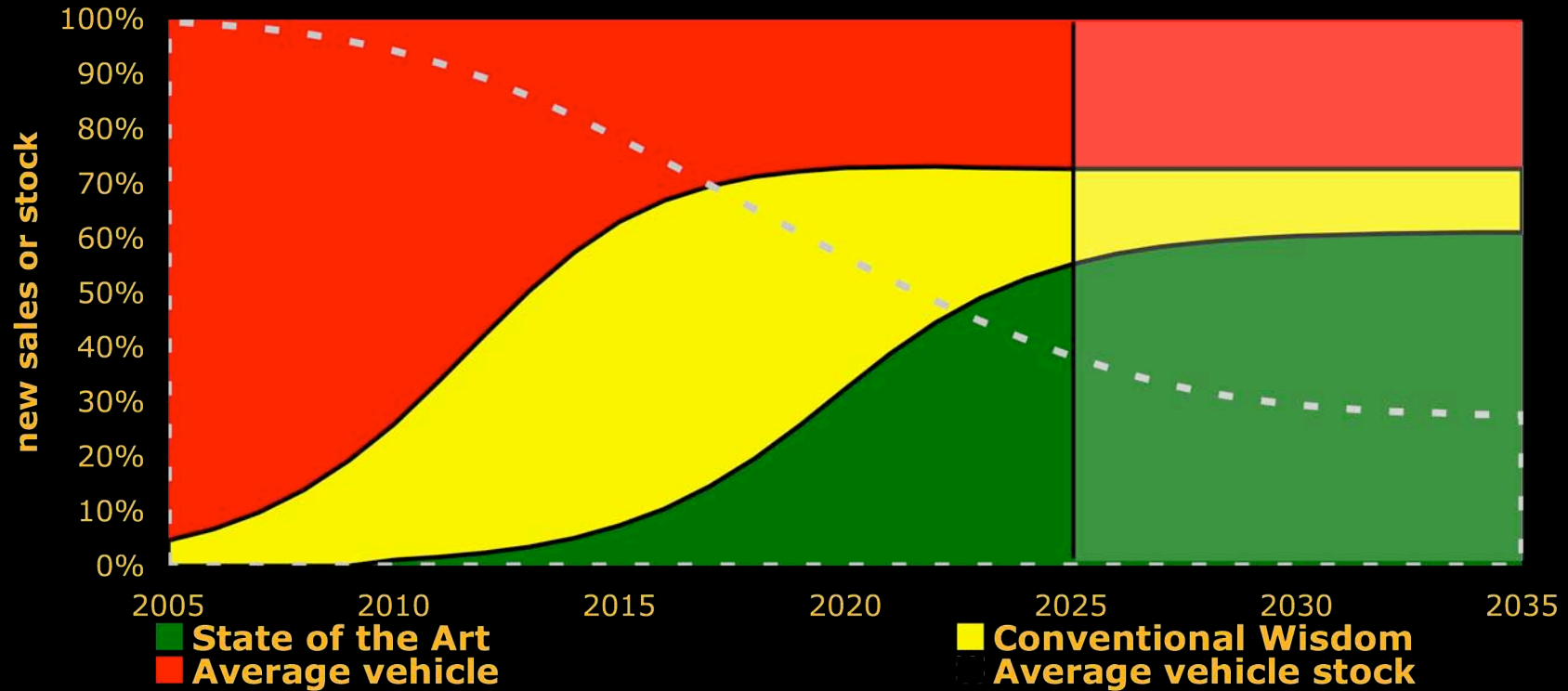


Technology	Policy	Retail fuel savings
Conventional Wisdom	Feebates at \$2,000 per 0.01 GPM	\$275 billion



Mobilization: Accelerating Change

Same feebate, but introduce *State of the Art (SOA, tripled-efficiency)* vehicles

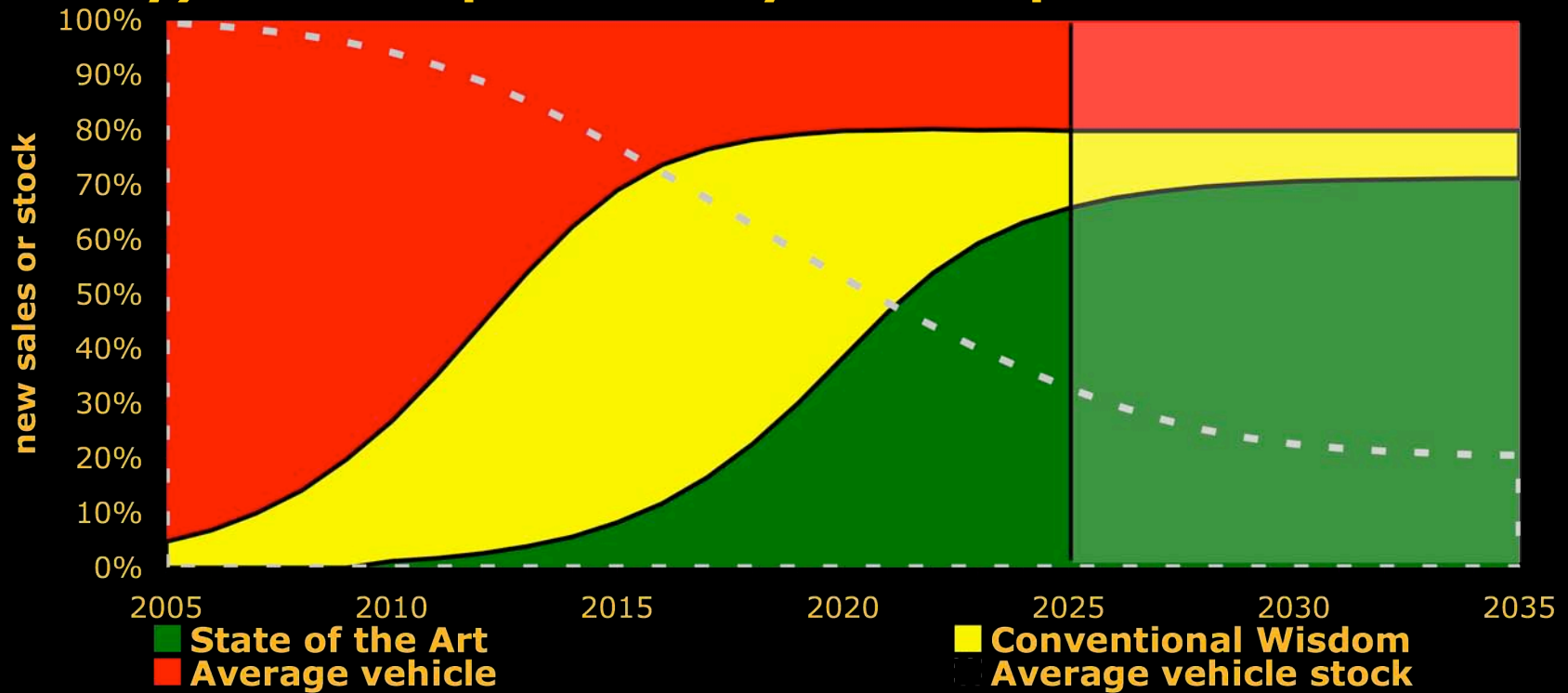


Technology	Policy	Retail fuel savings
Conventional Wisdom & State of the Art	Feebates at \$1,000 per 0.01 GPM	\$306 billion



Mobilization: Accelerating Change

Bigger feebate (equivalent to a \$3.5/bbl oil externality) further speeds entry and adoption of SOA vehicles

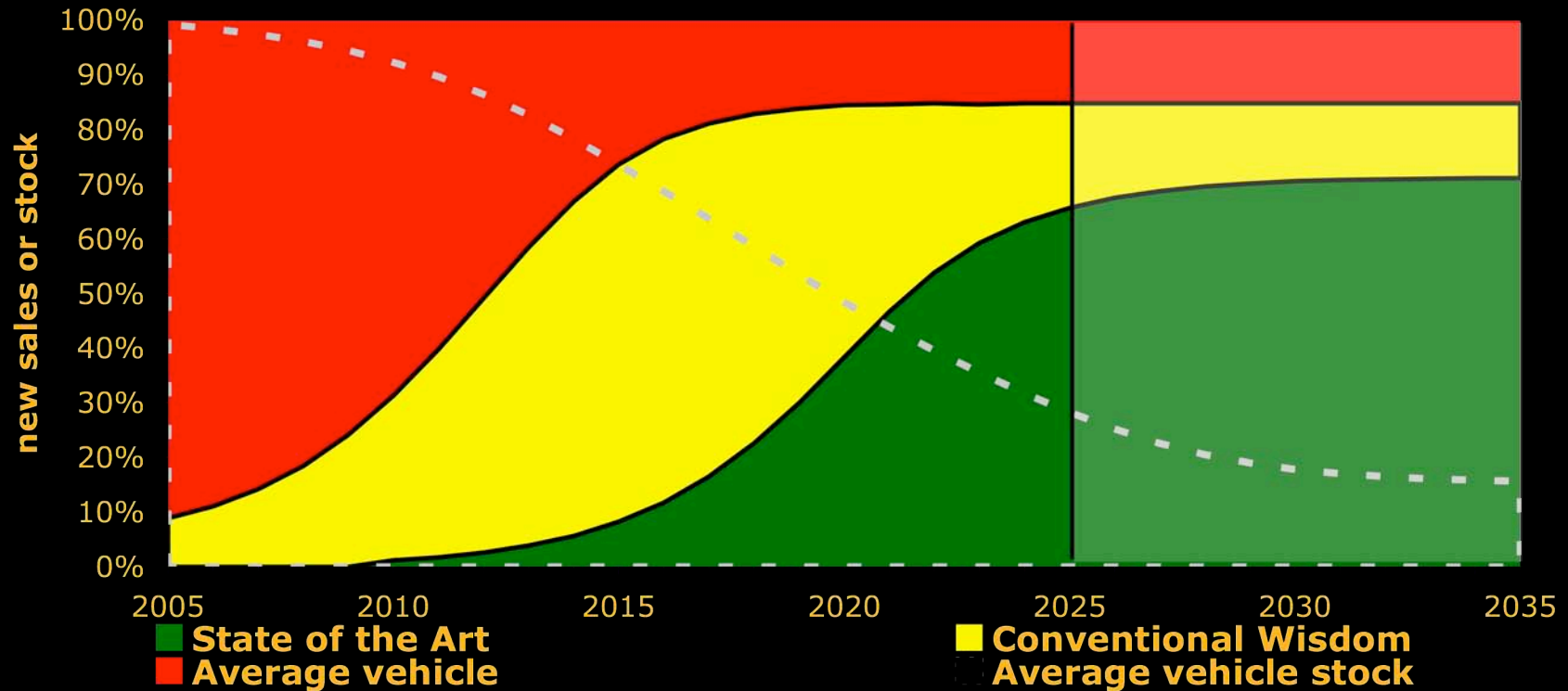


Technology	Policy	Retail fuel savings
Conventional Wisdom & State of the Art	Feebates at \$2,000 per 0.01 GPM	\$336 billion



Mobilization: Accelerating Change

Scrap/replace enhances savings slightly, equity a lot

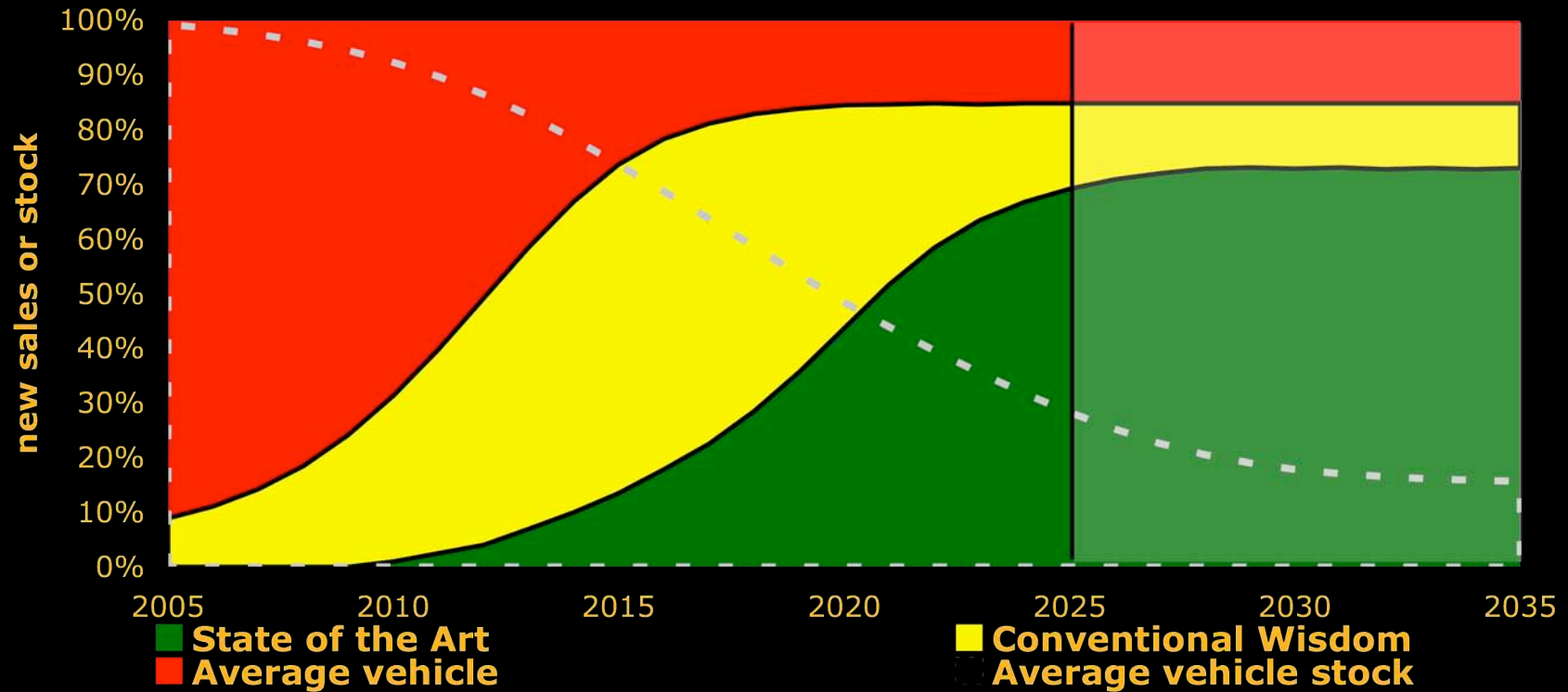


Technology	Policy	Retail fuel savings
Conventional Wisdom & State of the Art	low-income lease/scrap	\$364 billion



Mobilization: Accelerating Change

“Kickstart” policies speed initial adoption of SOA vehs.

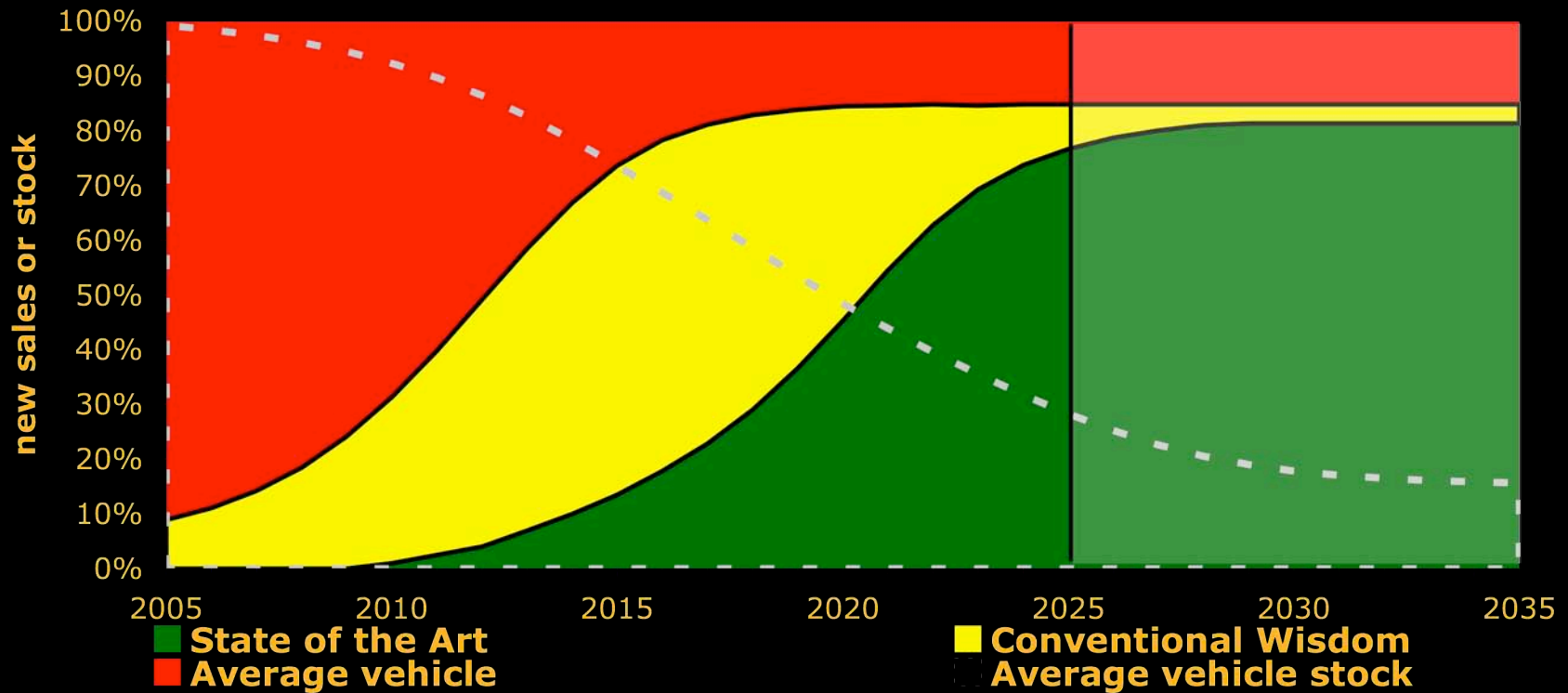


Technology	Policy	Retail fuel savings
Conventional Wisdom & State of the Art	Government purchase and “platinum carrot”	\$374 billion



Mobilization: Accelerating Change

Retooling support for industry expands long-term capture

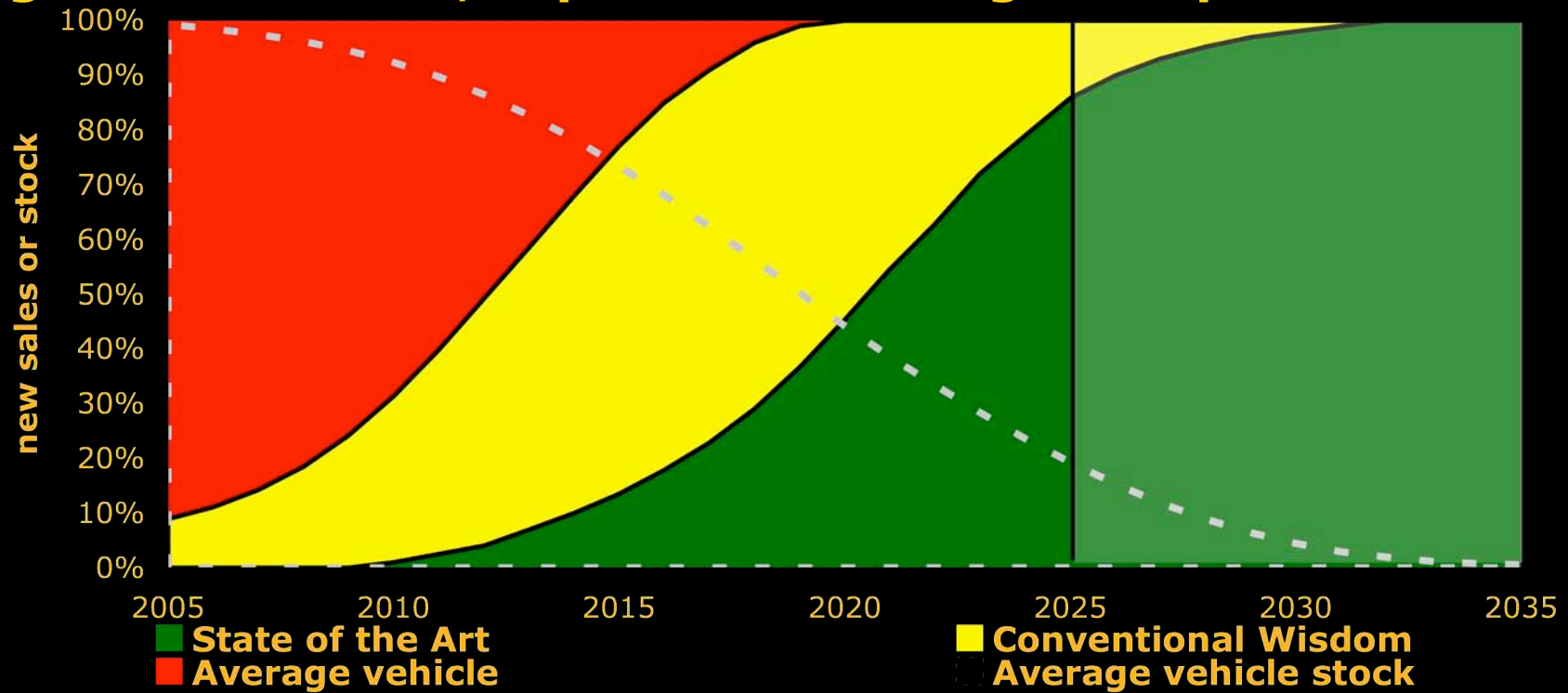


Technology	Policy	Retail fuel savings
<i>Conventional Wisdom & State of the Art</i>	matching OEM margins to efficiency via calibrated conversion credits	\$378 billion



Mobilization: Accelerating Change

Removing model constraints, so new vehicles keep improving as old ones do, captures their long-term potential

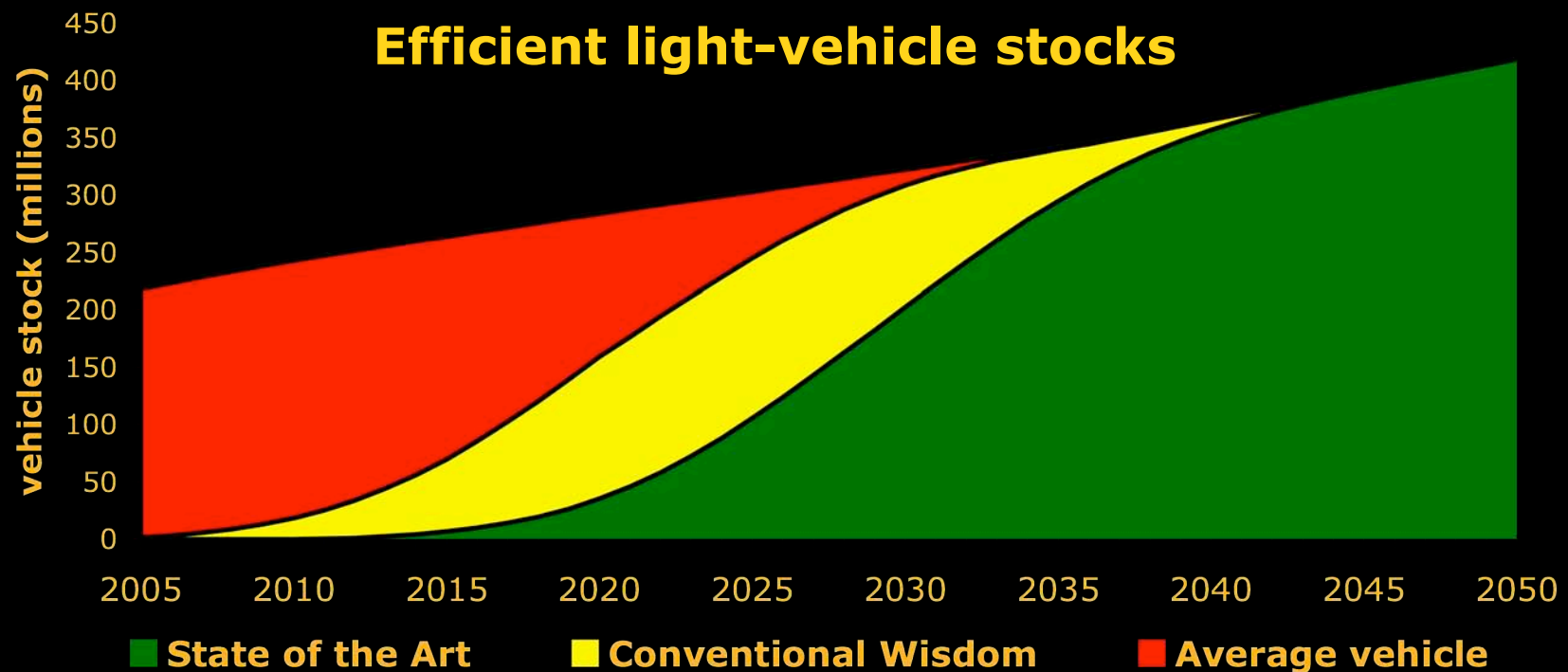


Technology	Policy	Retail fuel savings
continually improving <i>Conventional Wisdom & State of the Art</i>	All of the foregoing	~\$409 billion



Mobilization: Accelerating Change

Thus a portfolio of innovative policies can correct the main obstacles to turning over the light-vehicle fleet at a brisk pace, tripling on-the-road fleet efficiency by ~2040 (but CW vehicle uptake is still slower than 1976–82's was); of course, still further improvement (PHEV, FCEV,...), not shown within the green wedge, will continue too





Implementation topics

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Electricity: making negawatt markets



Obstacles that prevent buying energy efficiency

- ◇ Over 30 specific market failures of 8 types
 1. Capital misallocation
 2. Value-chain risks
 3. Organizational failures
 4. Informational failures
 5. Regulatory failures
 6. Perverse incentives
 7. False or absent price signals
 8. Absent markets
- ◇ Proven methods can turn each of these obstacles into lucrative business opportunities
- ◇ *Barrier-busting* should top the policy agenda

"Climate: Making Sense *and* Making Money," RMI, 1977,
www.rmi.org/images/other/Climate/C97-13_ClimateMSMM.pdf, pp. 11-20



1. Capital misallocation

- ◇ Energy, a 1–2% factor cost in most industries, gets little attention—many CEOs forget where saved overheads go!
- ◇ Most purchases are based on first cost only
 - Thicker office wiring (≤ 1 -y payback, often months) isn't bought
 - High-efficiency mag. ballasts with 60%/y IRR won only 9% market share
 - Utilities misallocate \$1b/y on dx xfrmrs (ignoring $\geq 14\%$ aftertax ROI)
- ◇ Only 1/5 of the U.S. firms that *do* look beyond first cost use discounted cashflow methods—but seldom on the shop floor
 - The rest, even a decade ago, sought a 1.9-y median *simple payback*—a $>50\%$ IRR, $\sim 6\times$ the *marginal cost of capital*; now even shorter-sighted; this wide practice *is equivalent to an order-of-magnitude price distortion*
 - Actually, efficiency merits a discount rate *below* marginal cost of capital, because it's lower-risk than general corporate investments
- ◇ U.S. by 1990 had misallocated \$1 *trillion* to unnecessary air-conditioning equipment (200 million tons) and its power supplies (~ 200 GW_p, 2/5 of total load), vs. well-designed buildings—thanks to perfectly perverse incentives in the value chain

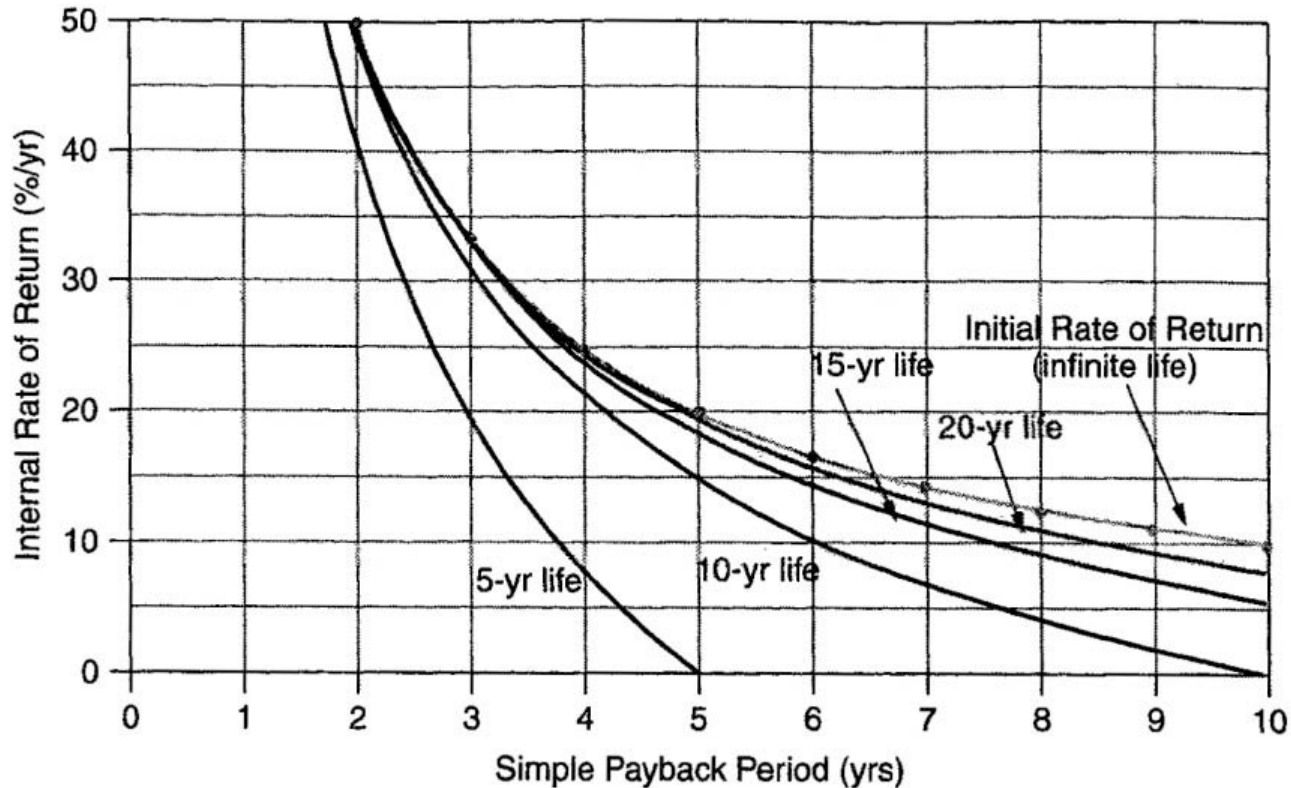


1a. Some solutions

- ◇ Remind senior executives to think of saved energy costs in bottom-line terms like earnings per share, and not to behave as if capital-rationed
- ◇ Get operating and financial staff to speak the same language—and to talk to each other
- ◇ International Performance Monitoring and Verification Protocol (IPMVP); wraparound mortgages
- ◇ Marketing initiatives to cut first cost (CFLs: SCE (give/leverage), leasing, Wal-Mart/GE)
- ◇ Standards where needed to correct inherently split incentives, *e.g.*, many appliances
- ◇ Engage financial sector (12–13 April 07 NYC)



1b. The missing Rosetta stone to translate between engineering & DCF



Gil Masters, *Renewable and Efficient Electric Power Systems*,
Wiley/Interscience, 2004, p. 246, Fig. 5.2

Put the comptroller and operating engineer at the same table with this graph in between them



2. Organizational failures

- ◇ Force of habit rules: why make waves?
- ◇ Schedule dominates: "infectitious repetitis," serial mediocrity
- ◇ Little measurement, hence no improvement
- ◇ Departments can't or won't cooperate
- ◇ Cut energy costs, lose budget: no rewards
- ◇ Energy managers got laid off long ago
- ◇ Firms "satisfice," not optimize: as anyone knows who works in a large organization, we live in a Dilbert world, not a perfect one



2a. Issues often observed in large process industries/plants

- ◇ “Fuel is free” mentality in design and operation, especially for electric auxiliaries (less care than with heat, steam, and molecules); no shadow pricing (someone else pays for utilities—not my department)
- ◇ Little accurate measurement, let alone real-time graphic presentation to operators, to keep improving and sharing best practice
- ◇ Reluctance to rewrite the firm’s huge and interlocked design manual
- ◇ Operators kept too busy to think about much beyond safety & uptime
- ◇ Underinvestment in people, stretched thin, no more bandwidth
- ◇ Capital rationing; gross underinvestment in essentially riskless high-return efficiencies, especially if the opportunity is in a generically disfavored sector; treat maintenance as cost center not profit center
- ◇ Lack of feedback from measured performance back to next design
- ◇ Extreme risk-aversion built into culture and reward structure, so engineers have no appetite for intelligent risk-taking, & learn slowly



2b. Some solutions

- ◇ Leadership (not the same as management)
- ◇ Competition (RMI's basic method)
- ◇ Compelling case-studies, esp. with lower capex
- ◇ Express cost of inaction as foregone profits
- ◇ Sell another attribute they *do* care about
- ◇ Occasional theatrics (Anita Burke's \$10 bill)
- ◇ Guerrilla tactics (secretly retrofit CEO's office)
- ◇ Share benefits to reward all (Washington State)
- ◇ Incentivize people (a utility that started paying its marketing staff for saved kW saw verified savings quickly get ~10x bigger and cheaper)
- ◇ Add energy criteria to performance reviews
- ◇ Bring the experience home (TI, Ben & Jerry's)



3. Regulatory failures

- ◇ Almost every utility in the world is rewarded for selling more energy and penalized for cutting your bill; EU-style restructuring further destroys any market incentives to save
- ◇ Just “meeting code” (the worst you’re allowed to do without going to jail) wastes money—CATNAP
- ◇ Transport sector is the most centrally planned and underpriced (L.A./Bangkok vs. Singapore)
- ◇ Obsolete rules (Singapore/HK “OTTV” std.)
- ◇ Dispersed land-use mandated by old zoning



3a. Some solutions

- ◇ Utility regulatory reform: decoupling + shared savings (www.raonline.com; NRDC)
- ◇ Real-estate developers: local authorities let efficient projects jump approvals queues; New Urbanism yields far greater value; locationally efficient mortgages; parking cashouts; annuitize transit pass instead of building parking spaces
- ◇ Homebuilders: sell w/capped or zero utility bills
- ◇ Specifiers: CDA wire-size table
- ◇ Zoning: publicize costs; congestion fees; optimize street parking price; new coalition ("immobilized class" + anti-taxers)



4. Informational failures

- ◇ Do *you* know exactly what to buy and where? your electricity tariff? your refrigerator's kWh/y? where to get one $\sim 2-20\times$ more efficient?
- ◇ Inattention to detail: U.S. uses 10–20 GW to run devices that are *turned off* (same convenience is available w/95% less drain, same capex)
- ◇ Information is viscous: it sticks to those who have it, but seldom gets to those who need it
- ◇ Cheap, powerful information is missing altogether
- ◇ Misinformation (common even in fine media)
- ◇ Deliberate disinformation (CA '01, Huber/Mills)



4a. Some solutions

- ◇ Labelling—official, voluntary, or guerrilla
- ◇ Easily available customer information—product guides, transparent bills, smart meters
- ◇ Voluntary but market-leading standards (LEED)
- ◇ Competitive transparency: η /load curves on computer power supply nameplates...
- ◇ Soon: remote diagnostics by your utility
- ◇ In firms, lending library of measuring tools, reward technogossips & data discoverers, build curiosity culture; operators will soon discover value
- ◇ Public discourse: hold liars to account



5. Value-chain risks

- ◇ Why should manufacturers take the risk of new products without knowing they'll sell?
- ◇ If they don't make it, how can you buy it?
- ◇ Distributors seldom stock the most efficient devices, so you can't buy them right away when you need an immediate replacement
- ◇ Litigation risks (esp. in U.S.) lead to inefficient defensive behavior and can inhibit innovation



5a. Some solutions

- ◇ “Golden carrot” relieves market-entry risk by pre-identifying and aggregating latent demand
- ◇ “Platinum carrot” (like Automotive X Prize) gets competitive juices flowing
- ◇ First-adopter risk relief (EPA/innovative WW tech)
- ◇ BC Hydro’s payment of extra carrying cost on premium motor stocks (share went 3→60% in 3 y)
- ◇ PG&E’s incentive to shop assistants, not to buyers
- ◇ Breakthrough design to eliminate whole zones of potential litigation; Electrolux not Monsanto culture



6. Perverse incentives

- ◇ Split incentives—one person choosing the technology, another buying the energy—are ubiquitous (landlord/tenant, builder/buyer, industrial equipment maker/user...)
- ◇ Architects and engineers get paid according to what they *spend*, not what they save
- ◇ All 20+ other parties in the real-estate value chain are also systematically rewarded for inefficiency and penalized for efficiency
- ◇ Wasteful old equipment is resold, not scrapped, because the secondary market rewards use value not non-use value



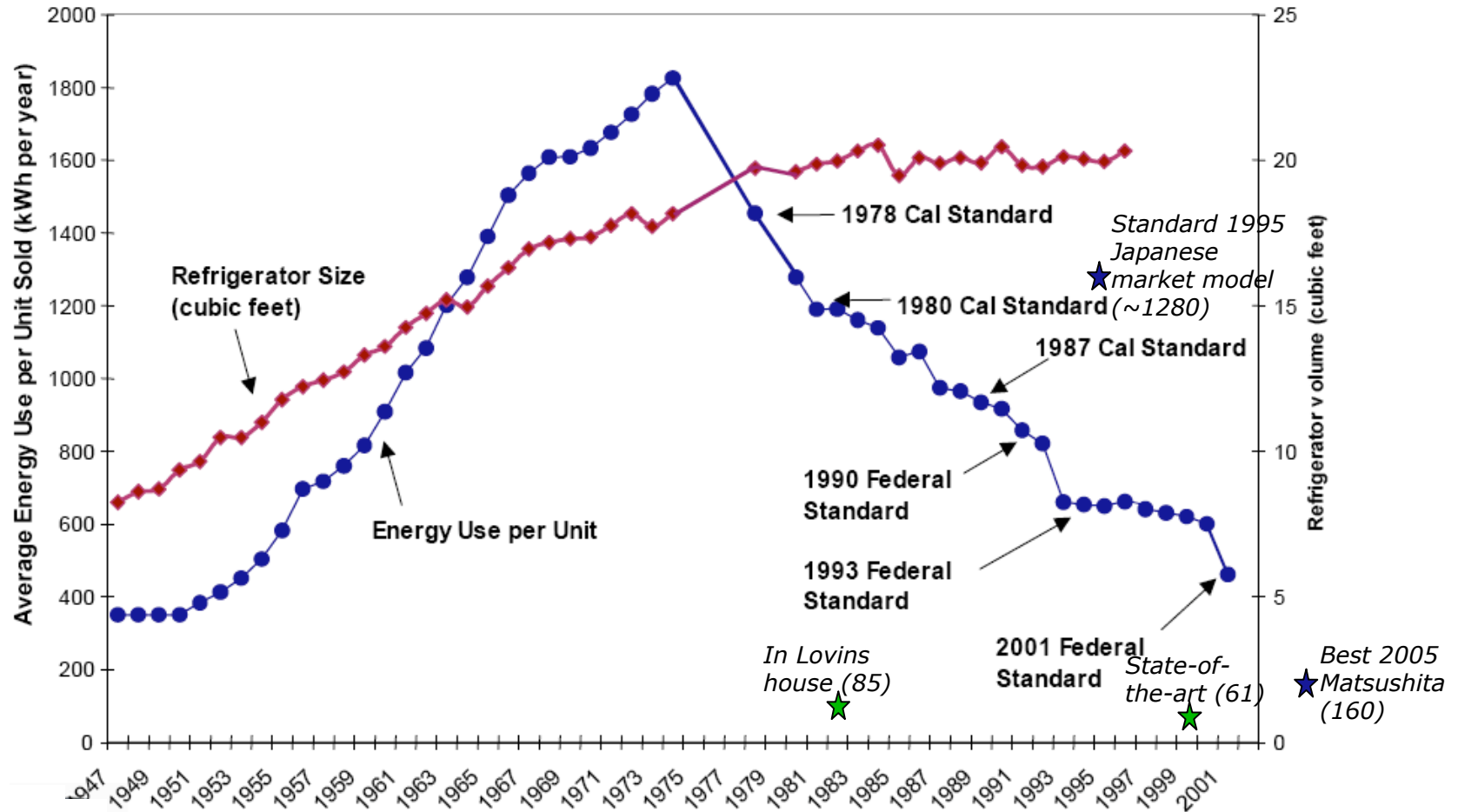
6a. Some solutions

- ◇ Landlord/tenant: lease rider to share costs and benefits equitably (can overlay triple-net and other common forms)
- ◇ Builder/buyer: standards, feebates, utility incentives to beat standards, service leasing ("solutions economy" models), developer's marketing low or no utility bills (Bigelow,...)
- ◇ Designers: Performance-Based Fees www.rmi.org/sitepages/pid174.php#D04-23
- ◇ Real-estate value chain: unrelenting attention, systematic exploitation of gaps, education of appraisers/brokers/..., publicize market success of early adopters to spur emulation
- ◇ Scrappage incentives (as for some appliances, or Unocal's clunker-cars program to offset its refinery emissions); build trade-in deals & reverse logistics into new-market channels
- ◇ Build global (NGO, development agencies,...) coalition to identify, track, label, and stigmatize inefficient electricity-using devices: eliminating them from commerce would be a huge boost for fair global development



Efficiency is a rapidly moving target

United States Refrigerator Use v. Time
 Annual drop from 1974 to 2001 = 5% per year

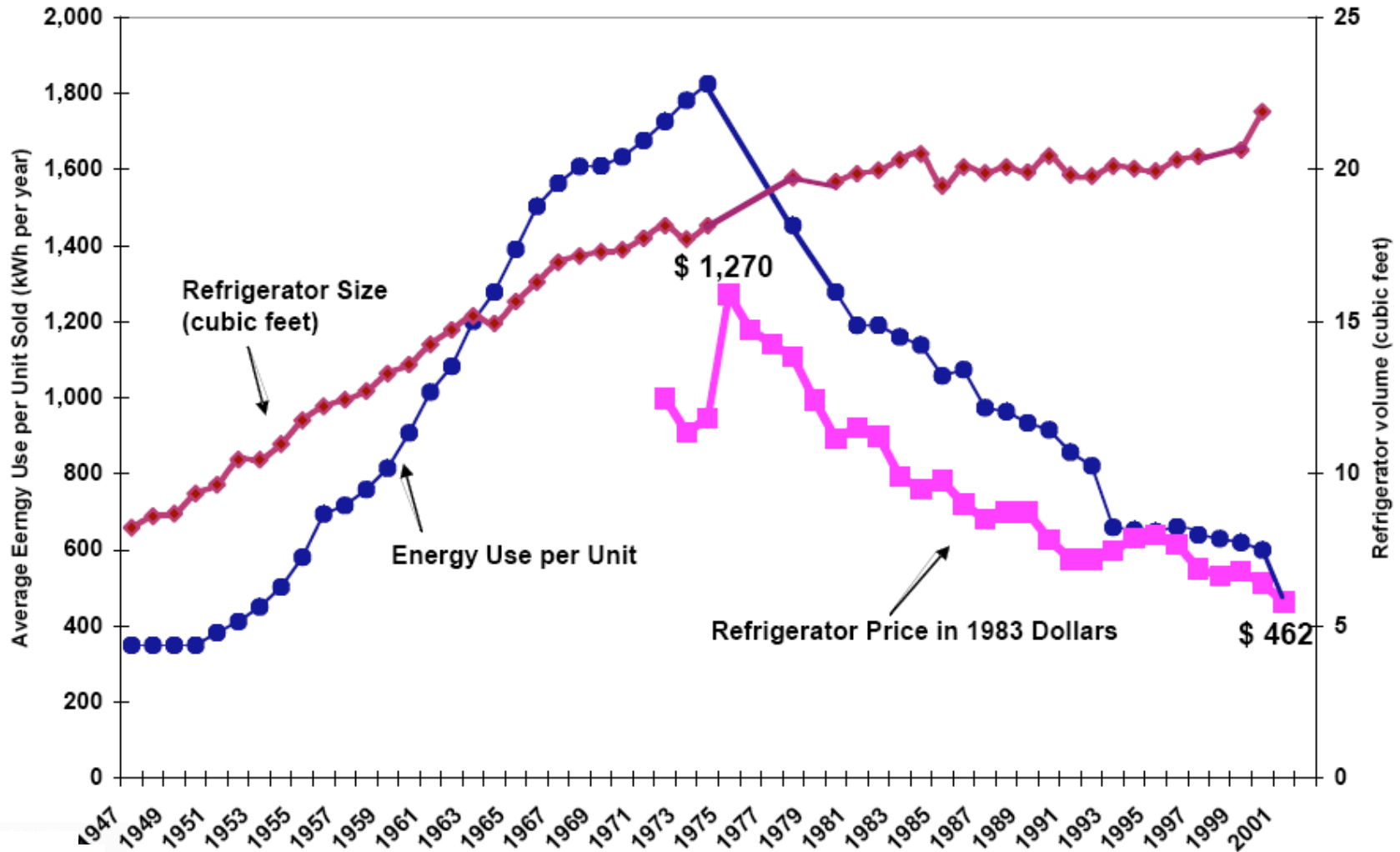


Japan's standards aim to cut el. use 30% from ~1997 levels for refrigerators, 16% for TVs, 83% for PCs, 14% for air conditioners,...; all can go much lower



Efficiency standards needn't raise costs

United States Refrigerator Use v. Time



Source: David Goldstein



7. False or absent price signals

- ◇ Energy subsidies (\sim \$230b/y to global fossil fuels per World Bank 1992) www.globalsubsidies.org, www.earthtrack.net
- ◇ Unpriced externalities—not just environmental
- ◇ Dilution by other costs: U.S. gasoline, still cheaper than bottled water, is only \sim 1/6th the total cost of driving (AAA 2006, \$2.40/USgallon)
- ◇ Poor tracking of energy costs to profit centers
- ◇ Opacity of aggregated bills (e.g., in your house)
- ◇ Real-estate appraisers seldom value energy efficiency, and claim that the market doesn't
- ◇ Tax asymmetries: fuel is expensed, but investments in efficiency must be capitalized (cf. Japanese FGD retrofits)



7a. Some solutions

- ◇ Name and shame subsidizers/-ees; track subsidies annually; engage economics community; offset with state tax regimes?
- ◇ Perhaps similarly for externalities; labeling?
- ◇ Light-vehicle feebates; scrappage rewards?
- ◇ Activity-based costing, submetering/dataloggers
- ◇ Informative bills (carbon content may soon appear on line-items on your bill at some big stores; 3d-party info providers)
- ◇ Cashflow method of appraisal; informed and assertively inquisitive leasing brokers and buyers; energy rating systems
- ◇ Introduce expensing of energy-saving investments to level the playing field: a strong business stimulus, boosts competitiveness, and may well yield net revenue gain to Treasury

Dr. Paul MacCready proposes a sign to go on every U.S. gasoline pump:

Burning each gallon of gasoline puts more than 19 pounds of CO₂ into the air, where it will remain for a hundred years, and buying each gallon provides over 40 cents to countries that hate the U.S.



8. Incomplete markets and property rights

- ◇ There's no market in saved energy
- ◇ You can't bounty-hunt for wasted energy
- ◇ You can't trade negawatt futures and options nor, usually, bid them against megawatts
- ◇ Few tradeable property rights in reduced or avoided depletion/pollution or reduced uncertainty of energy demand, so can't express value
- ◇ Standard measurement protocols for savings are now available, but only for buildings



8a. Some solutions

- ◇ Morro Bay's fungible water savings got 2/5 of houses retrofitted in the first four years; a fuller effort cut Goleta's use/person by >50% residential, >30% total, in one year with no loss of service quality
- ◇ NYC saved billions by protecting watershed instead of expanding potable-water treatment
- ◇ New England is just starting to let negawatts bid into the regional pool's supply auctions
- ◇ Bi-/trilateral deals needn't wait on regulators: business customers and customers can proceed by using side-contracts instead of tariffs; utilities can reward bounty-hunters regardless



In sum, each obstacle offers a major business opportunity

- ◇ Each of these scores of obstacles to using energy in a way that saves money corresponds to a known and proven *profit opportunity*
- ◇ Most of those opportunities have been grasped in only a few exemplary cases, because most businesspeople aren't yet paying close attention
- ◇ Competition and emulation can quickly make them do so, making climate a boon to business
- ◇ This has lately been starting to happen at a rapidly quickening pace, motivating emulation
- ◇ The traditional policy slate—prices/taxes plus regulation or deregulation—is clearly impoverished



The secret sauce: *paying attention*

- ◇ Southwire 1981–87: cut kWh per kg of product by 40%, gas by 60%, then even more, all with pay-backs <2 y; the two engineers responsible probably preserved 4,000 jobs in 10 plants in 6 states
 - It took only “an act of management will and design mentality, consistently applied”
—Jim Clarkson, Southwire
- ◇ Dow Louisiana Div. (3,400 workers), 1981–93
 - Shop-floor-level contest for energy- and waste-saving ideas
 - Year 1: 27 projects, av. 173%/y ROI; year 2: 32 projects, av. 340%/y ROI; worst year 97%/y; years 1–12: ~900 projects, av. 202% predicted and 204%/y audited ($n = 575$) ROI; +\$110M/y
 - Returns and savings trended upwards: engineers (as usual) discovered new tricks faster than they used up the old ones
 - Success *recognized* not rewarded; senior management not told
 - The key was shifting shop-floor culture to attention and curiosity



Even cheap energy can be saved very quickly

- ◇ U.S. 1979-86: GDP +19%, primary energy –6%
 - High and rising prices, sense of urgency
- ◇ Today we can substitute high and rising *skill and attention*, focused by any combination of “hooks”:
 - current or expected price signals (trading, insurer pressure,...)
 - political, business, social, or spiritual leadership at any level
 - public/customer concern (security, climate, Creation care,...)
 - similar investor, employee, and executives’ personal concerns
 - competitive pressures to capture efficiency’s advantages
 - competitiveness, jobs, community renewal, and local issues
- ◇ Private-sector leadership can quickly focus attention, shift fashions, and transform big systems
- ◇ Our capitalist society drives this by marketing...



Implementation topics

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Marketing efficiency

Electricity: public policy

Electricity: business strategy

Electricity: making negawatt markets



Why does efficient end-use get so little attention and respect?

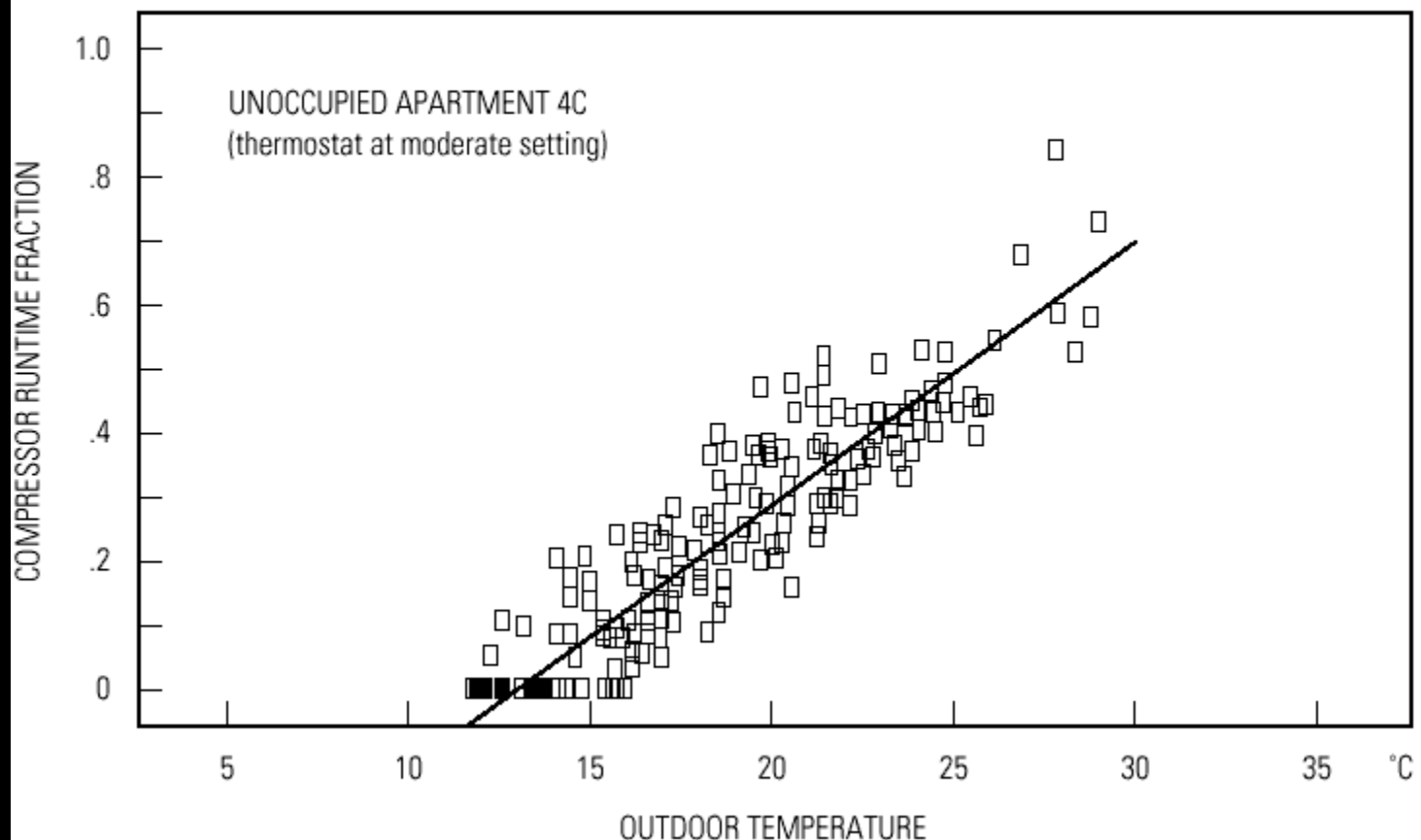
- ◇ It's invisible—zillions of little pieces, and they look unchanged
- ◇ Little attraction for TV cameras, politicians, rent-seekers
- ◇ Homebuyers often think it's binary—you have it or you don't
- ◇ Economists often presume that if it were worthwhile, it'd already have happened, so it must need higher prices to work
- ◇ Policymakers think they already did it in the '70s...and are often conditioned by ill-recalled economic theory to disdain a big potential as supposedly impossible (see Economists)
- ◇ Designers often aren't told or rewarded to diverge from comfortable past practice; also, most textbooks get it wrong
- ◇ Even many specialists can't keep up with the pace of progress
- ◇ Executives often focus on bigger factor costs
- ◇ Installers come only when you call, not ahead of time
- ◇ Journalists and editors forgot what they'd learned
- ◇ Marketers haven't yet seriously enrolled



The mysteries revealed by energy anthropology

Air-conditioner operation in an unoccupied NJ apartment validates the engineering theory of thermostats, but...

Air Conditioner Operation: Not Just Temperature-Driven

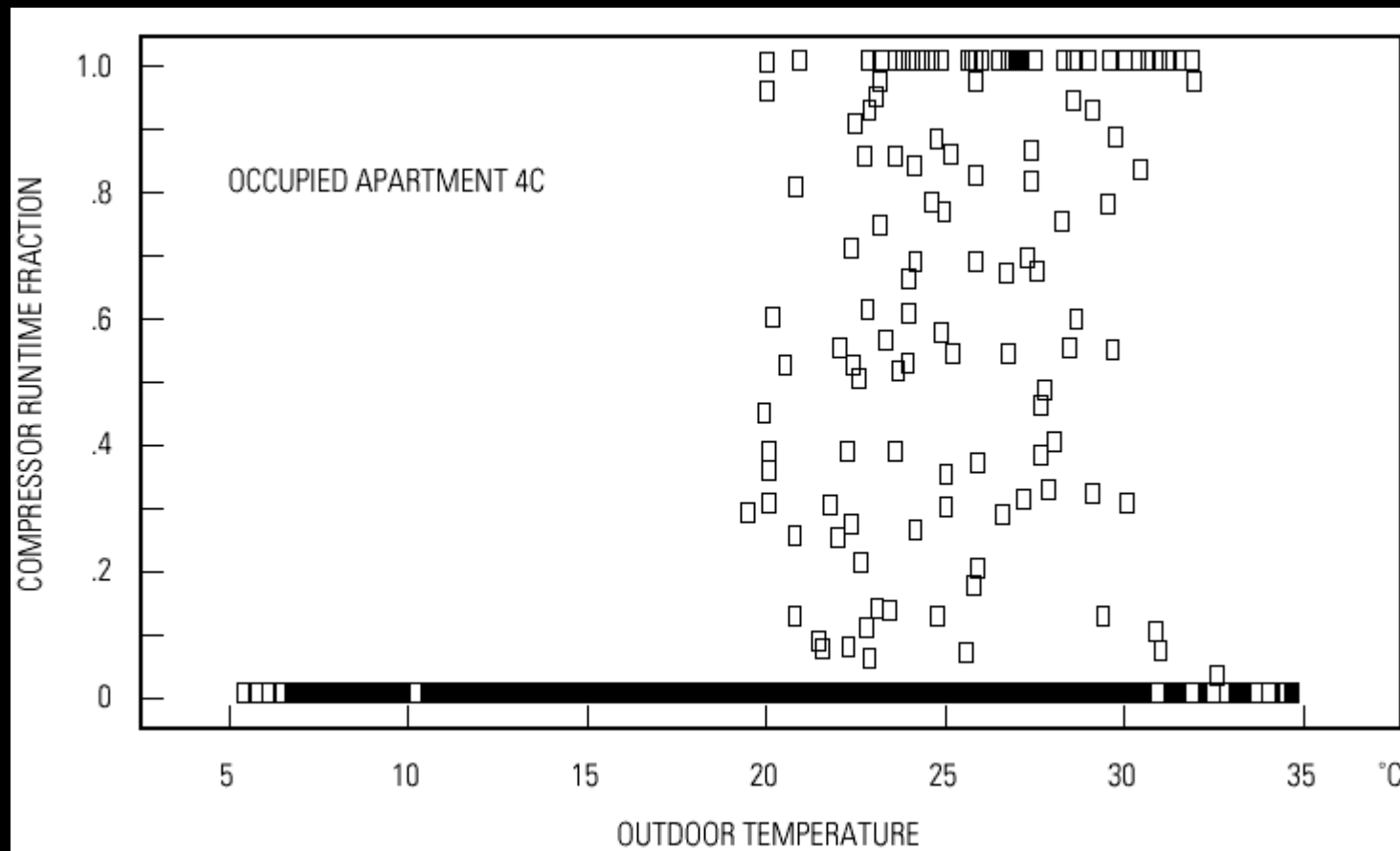


Kempton *et al.*, "I always turn it on super," *En. Bldgs.* 18(3):177–191 (1992)



Surprise—people are complicated!

...In an apartment whose occupants are told the air-conditioner and the electricity are *free*, air-conditioner operation and comfort aren't linked—six other drivers



Both graphs from E SOURCE (www.esource.com), SIP-1, 1992, by permission



Air-conditioner use: four paradigms

1. Utility load dispatcher
2. Comfort theorist
3. Econometrician
4. Energy anthropologist

- ◇ #4 is by far the most powerful explainer
- ◇ #2 and #3 are not simply incomplete; they're seriously misleading
- ◇ Similarly for space heating and hot water; little is known about most other end-uses
- ◇ Need to rethink policy and marketing accordingly



You can market energy efficiency without ever mentioning it

- ◇ The customer is interested in her business, not yours
- ◇ Speak to the customer's concerns in her language (Saul Alinsky: "Talk to folks where they're at, not where you're at"): sell energy efficiency as a profitable way to achieve what the customer wants—which may have nothing to do with energy
- ◇ The side-benefits you can sell are often worth one, sometimes two, occasionally three, *orders of magnitude* more money to the customer than are the direct energy savings!



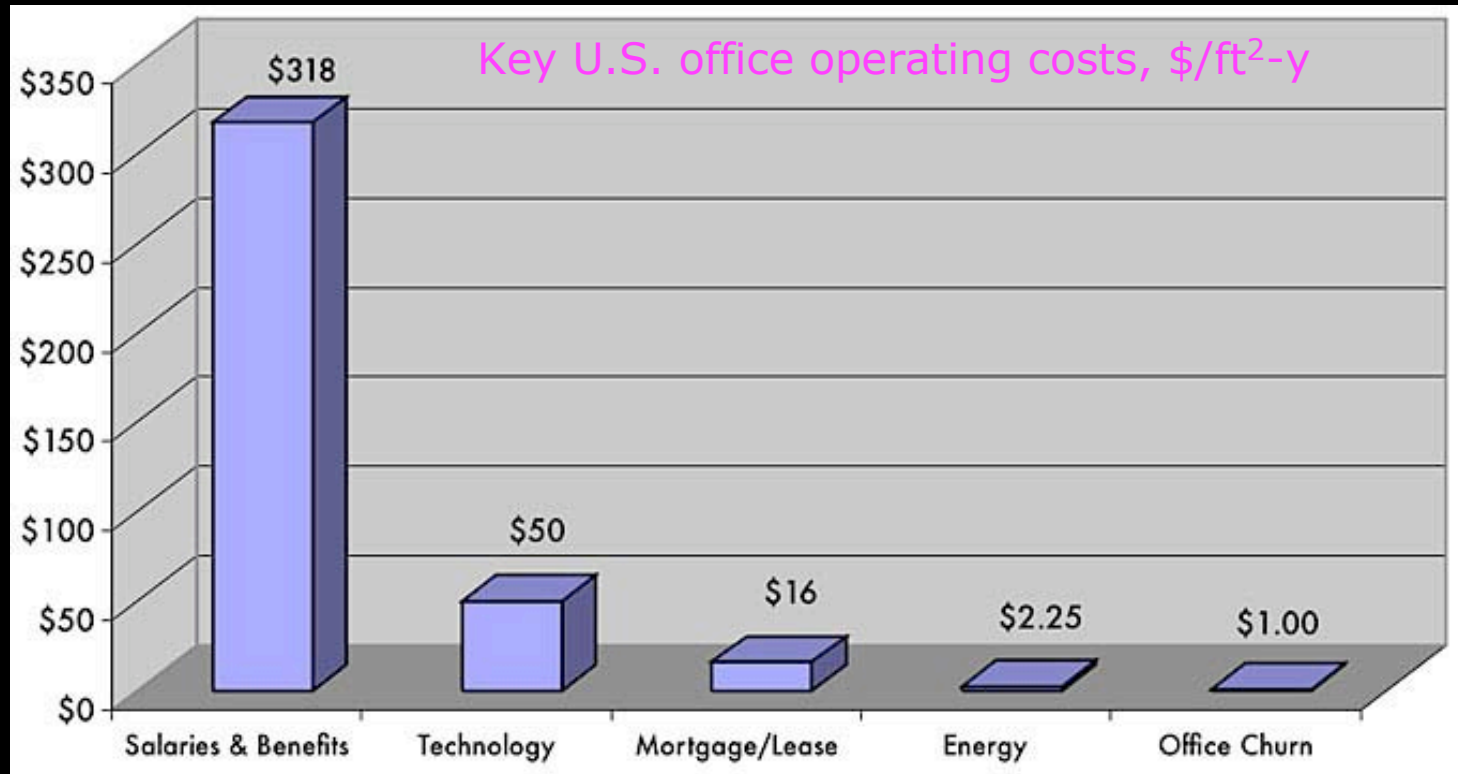
Side-benefits of energy efficiency

- ◇ Efficient buildings are more comfortable, healthful
- ◇ Efficient lighting systems can look better and let you see better
- ◇ Efficient motors can be more quiet, cool, reliable, and controllable
- ◇ Efficient refrigerators keep food fresher, longer
- ◇ Efficient factories make more and better products
- ◇ Efficient hospitals have faster healing, less pain, fewer infections, better financials
- ◇ Efficient supermarkets sell more and safer food
- ◇ Show me the numbers! OK, here are a few...



Office productivity gains are ~164× more valuable than energy savings

Occupants' salaries, w/o equipment & benefits, are ~85–92% of the cost of office operation. Salaries, benefits, and equipment total 164× energy costs. Before Romm & Browning (RMI, 1994), nobody had looked for productivity effects because business schools mistaught the "Hawthorne effect," so MBAs believed such effects were a myth. Now they're turning up everywhere.



Source: Carnegie Mellon University's Center for Building Performance and Diagnostics 2005 update of RMI's 1991 analysis, using typical U.S. data, posted at www.buildinggreen.com/auth/image.cfm?imageName=images/1310/chart_costs.jpg&fileName=131001a.xml



Lockheed 157

Sunnyvale, CA

- 55,762-m² office building for 2,700 engineers and support staff
- Textbook example of daylighting (by Leo A. Daly)





Lockheed 157 Sunnyvale, CA

- 75% reduction in lighting energy
- Half the energy consumption of a comparable standard building
- Cost \$2 million extra; saves \$500k/year worth of energy (4-year payback), but also...

Absenteeism dropped 15%, productivity increased 15% — paid back 100% in first year... then won contract whose profits paid for the whole building

Lockheed clammed up





Verifone Irvine, CA

- Retrofit of tilt-up
- Energy use fell to 59% below Title 24
- Utility costs fell by 72%



- 7.5-year payback expected...but
- Actually <1 y counting higher labor productivity





Wal-Mart

Eco-Store (Lawrence, Kansas) accidentally discovered the major sales benefits of daylighting





Daylighting study

Pacific Gas & Electric Co.
Heschong Mahone Group

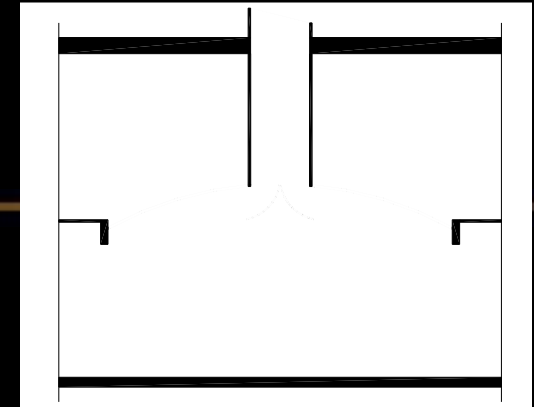
Retail sales are **40% higher** in daylit shops

[www.h-m-g.com/toppage11.htm#Skylighting and Retail Sales](http://www.h-m-g.com/toppage11.htm#Skylighting%20and%20Retail%20Sales)



Stop & Shop Foxboro, MA

- 38% energy savings
- Higher per-cart sales
- Improved customer satisfaction
- Preferred by employees



Skylights: 60–90% Daylight



Sainsbury's Grocery Store Greenwich, UK





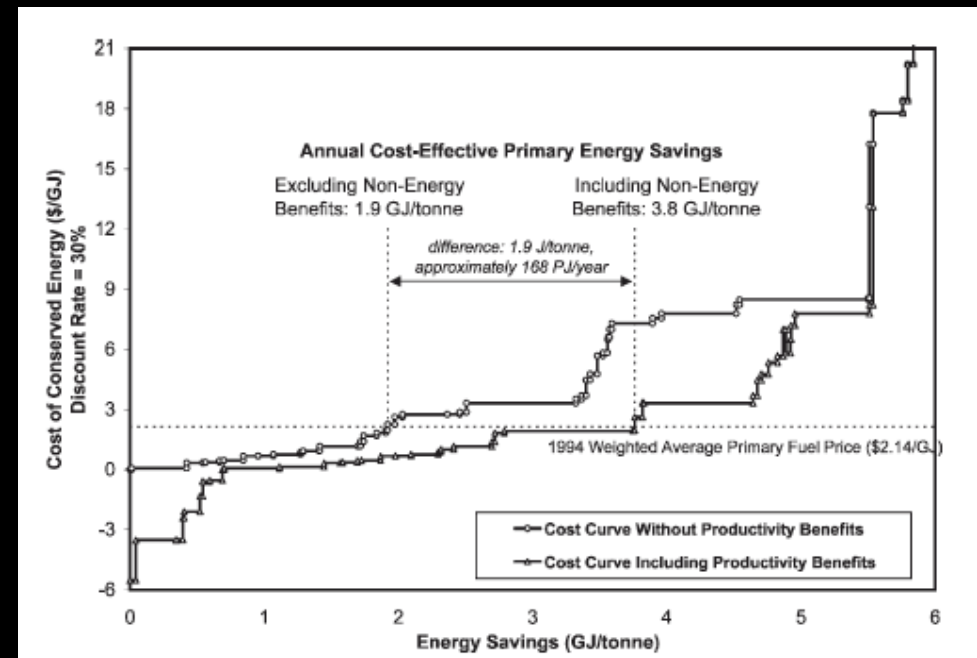
Boeing main assembly plants (Washington State)

- Lighting system retrofit in design & mfg. areas
- Cut lighting energy costs by up to 90% with <2-year payback; but also...
- Workers could see better
- Valuable improvements in avoided rework, on-time delivery, customer satisfaction—far more valuable!
- Unfortunately, lighting design (as distinct from engineering more efficient luminaires) is scarcely part of the industrial vocabulary: in few factories anywhere can workers properly see what they're doing



Counting side-benefits can double industrial energy savings

- A LBNL review of 52 industrial case-studies in 6 OECD countries found that explicitly valuing observed gains in industrial productivity (e.g., higher output and quality, lower wastes and emissions) cut average efficiency-retrofit payback times *in half*, from 4.1 to 1.9 y; *in 63% of cases, non-energy benefits exceeded energy benefits*
- In the U.S. iron & steel industry, counting non-energy benefits (various forms of productivity gains) from 47 kinds of energy-saving retrofits *doubles the cost-effective energy-saving potential* (see graph), assuming \$2.14/GJ primary energy and a high (30%/y) nominal discount rate



E. Worrell *et al.*, *Energy* **28**:1081–1098 (2003);
E. Worrell *et al.*, *Energy* **26**(5):513–536 (2001)



Marketers know innumerable other ways to make efficiency cool & sexy

- ◇ 2007 X Games ran global-cooling TV spots with famous hotdog snowboarders saying, "Keep winter cool—it's short enough already!"
- ◇ Cars are vehicles for emotions. Try this, for an experimental battery-electric performance car with $\sim 1/3$ the energy intensity of a *Prius*:





Implementation topics

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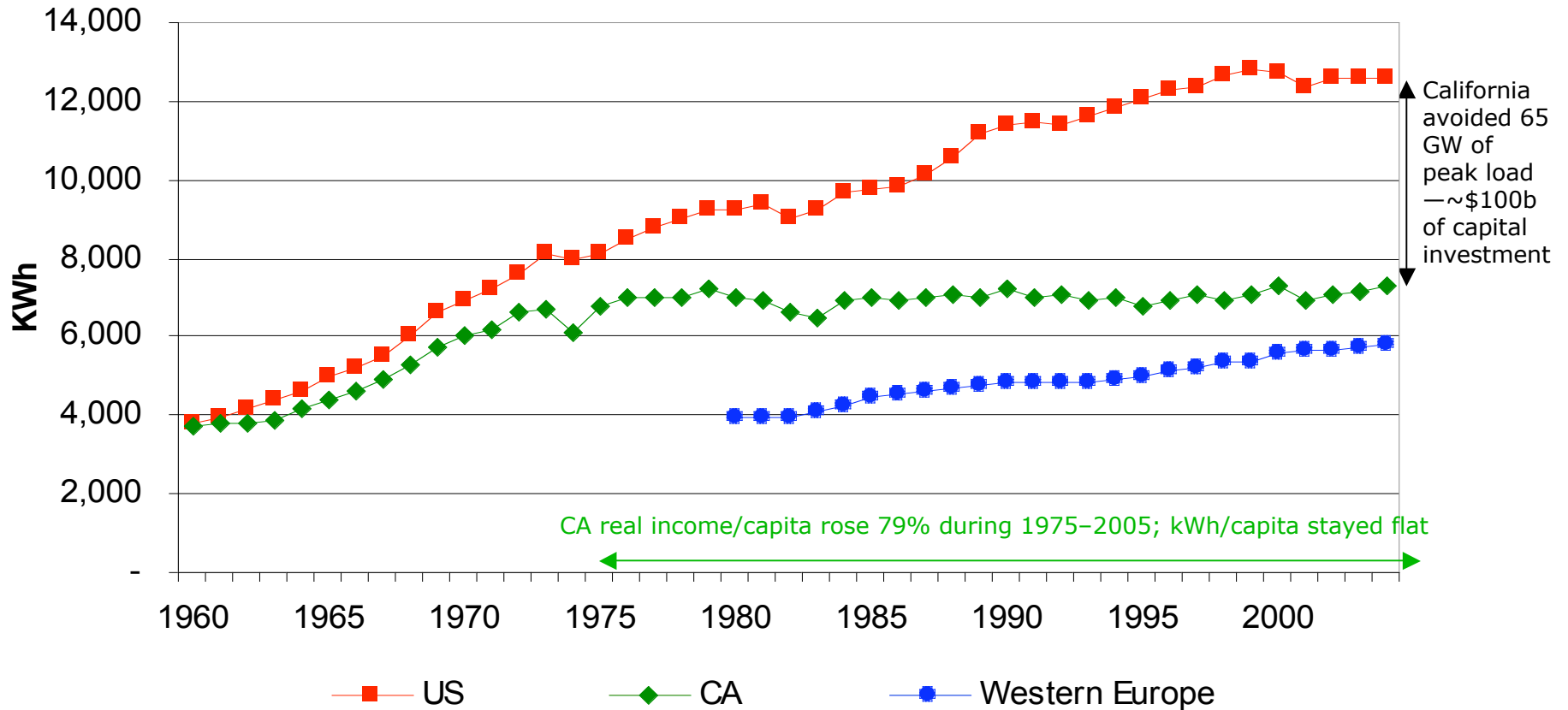
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Electric efficiency works in California and in Western Europe

Annual electricity use per capita



Source: California Energy Commission

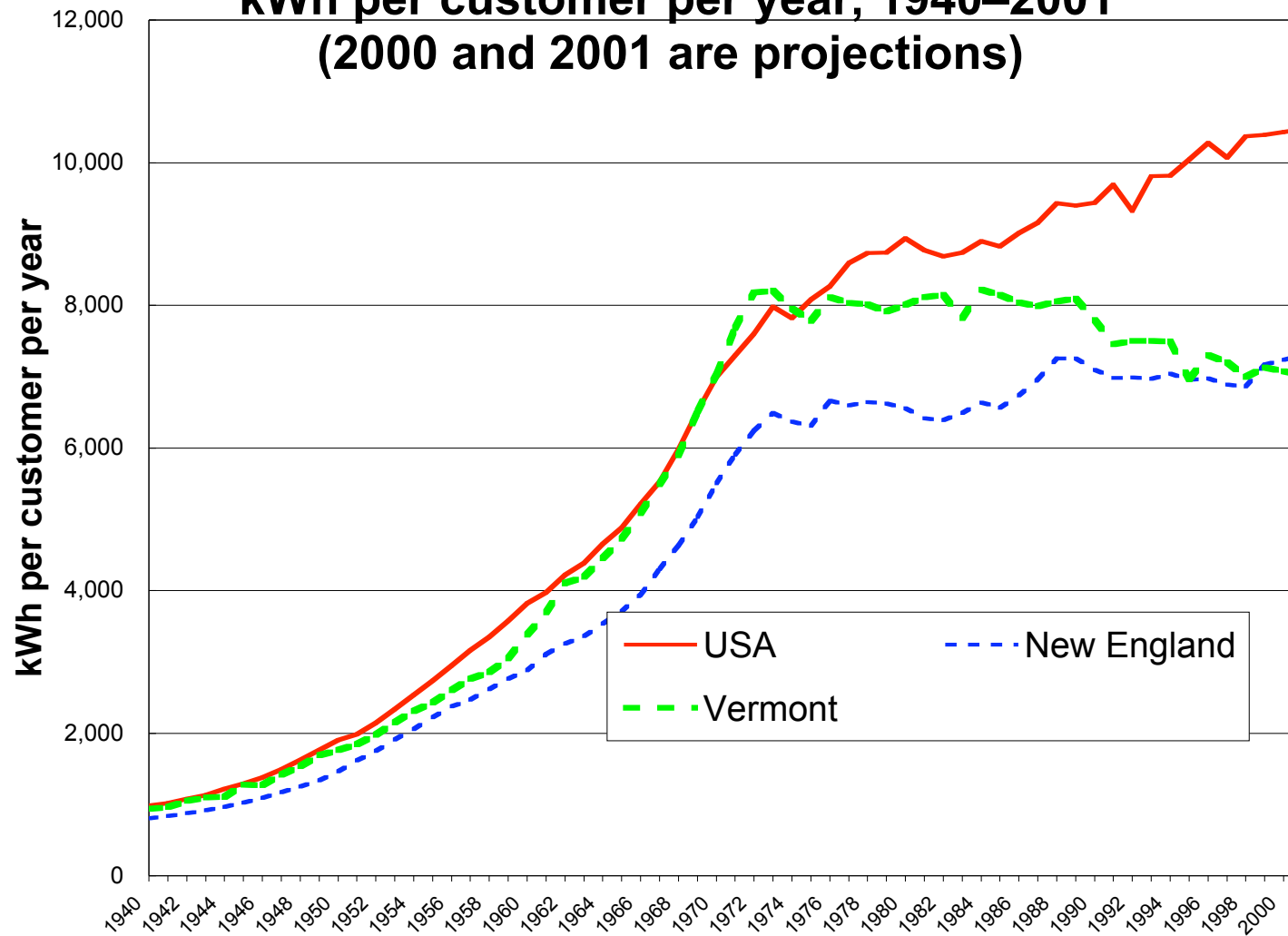
CA savings came roughly half from appliance and building efficiency standards, half from rewarding utilities for cutting customers' bills—not for selling more energy



...and in New England

(courtesy of Chairman Dworkin, Vermont Public Service Board)

Residential Electricity Use kWh per customer per year, 1940–2001 (2000 and 2001 are projections)





The biggest lever to pull: reward negawatt providers symmetrically

- ◇ Focus not on *price of kWh (tariffs)* but on *cost of electrical services (bills = tariff × consumption)*
- ◇ *Reward distribution companies for reducing customers' bills, not for selling more electricity*
- ◇ Fixing this perverse policy incentive is *the* most important possible reform in electricity, and one of the top two (w/car feebates) for CO₂
- ◇ Unanimously endorsed by U.S. state utility regulators 7/88, adopted in ~7–9 states, derailed by restructuring, now coming back: in place for electricity in CA and ID, for gas in ~8–10 states; many more on the way; NRDC and Energy Foundation lead these reforms
- ◇ Use modern program evaluation techniques—very accurate & reliable
- ◇ Purge all forms of discrimination against small, multiple-output, private, and variable-renewable options; eliminate RIM test
- ◇ Power-pool portfolio planners should properly credit distributed resources with their full value (*Small Is Profitable*): avoided grid capacity and outages, reserve margins, financial risks, etc.



Decoupling and shared savings

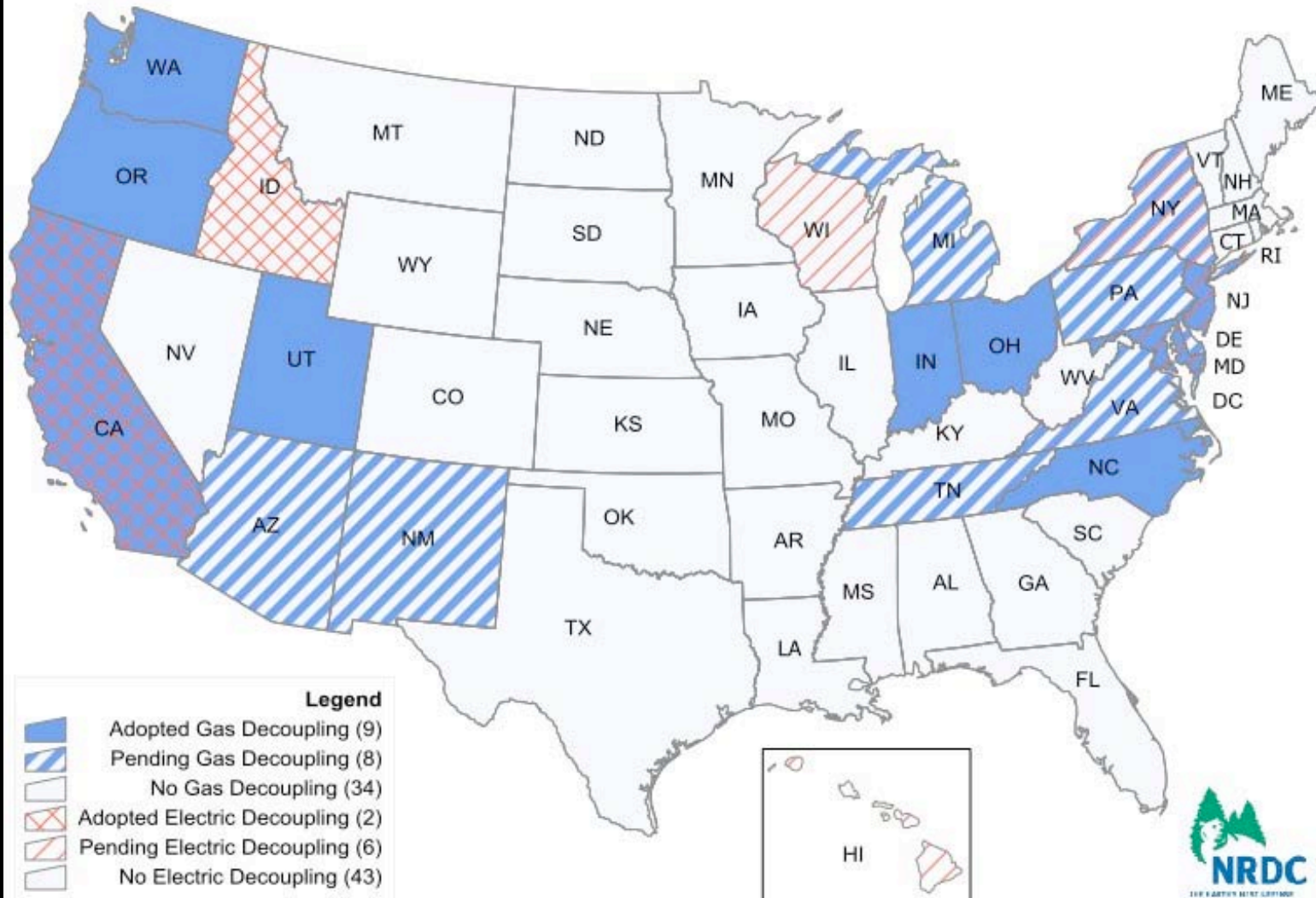
- ◇ The problem: under traditional rate-of-return regulation, setting a tariff to meet revenue requirement needs assumptions about how much electricity each rate class will buy
- ◇ Higher sales then raise profits, lower sales reduce profits
 - Utility thus at risk for variables it can't control; incentivized to game
- ◇ *A balancing account* decouples revenues from sales volume
 - Profits from higher-than-expected sales are escrowed
 - Losses from lower-than-expected sales are made good from escrow
 - Long-term effect on price of electricity smooths out, becomes tiny
- ◇ *Utility shares* a little of the *savings* achieved for customers
 - *E.g.*, PG&E in 1992 invested >\$170M to help customers make cost-effective savings; generated nearly \$400M present-valued benefits
 - Customers got 89% of savings as lower bills; shareholders got 11%
 - Shared saving was PG&E's second-biggest source of revenue, >\$40M
 - Aligning utility/customer incentives profoundly changes utility culture





**March 2007: 2 down, 48 to go,
but 6 of those on the way...**

Gas and Electric Decoupling in the US





Other state and local electricity-saving policy opportunities

◇ Administration

- Share savings between those responsible, dept., and general fund

◇ Appliances

- Have el. and gas companies (50/50?) buy out electric space and water heaters & electric stoves: new unit + \$100?

◇ Buildings

- Revenue-neutral feebates: more powerful/dynamic than standards
- Expedited approvals for efficient and green development projects
- Eliminate all barriers in building codes & code practice, purchasing
- Public-building managers should reach, then beat, BCBC's savings

◇ Integrate climate into land-use & all other regulation

◇ Energy-efficiency training and education at all levels

◇ Expense (not capitalize) energy-saving investments

◇ Community mass retrofits of homes and businesses



Hood River [Oregon] Conservation Project, 1983–85

- ◇ Retrofitted free superinsulation (R-19→R-49, ~0.4 ach, triple glazing,...) into $\geq 1,470$ houses in the Columbia River Gorge—almost rebuilding them
- ◇ Done by local contractors within the 2-y deadline
- ◇ Testing upper bounds of rapid, full installation & evaluation
- ◇ 83% of recommended measures were installed (7% of potentially installable savings lost); savings 5% above forecast; ~45% of measures were uninstallable
- ◇ Total savings per electric-heated house: ~6 MWh/y @ 4.2¢/kWh (over 35 y)—would have been ~2.5¢/kWh using old superwindows instead of triple glazing; even less today
- ◇ Installed ≥ 1 major measure in 85% of eligible homes in 2 y; >60% signed up before ads began; 27% signed up in the first 3 months; strong & widely replicable marketing success
- ◇ Hood River implementation experts are available elsewhere



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Basic verities of today's electricity business

- ◇ Negawatt-hours cost far less than megawatt-hours, usually even on the *short-run* margin
- ◇ This cost gap is widening in both price and externalities
- ◇ As customers figure this out, they'll want to buy less electricity and more efficiency: *nobody wants* raw kWh!
- ◇ The only question is who will sell them the efficiency
- ◇ It is a sound business strategy to sell customers what they want before someone else does
- ◇ Whether markets buy/sell negawatts or not, customers can and often do; markets will clear accordingly
- ◇ Every customer hassle in buying negawatts is a business opportunity for utilities, with their skills, cash, bill-ing relationship, customer knowledge, & market power
 - These advantages must not be abused
 - Utilities always have a make-or-buy choice—& partners



The inside-out utility: build from the customer's end-use needs

- ◇ **Traditional:** project demand, build generation, size & build grid to deliver output to customers
- ◇ **Customer-focused:** start with end-uses
 - In each distribution area that's about to invest...
 - Target efficiency and demand response on the key end-uses found to be causing that neighborhood's load growth
 - Augment as necessary with distributed generation, reactance control, other minor grid improvements
 - Thus work from end-use back upstream, and target negawatts like a rifle, not a shotgun
- ◇ **When tried at PG&E and Ontario Hydro...**
 - Generation and (usually) transmission expansion proved needless
 - All customer needs were met more reliably and quickly
 - *Required capital investment decreased by up to ~90%*
 - Ontario Hydro alone saved US\$0.5b in two experiments (two out of ~200 distribution planning areas)



Electric end-use efficiency can work quickly even with old methods

- ◇ In ~1975–85, most new U.S. end-use devices—cars, buildings, refrigerators, lighting systs., etc.—doubled in efficiency ($\sim 7\%/y$)
- ◇ In 1983–85, 10 million people served by Southern California Edison Company (then the #3 US investor-owned utility) were cutting its 10-years-ahead forecast peak load by $8\frac{1}{2}\%$ *per year*, at $\sim 1\%$ of marginal supply cost
- ◇ In 1990, New England Electric System got 90% of a small-business retrofit pilot program's market ($1.5\times$ target) in 2 months
- ◇ PG&E got 25% of its 1990 new-commercial-construction market in 3 months, raised its 1991 target, and got it all during 1–9 Jan.
- ◇ Even without helpful policy (in all but a few states), the U.S. has cut electric intensity $> 2\%/y$ in 4 of the past 6 years
- ◇ New delivery methods are even better—not just marketing negawatts but making markets *in* negawatts, thus maximizing competition in who saves and how—and marketing efficiency for its side-benefits, not only cutting energy costs



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Old methods of marketing negawatts (can maximize participation and savings per participant)

- ◇ Information, exhortation, education
 - General public
 - Targeted or technical: builders, designers,...
- ◇ Financing
 - Low- or no-interest loans, then gifts (usually cheaper)
- ◇ Direct delivery (utility installs everything for free)
- ◇ Pilot and demonstration projects
- ◇ Third-party investors, Energy Service Companies (ESCOs, which can be utility-owned)
- ◇ Leasing (\$0.30/CFL-month?...)—pay for it over time just like other utility assets



Old methods (continued)

◇ Rebates

- Targeted, then generic per kW or kWh
- To buyer, wholesaler, retailer, manufacturer, other trade allies,...; leverage markups (as in SCE's CFLs)
- Plus scrapping inefficient old devices
- For beating minimum standards
 - > Equipment, buildings,...
 - > Standards really work, but are relatively static
- Not for equipment but for *efficient design* (very powerful!)
 - > Efficient equipment typically costs *less*; why pay for it?

◇ "Golden carrots" to elicit innovation

◇ Load-management cooperatives

◇ Community programs (see *Brittle Power*, 2001, Ch. 17, www.rmi.org/sitepages/pid533.php#S82-03, for outstanding 1970s examples that most places would be proud to replicate today)



New methods: make markets *in* negawatts (can also maximize competition in who saves and how)

- ◇ **Competitive bidding processes**
 - Industrial modernization grants (Maine)
 - Generalized ("all-source") auctions (New England)
- ◇ **Fungible savings (with grid credit)**
 - Morro Bay example for saving water
 - Wheeling savings between customers, utilities, States, even countries (Québec/VT)
 - Negawatt/megawatt arbitrage and derivatives
- ◇ **Peak-load-limit commitments**
 - Can be traded in secondary market
 - Value reduced demand uncertainty
- ◇ **Human/organizational capital: O&M, commissioning, training, education, operator graphics/sims.**
- ◇ **Bootstrap operational savings *in utility* (motors...)**



New methods (continued)

- ◇ C&I load-management coops (CA, NY, MA, IL, S)
- ◇ Efficiency cross-marketing (electricity/gas)
- ◇ Market transformation, *e.g.*, BC Hydro/big motors
- ◇ Performance-linked feebates for new buildings
 - Feebates don't become obsolete like standards
 - Feebates aren't static: reward & elicit continuous improvement
- ◇ Maximize free drivers (and maybe even free riders)
 - Strong outreach helps unpaid onlookers follow suit—a *benefit*
- ◇ Systematic "barrier-busting"
- ◇ Near-zero-cost distribution (KISS stories)
- ◇ Targeted mass retrofits
- ◇ Cooperation and competition between gas and electric companies, both swapping customers and getting rewarded for saving both kinds of energy



New partners (continued)

- ◇ Multi-resource consortia
 - *E.g.*, pay for superefficient washing machines by monetizing savings of most of its water and sewage flows, chemical discharges, and landfill space (if it's more durable, remanufacturable, or recyclable), while providing local manufacturing jobs and capturing their multiplier
- ◇ Marketing partners willing to pay for access to a utility's customers for their own purposes, or to provide to those customers other valuable concessions that help to market efficiency
 - Janet Benjamin got a major bank to cut construction-loan & mortgage interest rates for PowerSmart customers, and a major lighting-equipment manufacturer to equip one house free for every ten buying its PowerSmart products
- ◇ Sell advanced energy retrofits' potential to turn around distressed commercial properties to financial institutions with nonperforming assets
- ◇ Piggyback on CFC HVAC retrofits, a/c replacements



"The gift in the arms of the problem"

◇ Residential air conditioning

- Your air conditioner dies; you go to the dealer for a new one
- The dealer offers a better deal to fix up your house so it won't need an air conditioner
- The dealer makes more money selling you that service than selling you a new air conditioner
- You get better comfort at lower cost—and you don't care how

◇ Power factor

- A utility realizes that it has to pay for VARs even though it can't charge for them through real-power meters
- It starts charging penalties on $PF < 0.9$; low-PF customers gripe
- Anyone whose bill goes up because of the new PF penalty is offered a profitable solution—*e.g.*, motor-system retrofits (right-sized premium motors, etc.) that correct PF as a profitable by-product of the free energy savings
- Thus customers' bills don't go up from the new PF penalty; they go down from kWh savings
- The utility saves important capex as well as opex



New methods (continued)

- ◇ Integrate new plays to blast through cost barriers:
 - Make performance-based fees the norm in public- and private-sector engagements of design professionals
 - Introduce revenue-neutral sliding-scale hookup fees (feebates for new buildings) to shift new design toward radical energy efficiency and advantage early adopters
 - Provide intensive retreading of designers, HVAC contractors, homebuilders, and other key partners to compensate for weaknesses in design pedagogy (www.10xE.org)
 - Work with wholesale and retail outlets to make efficient hardware easy to get and inefficient hardware hard to get
 - Propagate cheap financing, *e.g.*, via IPMVP, mortgage markets
 - Demonstrate radical savings (*e.g.*, cheaper new buildings w/o space conditioning) and build local capability by rapid ACT²s
 - Carefully reward utility personnel for audited savings
 - Strongly emphasize whole-system design synergies



Gridlock as usual, according to Thucydides, ~431–404 BCE

As the noted Athenian soldier and historian related:

“Thucydides reported that the Peloponnesians and their allies were mighty in battle but handicapped by their policy-making body—in which, he related, ‘each presses its own end...which generally results in no action at all...they devote more time to the prosecution of their own purposes than to consideration of the general welfare—each supposes that no harm will come of his own neglect, that it is the business of another to do this and that—and so, as each separately entertains the same illusion, the common cause imperceptibly decays.’”

—President John F. Kennedy, Paulskirche (Frankfurt) speech “A New Social Order,” 24 June 1963

[6] māx' mçn gār mið prÚw ëpantaw
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Thucydides, *The Peloponnesian War* 1.141.6–7
(including what the President paraphrased)

Are we there yet?



A modest proposal (but spherically sensible)*

*Marv Goldberger

- ◇ Simply allow all ways to save or produce energy to compete fairly, at honest prices, no matter:
 - Which kind they are (efficiency or supply)
 - What technology they use
 - Where they are
 - How big they are
 - Who owns them
- ◇ Who wouldn't be in favor of that?

"You can always count on the Americans to do the right thing...after they've exhausted all other alternatives."



—Churchill