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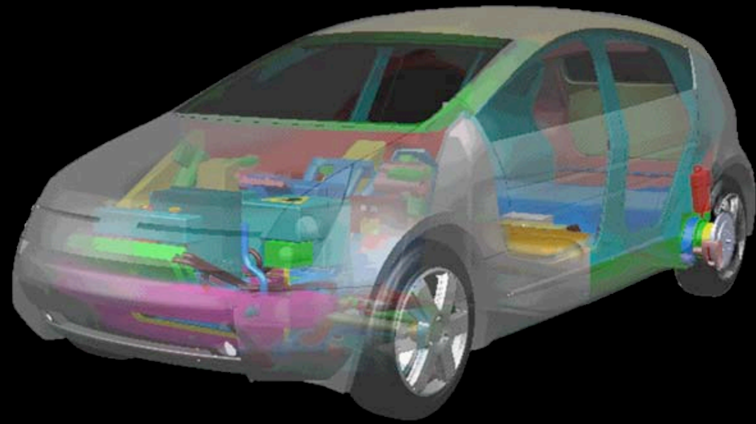
INSTITUTE

Berlin Conference on the Human Dimensions of Global Environmental Change (by video), 23 February 2008

Profitable, Business-Led Solutions to the Climate, Oil, and Nuclear Proliferation Problems



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

— Raymond Williams

Amory B. Lovins

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Energy policy: a multiple-choice test

Would you rather die of:

1. climate change?
2. oil wars?
3. nuclear holocaust?

The right answer, often left out, is:

4. none of the above

Let's just use energy in a way that saves money, because that will solve the climate, oil, and proliferation problems—not at a cost but at a profit

What has reduced energy intensity already done? What more can it do?

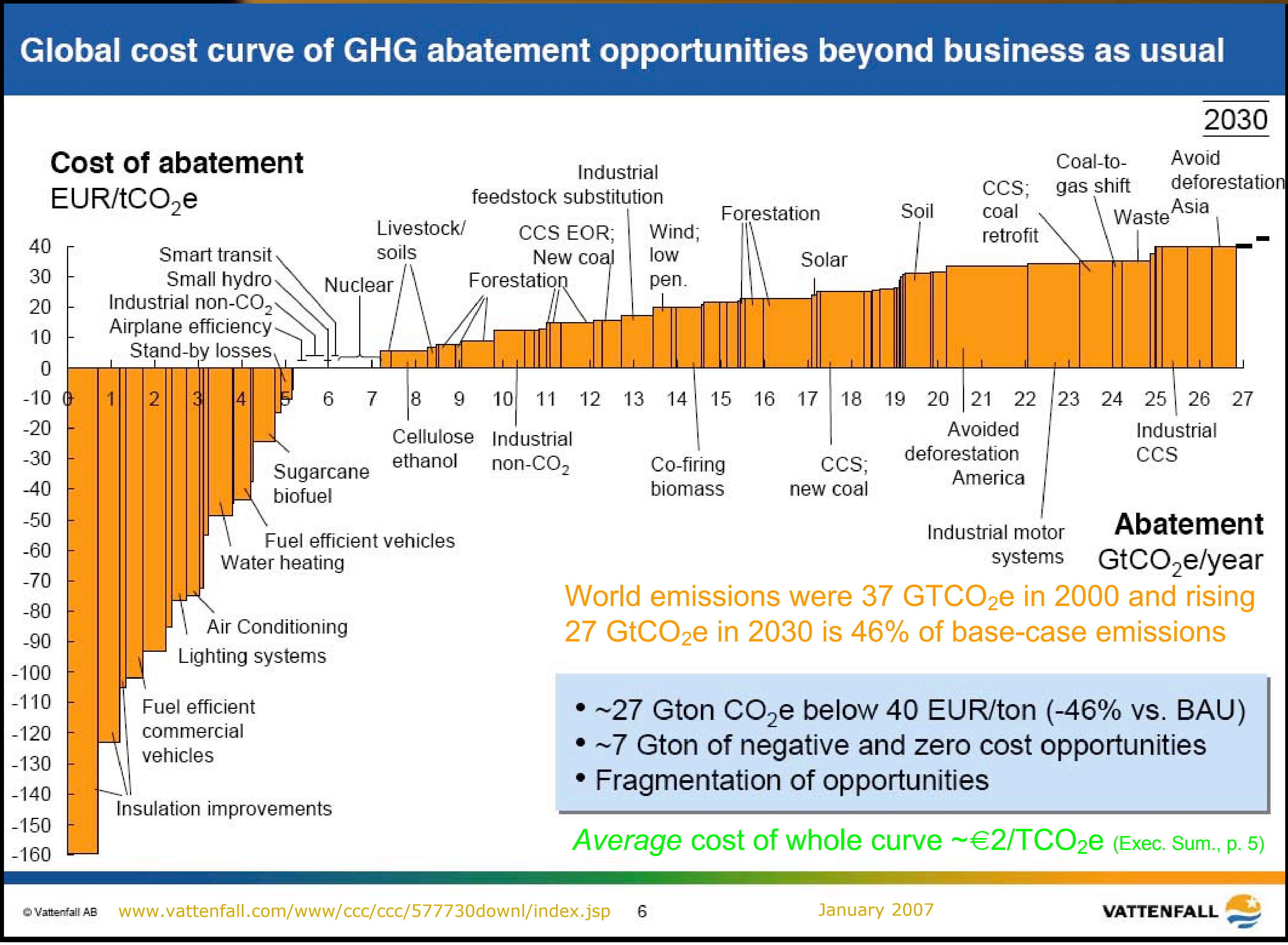
- During 1975–2006, the U.S. made a dollar of real GDP with 48% less total energy, 54% less oil, 64% less directly used natural gas, 17% less electricity, and two-thirds less water
  - Despite stagnant light-vehicle efficiency for >20 years, and perverse incentives rewarding electricity sales in 48 states
  - Nobody noticed: we haven't paid attention since the mid-1980s
- Full use of today's best end-use efficiency techniques would deliver the same or better services but save:
  - half the oil, at a sixth of its price
  - half the natural gas, at an eighth of its price
  - three-fourths of the electricity, at an eighth of its price
- Investing to achieve those savings over several decades would cost 6× less than buying the energy, and would make energy prices lower and less volatile
- Proper pricing matters less than barrier-busting

Q. How is climate protection like the Hubble Space Telescope?

A. Both were spoiled by a sign error ("+" *vs.* "–")

The incorrect *assumption* that climate protection will be costly is the biggest obstacle to climate protection

2007 Vattenfall/McKinsey supply curve for abating global greenhouse gases
(technologically *very* conservative, esp. for transport)



Saving energy is cheaper than buying it, so firms are starting to buy energy efficiency whether or not they worry about climate

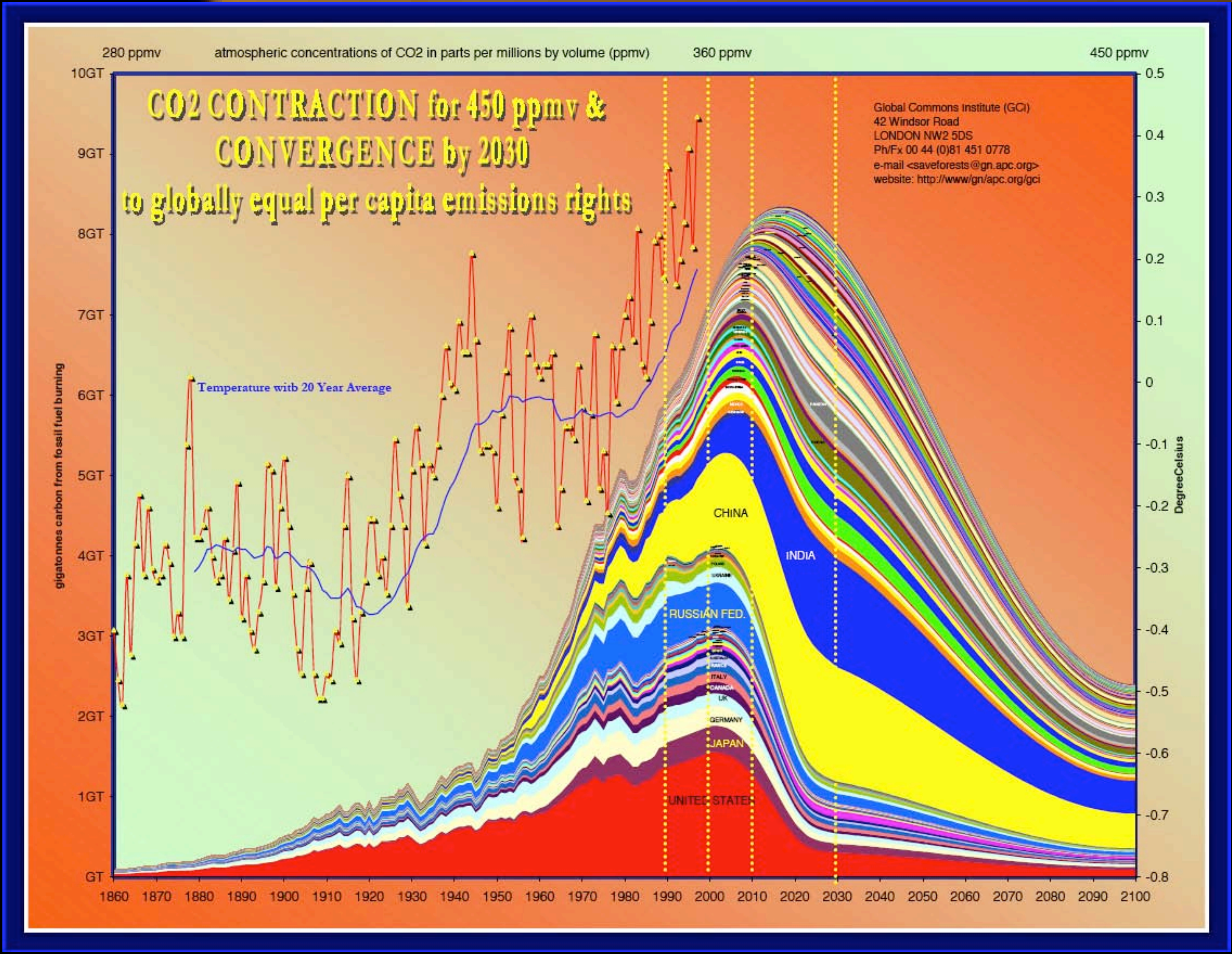
- IBM and STMicroelectronics
  - CO_2 emissions –6%/y, fast paybacks
- DuPont's 2000–2010 worldwide goals
  - Energy use/$ –6%/y, add renewables, cut absolute greenhouse gas emissions by 65% below 1990 level
  - By 2006: actually cut GHG 80% below 1990, $3b profit
- Dow: cut E/lb 22% 1994–2005, $3.3b profit
- BP's 2010 CO_2 goal met 8 y early, $2b profit
- GE pledged 2005 to boost its eff. 30% by 2012
- Interface: 1994–2006 GHG –60% (–9.2%/y)
- TI new chip fab: –20% en., –35% water, –30% capex

- So while the politicians endlessly debate theoretical "costs," smart firms race to pocket real *profits!*

Profitable climate protection

- Global CO_2 emissions will triple by 2100 if we reduce E/GDP by 1%/y; level off if 2%/y; and drop—stabil-izing the Earth's climate—if ~3%/y. Is that feasible?
- The U.S. has spontaneously saved >2%/y since '97; 3.4%/y 1981–86; 3.2%/y in '01 & '05, 4.0% in '06
- California was ~1 percentage point faster; its new homes use 75% less energy; still saving much more
- China did even better—saved >5%/y for >20 y, 7.9%/y 1997–2001; energy efficiency is top priority
- Attentive corporations routinely save ~6–9%/y
- Even Japan can profitably save 2/3 of *its* energy, so the US, with 2–3× more E/GDP, has a long way to go
- Oil causes 42% of all CO_2 emissions, electricity 40%

Surprisingly, the vision of contraction & convergence is both feasible & profitable



Independent, transparent, peer-reviewed, uncontested, DoD-cosponsored, Sept 04

For business/mil. leaders

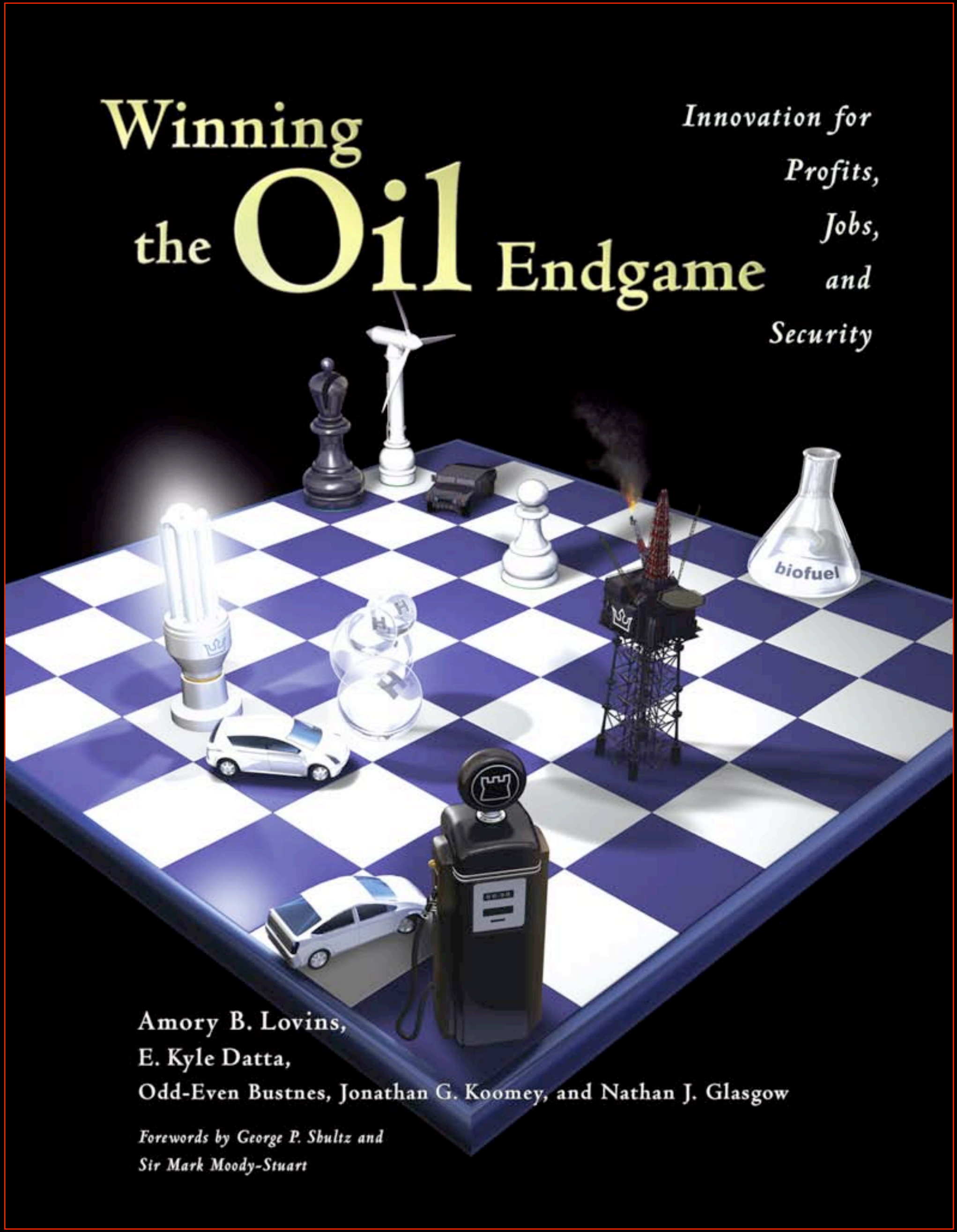
Based on competitive strategy cases for cars, trucks, planes, oil, military

Book and technical backup are free at:

www.oilendgame.com

Over the next few decades, the U.S. can eliminate its use of oil and revitalize its economy, led by business for profit

(So, probably, can Germany)



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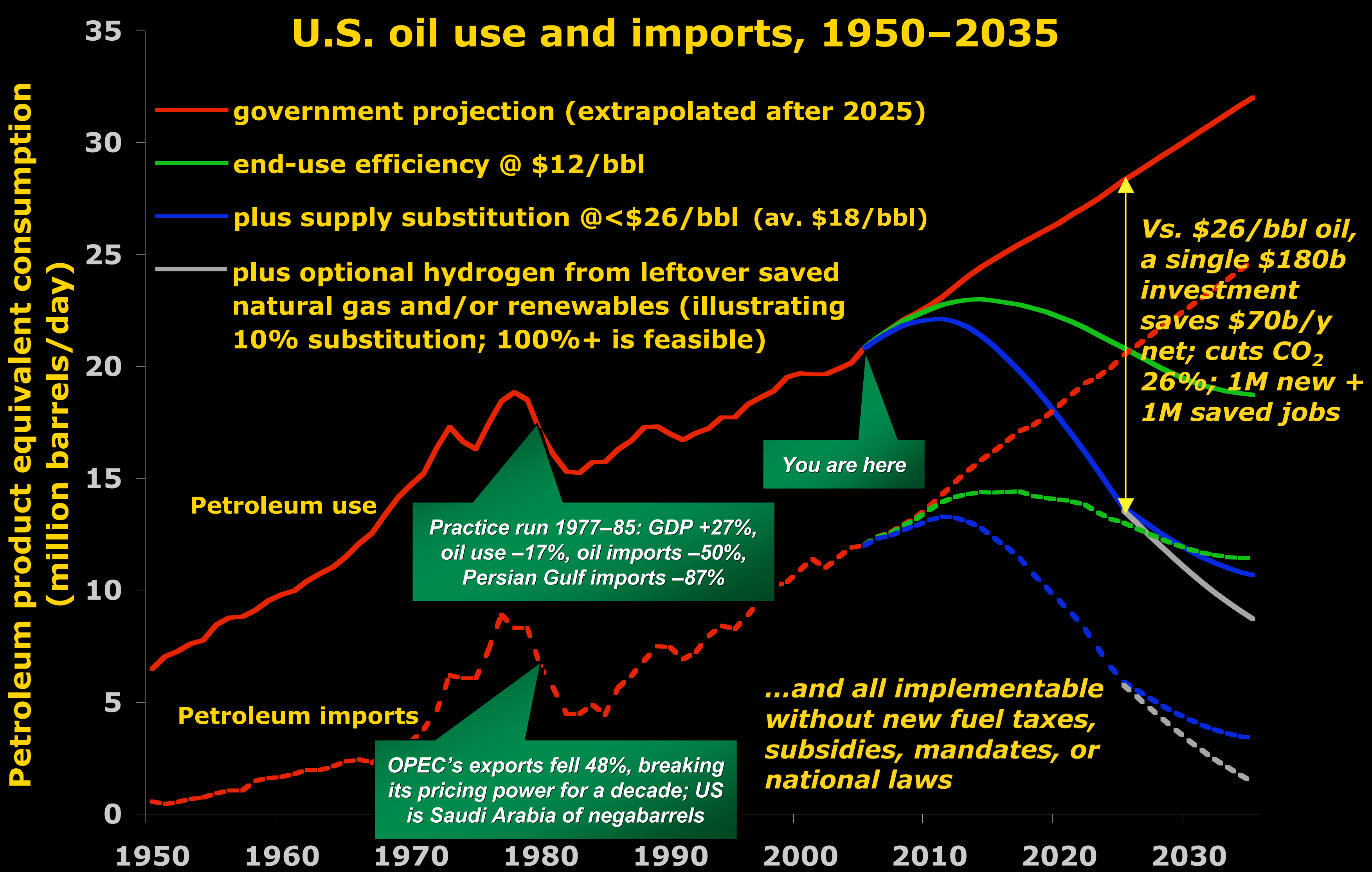
A profitable US transition beyond oil (with best 2004 technologies)



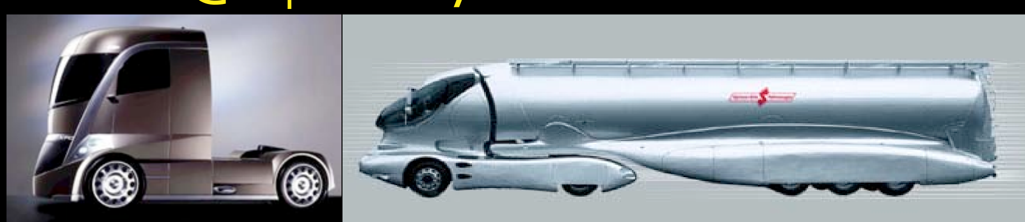
Vehicles use 70% of US oil, but integrating low mass & drag with advanced propulsion saves ~2/3 very cheaply

CARS: save 69% at $0.15/L

Surprise: ultralighting is ***free*** **—** offset by simpler automaking and the 2–3× smaller powertrain

250 km/h, 2.5 L/100 km

TRUCKS: save 25% free, 65% @ $0.07/L

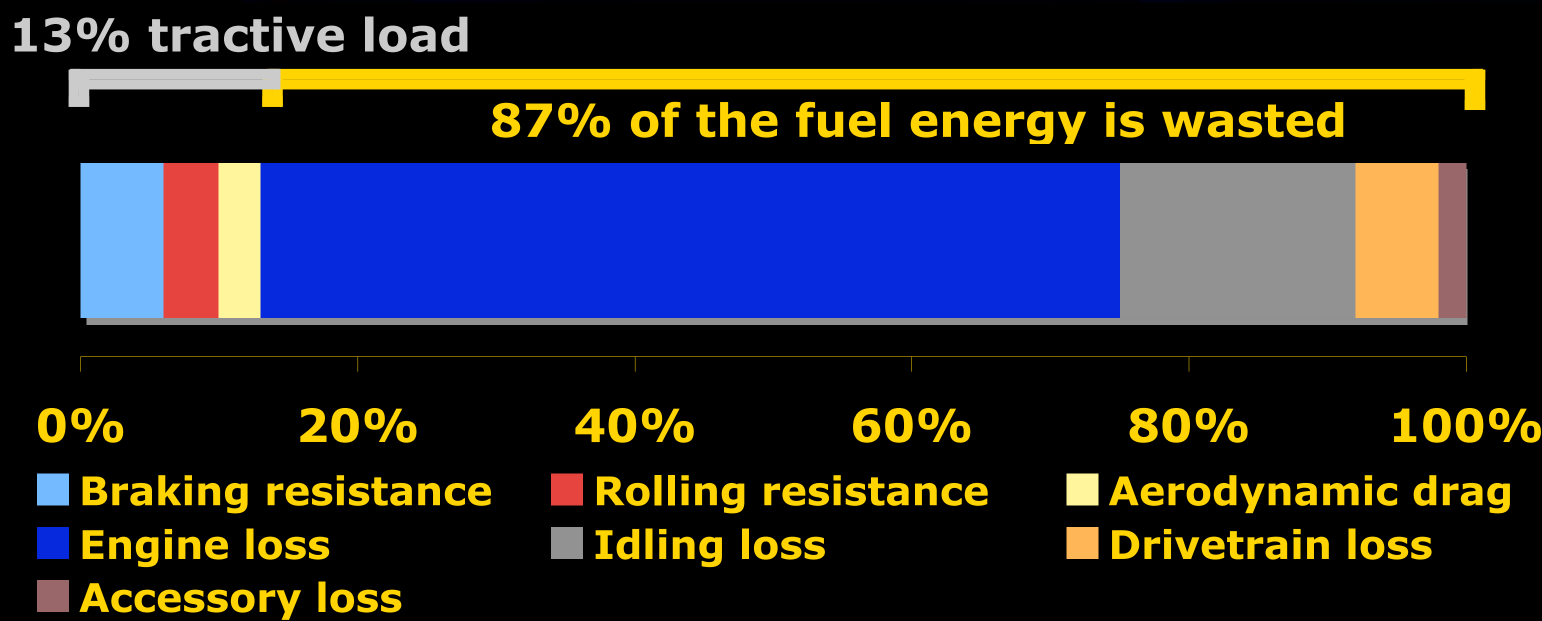


PLANES: save 20% free, 45–65% @ ≤$0.12/L

BLDGS/IND: big, cheap savings; often *lower* capex

Technology is improving faster for efficient end-use than for energy supply

Each day, your car uses ~100× its weight in ancient plants. Where does that fuel energy go?

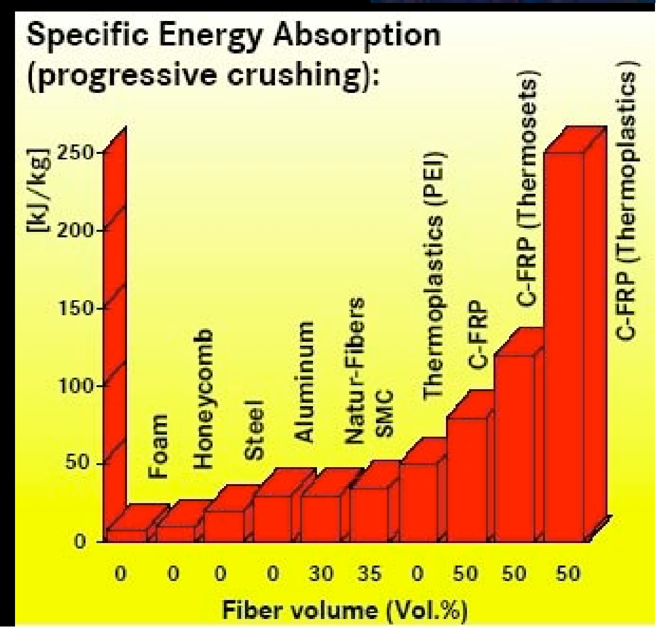


- 6% accelerates the car, 0.3% moves the driver
- Three-fourths of the fuel use is weight-related
- Each unit of energy saved at the wheels saves ~7–8 units of gasoline in the tank (or ~3–4 with a hybrid)
- **So first make the car radically lighter-weight!**

Three technology paths: aluminum, light steels, carbon composites (the strongest & lightest)

- *SLR McLaren* suffers immaterial damage in side impact by *Golf*
- 7 kg of woven carbon crush cones (0.4% of car's mass) can absorb all frontal crash energy at 105 km/h with thermoset (better w/thermoplastic)

Graphics courtesy of DaimlerChrysler AG



- **Carbon-composite crush structures can absorb 6–12× as much energy per kg as steel—and more smoothly**
- **Size is protective, weight hostile; so adding size without weight adds protection and comfort without aggressivity or fuel inefficiency …saving both oil *and* lives (and $)**

Ultralight safety confirmed by racecar crash experience
(even with relatively brittle thermosets)

Katherine Legge’s 290-km/h walk-away *ChampCar* wall crash on 29 September 2006

Midsize* Revolution *midsize SUV, 5 adults in comfort, 2 m³ cargo
Ultralight (–53%, 857 kg) but ultrasafe
0–100 km/h in 8.3 s (later 7.2)
3.56 L/100 km w/gasoline hybrid
2.06 "L"/100 km w/H_2 fuel cell

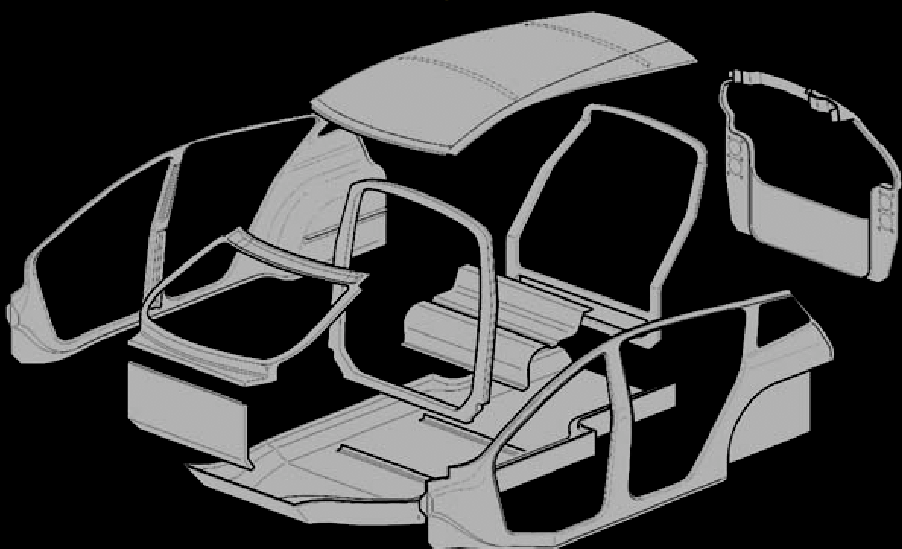
"We'll take two."
— *Automobile* magazine

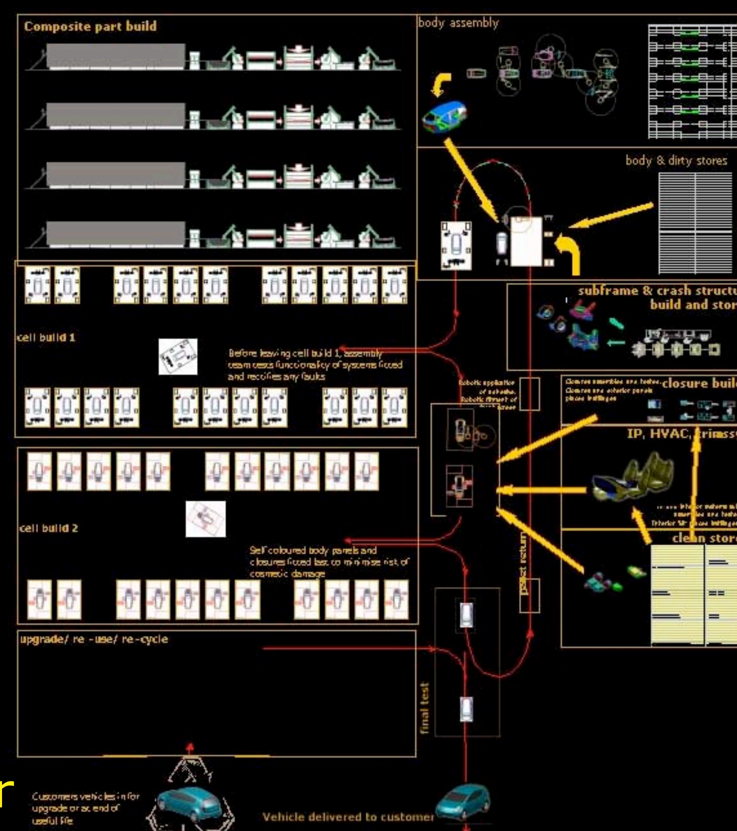
World Technology Award, 2003

Show car and a complete virtual design (2000), uncompromised, production-costed, manufactur-able; hybrid yields 1-y payback *vs* EU gasoline

Radically simplified manufacturing

- Mass customization
  - *Revolution* designed for 50k/year production volume
  - Integration, modular design, and low-cost assembly
  - Low tooling and equipment cost





- 14 major structural parts, no hoists
- 14 low-pressure diesets (not ~10^3)
- Self-fixturing, detoleranced in 2 dim.
- No body shop, optional paint shop
- Plant 2/5 less capital/car-y, 2/3 smaller

Selected examples

Carbon-fiber composites: some automotive uses today

- Ford: *GT*—adv. composites + light metals
  - The most technologically advanced vehicle made in a production envt. using advanced light materials

- BMW: 60 specialists at Landshut with world's biggest RTM press
- GM: *Corvette Z06* panels
- Tesla: *Roadster* full body
- Honda and Toyota: Carbon-fiber airplanes

- Fiberforge®: 1999 RMI spinoff (W. Colo.)
  - Thermoform to net shape, ≤1-minute cycle time
  - Near aerospace performance, near automotive cost
  - Development customers include OEMs and Tier 1s, *e.g.*, JCI *Genus* seat (NAIAS 05); first manufacturing machine (aerospace) shipped 2007

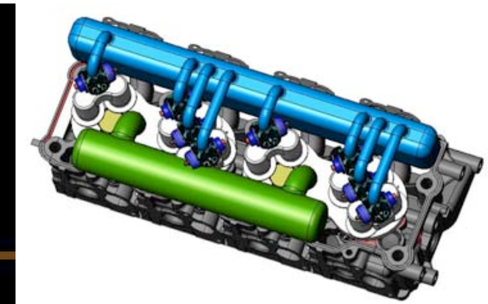
Toyota's Hypercar®-class *1/X* concept car (Tokyo Motor Show, 26 Oct 2007)

- ◇ 2× *Prius* efficiency, similar interior vol. (4 seats)
- ◇ 3× lighter (420 kg)
- ◇ carbon-fiber structure
- ◇ 0.5-L flex-fuel engine
- ◇ plug-in hybrid-electric
- ◇ powertrain under rear seat), rear-wheel drive

• One day before, Toray announced a ¥30b plant to mass-produce carbon-fiber autobody panels and other parts for Toyota *et al.*

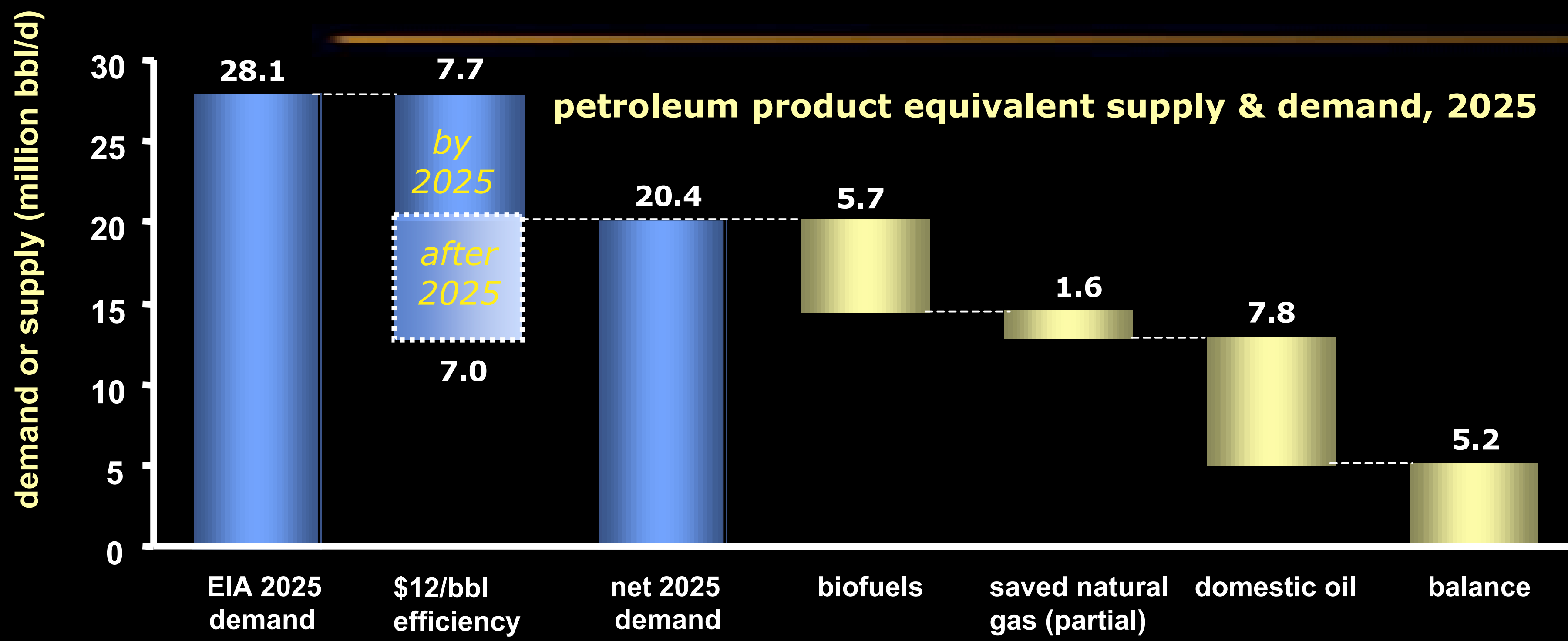
• William Clay Ford Jr., 13 Nov 2007: "In the mid-term—between 2012 and 2020—weight reduction becomes a critical part of our strategy. One of the lessons we have learned is the synergistic benefits of weight reduction, which are even greater than we anticipated."

Emerging powertrain breakthroughs too…



- Fast, small, light, cheap, proven, mature electronic valves permit extremely precise fuel and air injection under real-time closed-loop control
- This in turn permits unusual event sequences and combustion cycles in camless engines
- Those are expected to yield ~55–60+% efficiency from any fuel (on the fly), with >50% higher torque, >30% smaller size, >10% lower cost, and extremely low emissions with no cleanup
- Demonstrated 1/07 (www.sturmanindustries.com)
- Or inject a tiny squirt of ethanol into IC engine: 3 pressure, no knock; 2× smaller engine, 1.25–1.3×η (Sloan Automotive Lab, MIT)

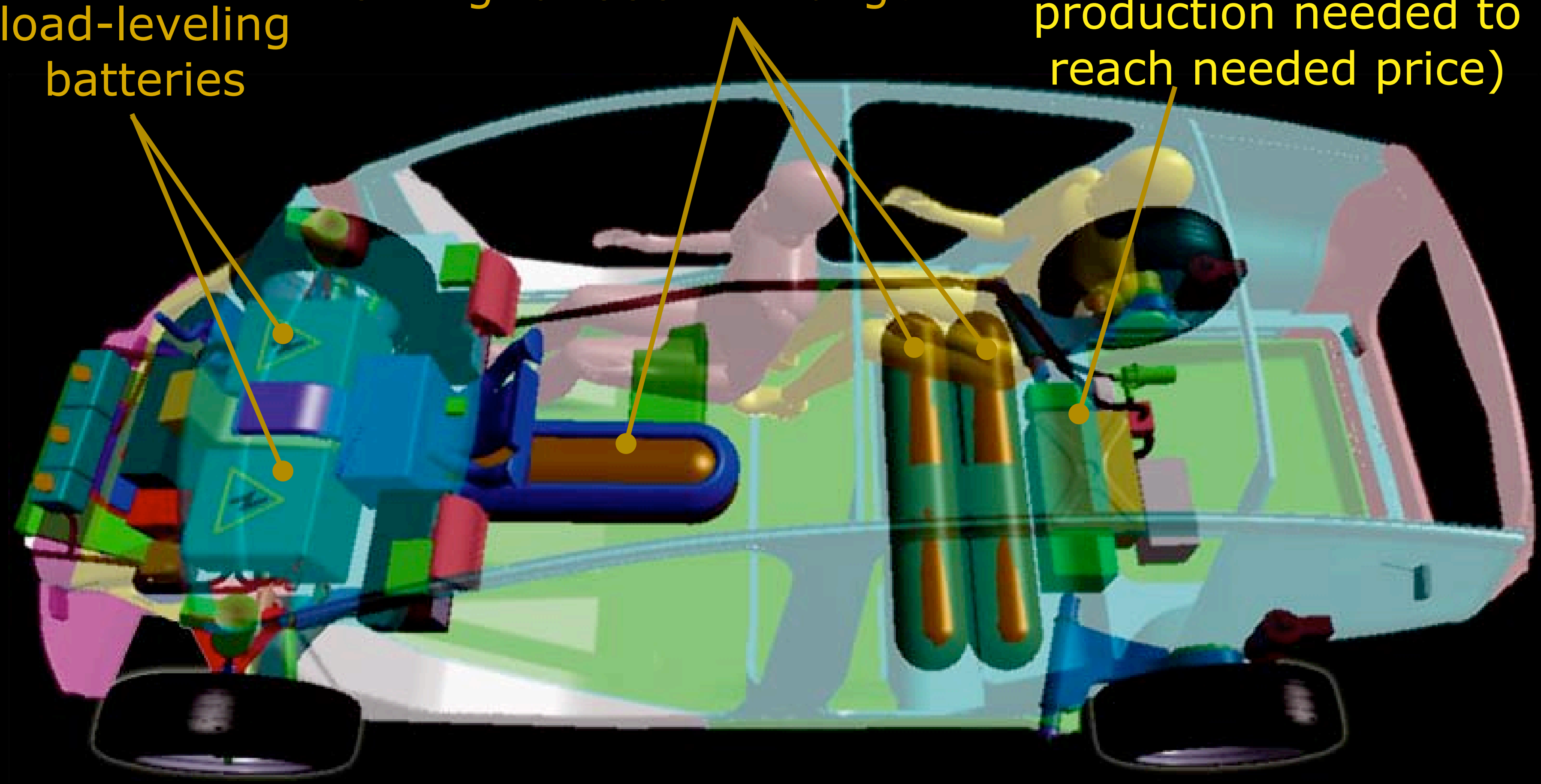
2025 demand-supply integration



Great flexibility of ways and timing to *eliminate* oil in next few decades

- **Buy more efficiency (it's costing only half as much as the oil it replaces)**
- **Efficiency is only half captured by 2025 — 7 Mbbl/d is still in process**
- **"Balance" can import crude oil/product (can be all N. Amer.) or biofuels**
- **Or saved U.S. natural gas @ $0.9/GJ can fill the "balance"…or**
- **H_2 from saved U.S. natural gas can displace "balance" *plus* domestic oil**
- **Not counting other options, *e.g.*, Dakotas windpower—huge H_2 resource**

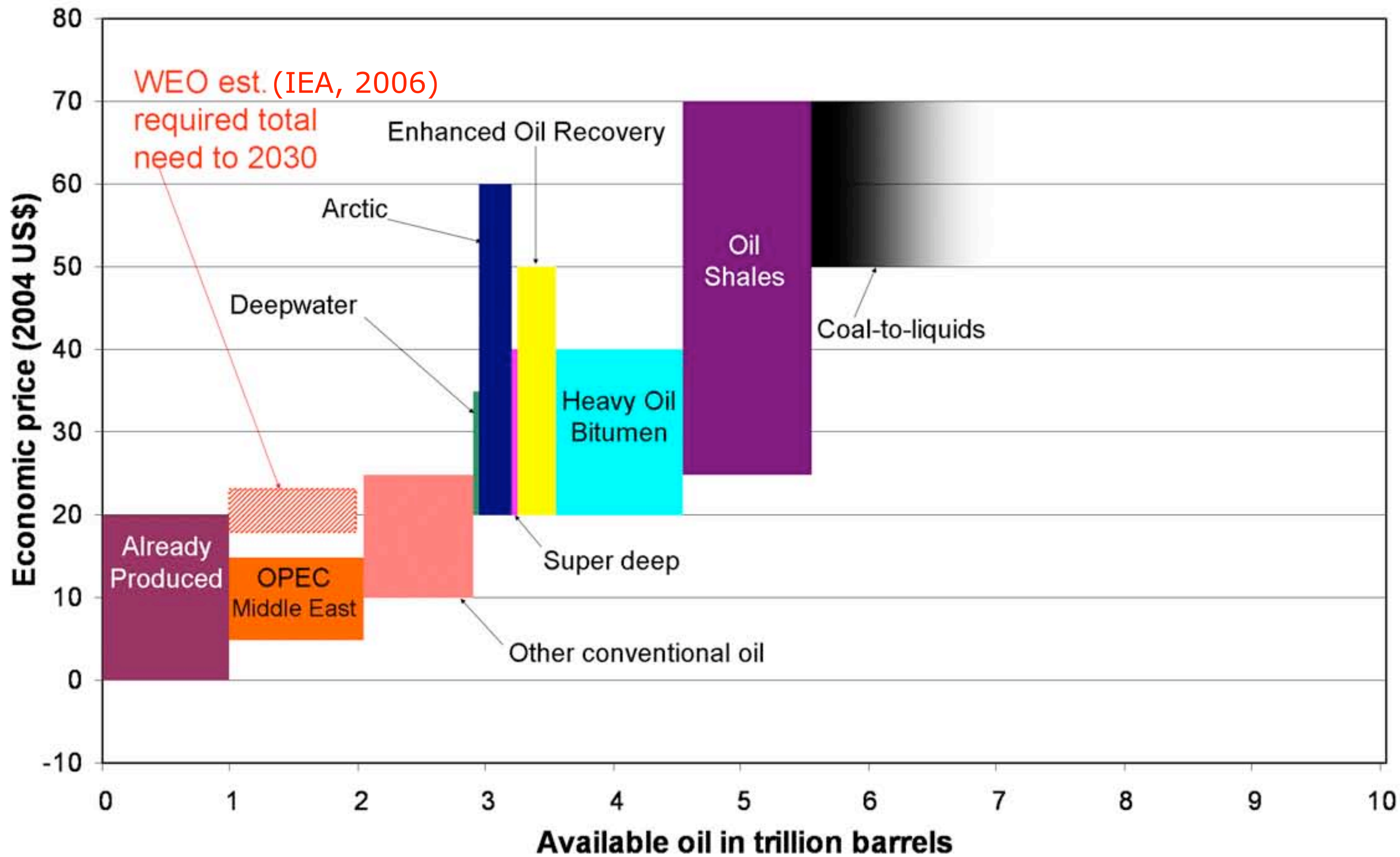
857-kg curb mass (÷2), low drag, load ÷3, so 89 km/h on same power as normal a/c, so ready now for direct hydrogen fuel cells



Implementation is underway via "institutional acupuncture"

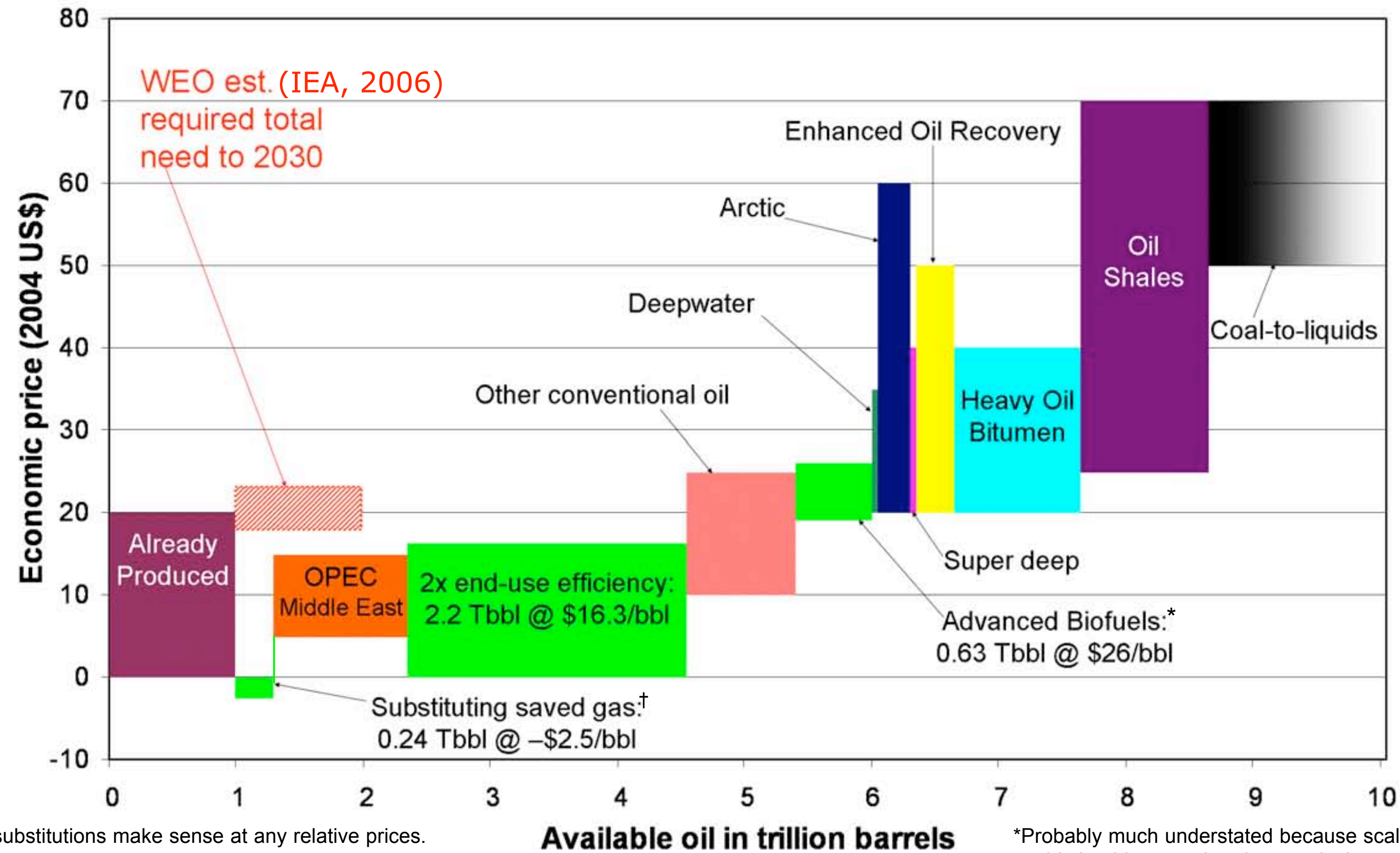
- RMI's 3-year, $4-million effort is leading & consolidating shifts
- Need to shift strategy & investment in six sectors
  - Aviation: Boeing did it (*787 Dreamliner*)…and beat Airbus
  - Heavy trucks: Wal-Mart led it (with other buyers being added)
  - Military: emerging as the federal leader in getting U.S. off oil
  - Fuels: strong investor interest and industrial activity
  - Finance: rapidly growing interest/realignment will drive others
- Cars and light trucks: slowest, hardest, but now changing
  - Alan Mulally's move from Boeing to Ford with transformational intent
  - Workers and dealers not blocking but eager for fundamental innovation
  - Schumpeterian "creative destruction" is causing top executives to be far more open to previously unthinkable change
  - Emerging prospects of leapfrogs by China, India, ?new market entrants
  - RMI's two transformational projects and "feebate" promotion are helping
  - Competition, at a fundamental level and at a pace last seen in the 1920s, will change automakers' managers or their minds, whichever comes first

The oil industry's conventional wisdom: approximate long-run supply curve for world crude oil and substitute fossil-fuel supplies



Source: BP data as graphed by USDoD JASON, "Reducing DoD Fossil-Fuel Dependence" (JSR-06-135, Nov. 2006, p. 6, www.fas.org/irp/agency/dod/jason/fossil.pdf), plus (red crosshatched box) IEA's 2006 *World Energy Outlook* estimate of world demand and supply to 2030, plus (black/gray) RMI's coal-to-liquids (Fischer-Tropsch) estimate derived from 2006–07 industry data and subject to reasonable water constraints. This and following graphic were redrawn by Imran Sheikh (RMI)

How that supply curve stretches ~3 Tbbl if the U.S. potential shown in *Winning the Oil End-game* scales, very approximately, to the world

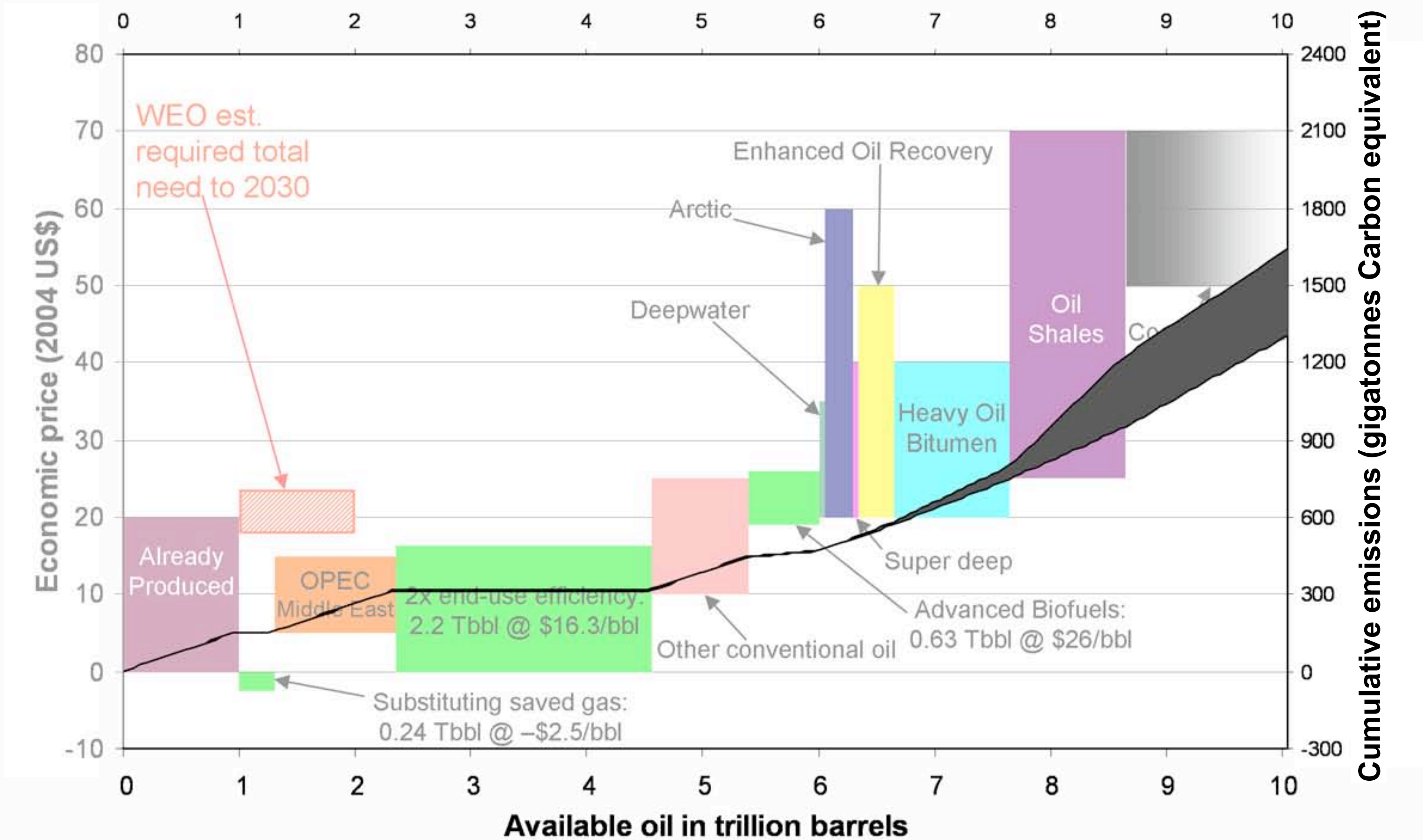


†These substitutions make sense at any relative prices. Depending on future prices, additional such substitutions several- to manyfold larger than shown are also available

*Probably much understated because scaling from U.S. to world should count abundant tropical cane potential; also, the estimate does not include emerging major options like algal oils

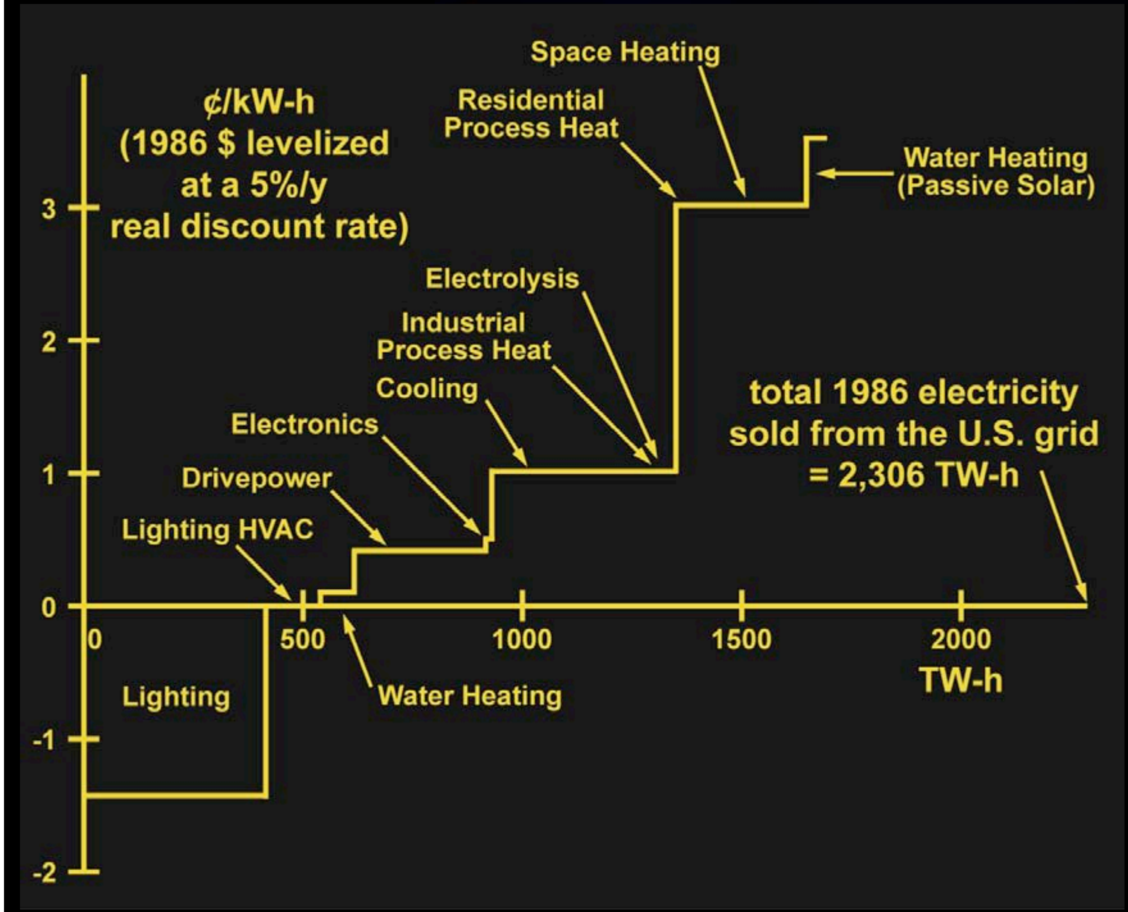
To scale from U.S. alternatives-to-oil potential in Mbbl/d achievable by the 2040s (at average cost $16/bbl in 2004 $: www.oilendgame.com) to world potential over 50 y, multiply the U.S. Mbbl/d × 146,000: 365 d/y × 50 y × 4 (for U.S.→world market size) × 2 (for growth in services provided). Obviously actual resource dynamics are more complex and these multipliers are very rough, so **this result is only illustrative and indicative.**

Stretching oil supply curve by ~3 Tbbl averts >1 trillion tonnes of carbon emissions and tens of trillions of dollars + OPEC rent



Nobody can know who's right about peak oil, but it doesn't matter

1989 supply curve for saveable US electricity (*vs.* 1986 frozen efficiency)



Best 1989 commercially available, retrofittable technologies

Similar S, DK, D, UK…

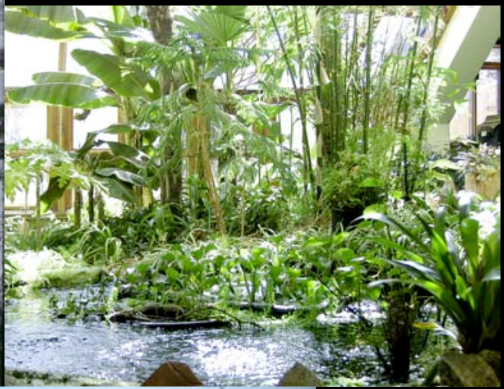
EPRI found 40–60% saving 2000 potential

Now conservative: savings keep getting bigger and cheaper faster than they're being depleted

Measured technical cost and performance data for ~1,000 technologies (RMI 1986–92, 6 vol, 2,509 pp, 5,135 notes)

−44 to +46°C with no heating/cooling equipment, *less* construction cost

2200 m, frost any day, 39 days' continuous midwinter cloud…yet 28 banana crops with no furnace



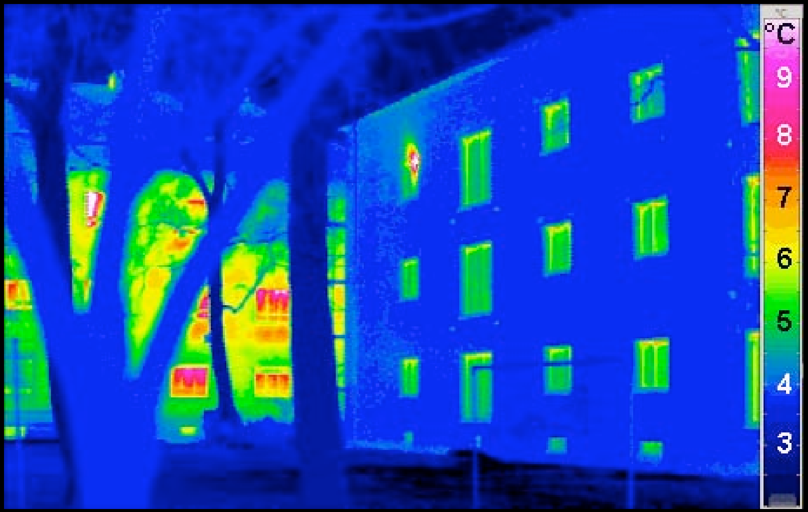
- Lovins house / RMI HQ, Snowmass, Colorado, '84
  - Saves 99% of space & water heating energy, 90% of home el. (372 m^2 use ~120 W_{av} costing ~$5/month @ $0.07/kWh)
  - 10-month payback in 1983
- PG&E ACT^2, Davis CA, '94
  - Mature-market cost −$1,800
  - Present-valued maint. −$1,600
  - 82% design saving from best 1992 std., ~90% from US norm
- Prof. Soontorn Boonyatikarn house, Bangkok, Thailand, '96
  - 84% less a/c capacity, ~90% less a/c energy, better comfort
  - No extra construction cost

Key: integrative design—multiple benefits from single expenditures

Passive comfort in cold, cloudy climates like Germany (Passivhaus Institut)

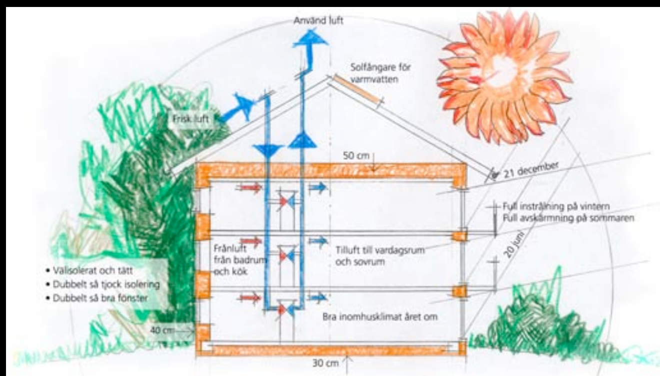
http://en.wikipedia.org/wiki/Passive_house, www.passiv.de; Affordable Comfort Institute

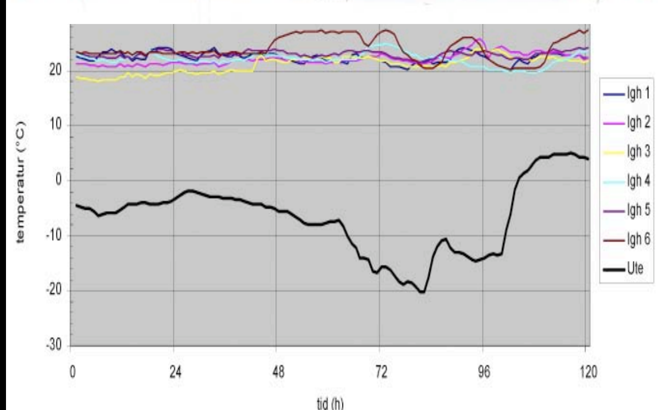
- No central heating system; can add small exhaust-air heat pump or solar panel if desired, but not necessary
- Total primary energy use ≤120 kWh/m²-y
- ≤15 kWh/m²-y & <10 W/m² heating energy—5–25% of U.S. allowables
- *k*-0.10–0.15 (*k*-0.066 roof in Sweden), airtight, high comfort, loses <0.5 C°/d w/ 0 el.
- >10k built in 5 EU nations; Vorarlberg (ÖS) standard
- *Zero marginal capital cost* (at least at <60°N lat)



Infrared images of ordinary German apartment (L) and Passivhaus (R)

Houses comfortable with no heating system in Göteborg, same capital cost





- Hundreds of "Passivhus" examples around Göteborg, typically designed by architects Hans Eek or Christer & Kerstin Nordström
- No extra capital cost

PASSIVE HOUSES AT LINDÅS

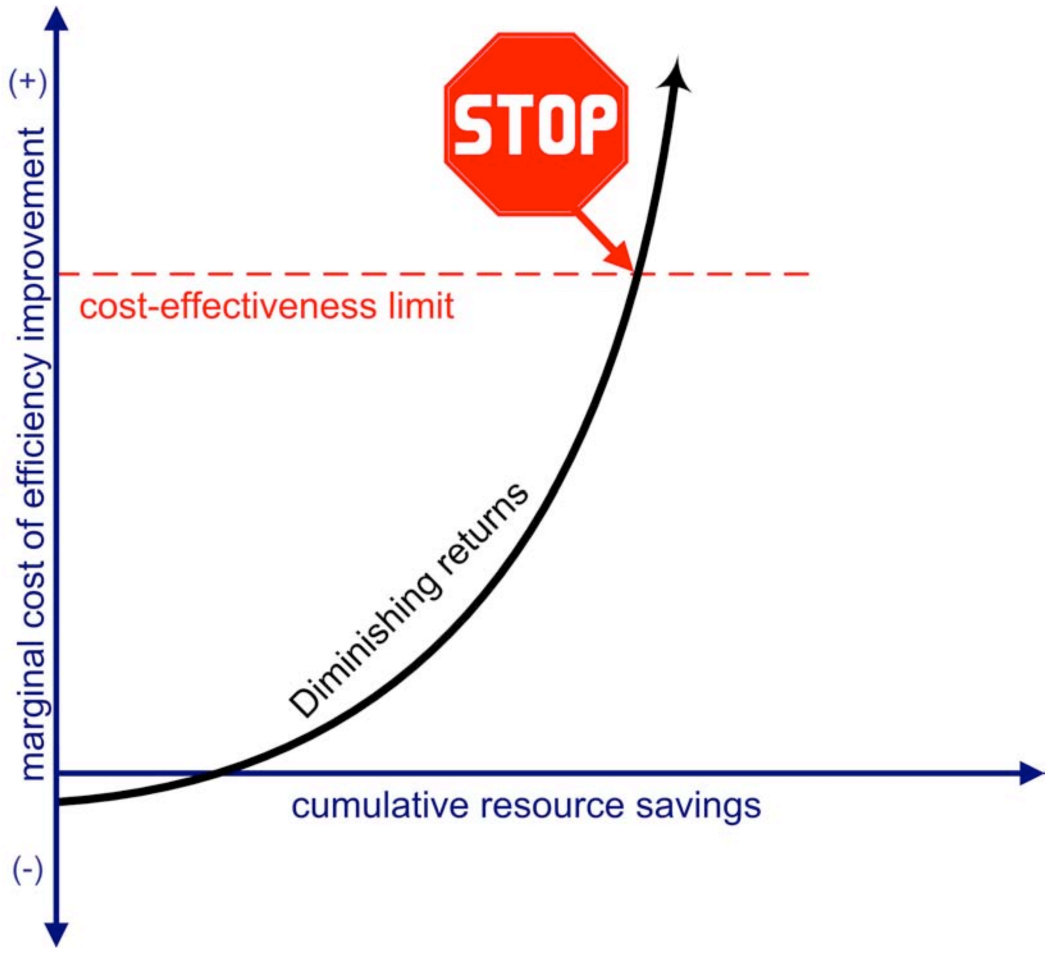
Selling price: ca 2 000 000 SEK

EXTRA COSTS:	SEK
Insulation:	15 – 20 000
Air-to-air heat exchangers	10 – 15 000
Windows U=0,85	15 – 20 000
TOTAL:	40 – 50 000

MINUS HEATING SYSTEM – 40 – 50 000

- Cost-effectively retrofittable too

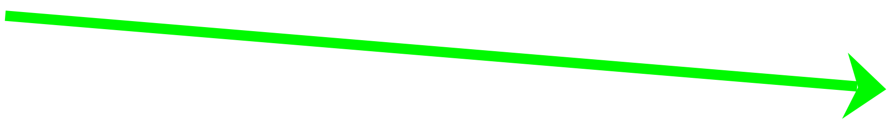
Old design mentality: always diminishing returns…



New design mentality: expanding returns, "tunneling through the cost barrier"

New design mentality: expanding returns, "tunneling through the cost barrier"

"Tunnel" straight to the superefficient lower-cost destination rather than taking the long way around

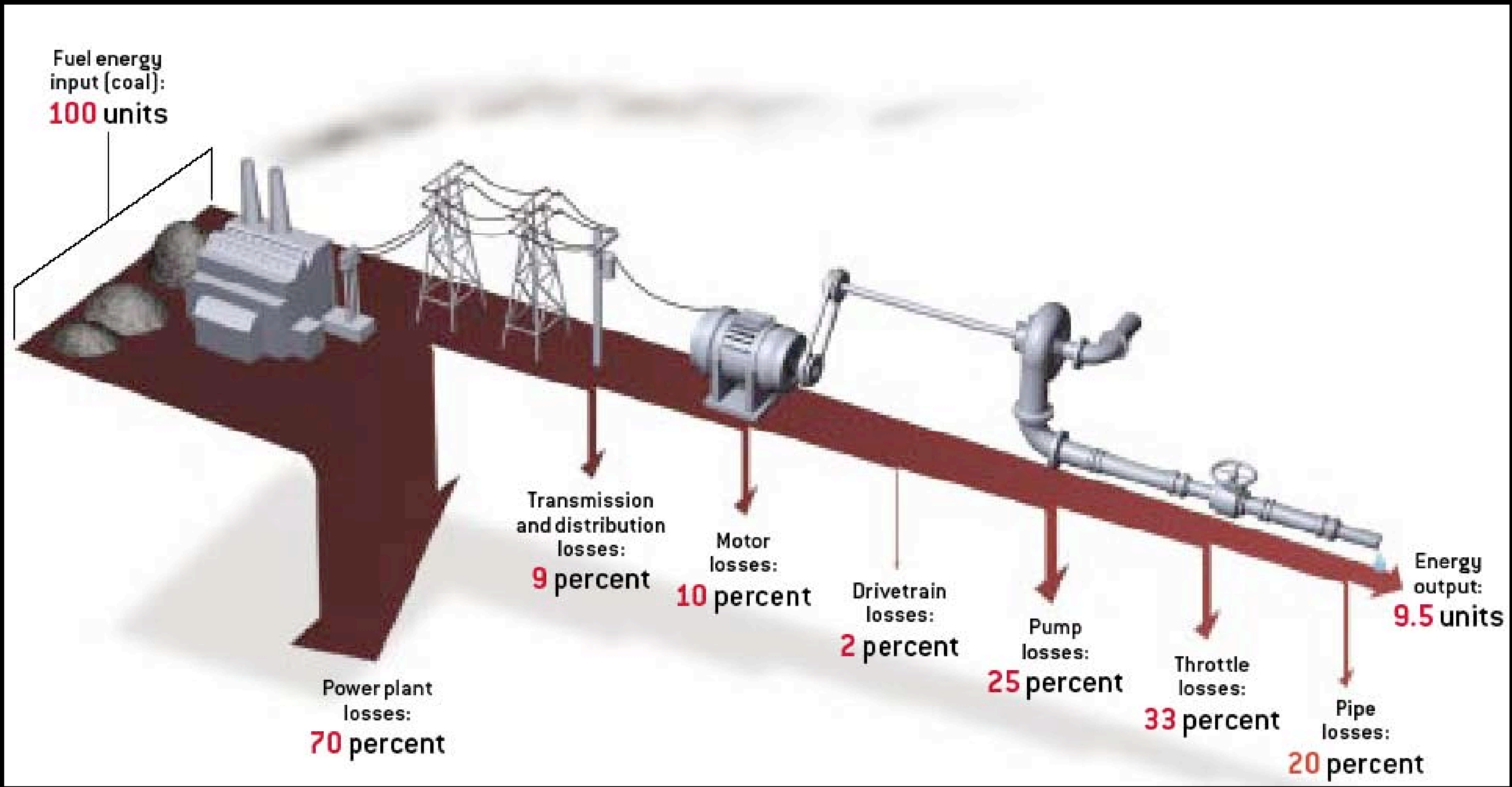


To see how, please visit www.rmi.org/stanford

New design mentality

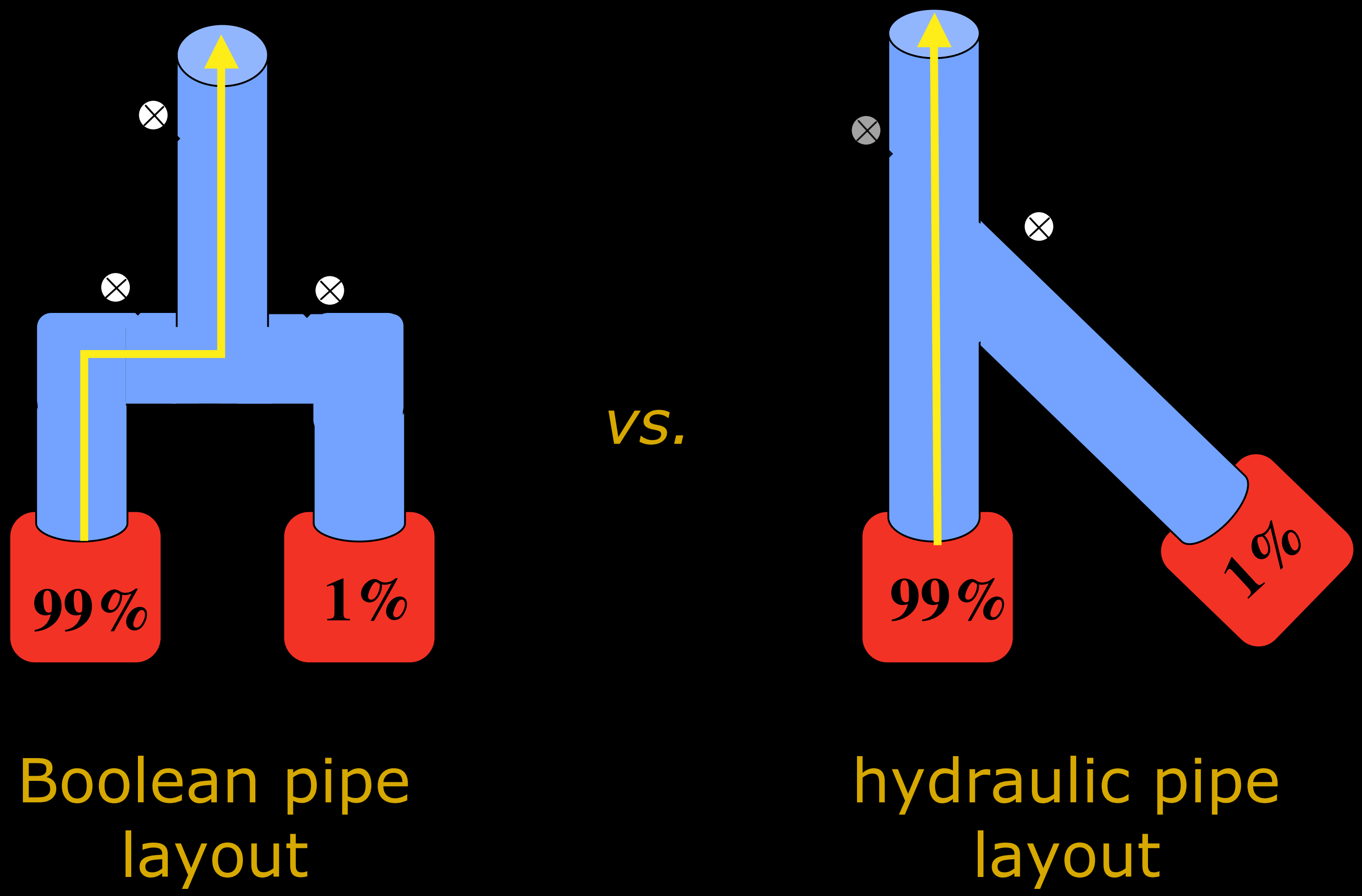
- Pumps and fans use half of motor energy; motors use 3/5 world electricity
- Redesigning a standard (supposedly optimized) industrial pumping loop cut its power from 70.8 to 5.3 kW (–92%), cost less to build, and worked better
- Just by specifying fat, short, straight pipes—not (as usual) thin, long, crooked pipes!
- Even better design could have saved ~98% and cost even *less* to build
- This example is archetypical

Compounding losses…or savings…so start saving at the *downstream* end to save ten times as much energy at the power plant



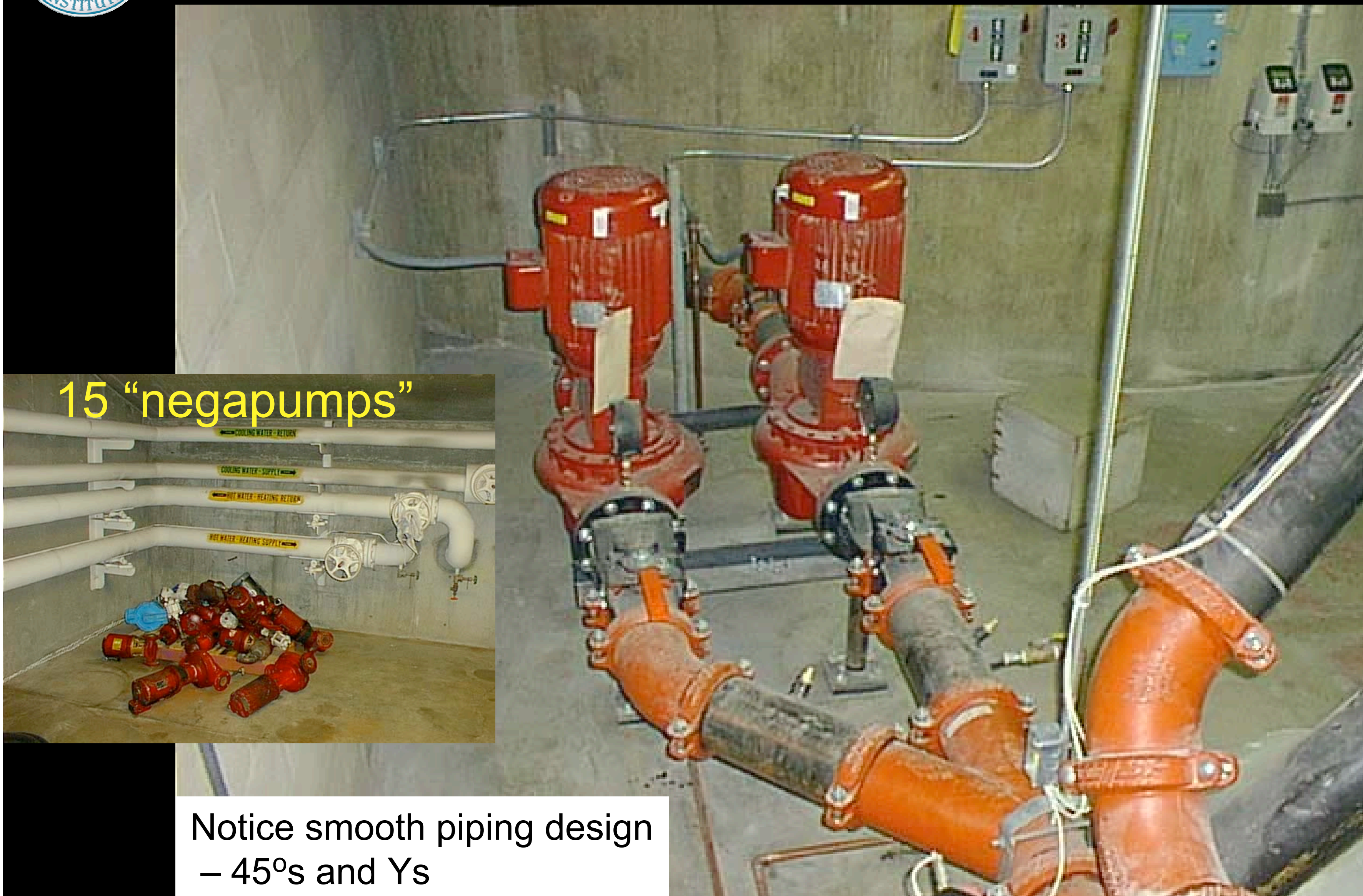
Also makes upstream equipment smaller, simpler, cheaper

It's often remarkably simple



High-efficiency pumping / piping retrofit

(Rumsey Engineers, Oakland Museum)



15 "negapumps"

Notice smooth piping design – 45°s and Ys

Downsized condenser-water pumps, ~75% energy saving

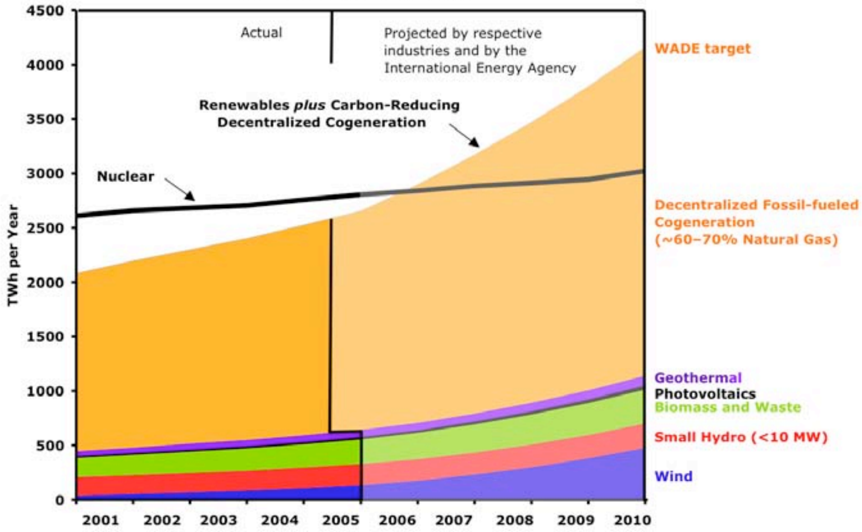
Examples from RMI's industrial practice (>$30b of facilities)

- Save half of motor-system electricity; retrofit payback typically <1 y
- Retrofit chip fabs, save 30–50+% of cooling/fan/pump power, 2-y paybk
- Retrofit very efficient oil refinery, save 42%, ~3-y payback
- Retrofit North Sea oil platform, save 50% el., get the rest from waste
- Retrofit USNavy *Aegis* cruiser's hotel loads, save ~50%, few-y paybacks
- Retrofit huge LNG plant, ≥40% energy savings; ~60%? new, cost less
- Redesign $5b gas-to-liquids plant, –$1b capex, save >50% energy
- Redesign giant platinum mine, 43% energy savings, 2–3-y paybacks
- Redesign new data center, save 89%, cut capex & time, improve uptime
- Redesign next new chip fab, eliminate chillers, save 2/3 el., 1/2 capex
- Redesign supermarket, save 70–90%, better sales, ?lower capex
- Redesign new chemical plant, save ~3/4 of auxiliary el., –10% capex
- Redesign cellulosic ethanol plant, –50% steam, –60% el, –30% capex
- Redesign new 58m yacht, save 96% potable H_2O & 50% el., lower capex
- "Tunneling through the cost barrier" now observed in 29 sectors
- None of this would be possible if original designs had been good
- Needs engineering pedadogy/practice reforms; see www.10xE.org

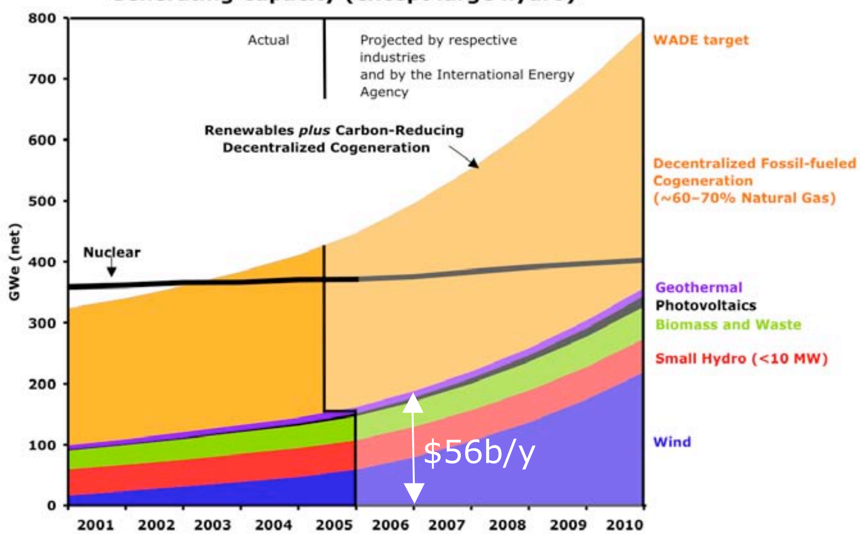
Electric shock: low-/no-carbon decentral-ized sources are eclipsing central stations

RMI analysis: www.rmi.org/sitepages/pid171.php#E05-04

Low- or No-Carbon Worldwide Electrical Output (except large hydro)



Low- or No-Carbon Worldwide Installed Electrical Generating Capacity (except large hydro)



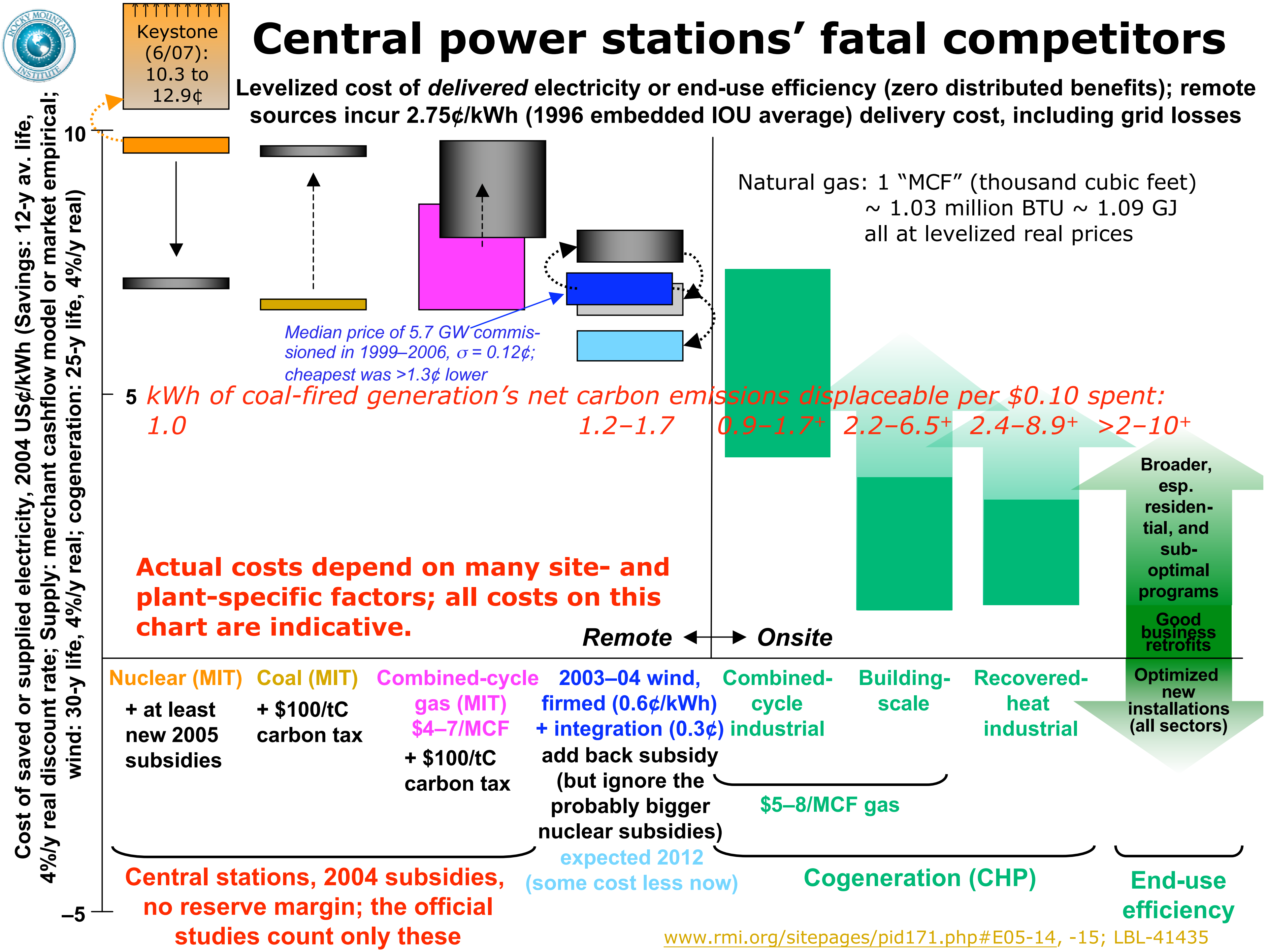
- Two-thirds combined-heat-and-power (cogeneration)*, ~60–70% gas-fired, ≥50% CO_2 reduction

  *Gas turbines ≤120 MWe, engines ≤30 MWe, steam turbines only in China

- One-third renewable (including hydropower only up to 10 MW_e)
- In 2005, micropower added 4× as much output and 11× (excl peaking & standby units, 8×) as much capacity as nuclear power added
- *1/6 of el, 1/3 of new el, & rising*
- 1/6 to >1/2 of all electricity in 13 industrial nations
- Negawatts comparable or bigger; central plants have <1/2 of market!
- Micropower is winning due to lower costs & financial risks, so it's financed mainly by private capital (only central planners buy nuclear)

Central power stations’ fatal competitors

Levelized cost of *delivered* electricity or end-use efficiency (zero distributed benefits); remote sources incur 2.75¢/kWh (1996 embedded IOU average) delivery cost, including grid losses



So it's not surprising that worldwide in 2006 …

- New nuclear capacity was smaller than solar PV additions, or 1/10th of windpower additions
- Nuclear retirements exceeded additions, so *net* nuclear capacity fell by 0.5 GW while micropower added >30 net GW
- Micropower passed nuclear power in total annual electricity production (16% of total)
- Distributed renewables got $56b of private risk capital; nuclear, as always, got zero
- And in China, distributed renewables had 49 GW—7× nuclear capacity—and added 7× more per year

All options face implementation risks; what does market behavior reveal?

- California's 1982–85 fair bidding with roughly equal subsidies elicited, *vs.* 37-GW 1984 load:
  - 23 GW of contracted electric savings acquisitions over the next decade (62% of 1984 peak load)
  - 13 GW of contracted new generating capacity (35% of 1984 load), most of it renewable
  - 8 GW (22%) of additional new generating capacity on firm offer
  - 9 GW of new generating offers arriving per year (25%)
  - Result: glut (143%) forced bidding suspension in April 1985
  - Lesson: real, full competition is more likely to give you too many attractive options than too few!
- Ultimate size of alternatives also dwarfs nuclear's
  - El. end-use efficiency: ~2–3× (EPRI) or 4× nuclear's 19% US share at below its *short*-run marginal delivered cost
  - CHP: industrial alone is comparable to nuclear; + buildings CHP
  - On-/nearshore wind: >2× US & China el., ~6× UK, ~35× global*
  - Other renewables: collectively even larger, PVs almost unlimited
  - Land-use and variability *not* significant issues

*www.stanford.edu/group/efmh/winds/global_winds.html, on- and nearshore sites with annual mean windspeeds ≥6.9 m/s at 80m hub, ~72 TW

Negawatts can be fast, even with old implementation methods

- In ~1975–85, most new U.S. end-use devices—cars, buildings, refrigerators, lighting systs., etc.—doubled in efficiency (~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 $8^1/_2$% *per year*, at a reported cost ~1% that of adding supply
- In 1990, New England Electric System got 90% of a small-business retrofit pilot program's market (1.5× 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 6 of the past 10 y (av. 1.7%/y)
- 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 for cutting energy costs

Nuclear power's market collapse is *good* for climate and security

Lovins *et al.*, *Foreign Affairs*, Summer 1980; Lovins, *Scientific American*, Sept. 2005

- Buy 2–10× more climate protection per $ & per year
- Inhibits spread of nuclear bombs (Iran, N. Korea,…)
- Frees up money and attention for superior alternatives—~10^4× macroeconomic leverage to fund other needs (development/health/education/public safety)
- How? Just let all ways to save or produce energy compete fairly—no matter which they are, where they are, what technology they use, how big they are, or who owns them
- More prosperity, stronger democracy, safer world

Two 1989 climate-strategy cases that scope the world's conditions

- Sweden: Vattenfall, "The Challenge of Choices"
  - Cold, cloudy, far north, heavily industrialized, relatively efficient
  - Half of Swedish el. saveable at 78% lower cost than making more
  - Least-cost strategy (doubled el. end-use eff. + some fuel-switching + environmental dispatch) could achieve forecast 54% GDP growth 1987–2010, shut down nuclear half of el. supply, reduce heat-and-power-sector CO_2 emissions by 1/3, cut el. service cost $1b/y
  - Report (in T B Johansson's *Electricity)* little-known, ignored, valid
- India: Amulya Reddy, roadmap for Karnataka state
  - A little efficiency & natural gas, bagasse CHP, biogas/producer gas, solar water heaters, small hydro—far from comprehensive mix
  - Would achieve far greater and faster economic development
  - Would have 3/5 lower el. demand, 2/3 lower cost, and 99.5% less fossil-fuel CO_2 than utility's official plan (*both* plans were rejected)
- Both: efficiency more than pays for renewables, making major carbon savings better than free
- Today's technologies/designs are far better & cheaper

Five implementation myths

- "It isn't happening—why not?"
  - U.S. E/GDP (1975–2006) fell 48% for energy, 54% for gas, 64% for direct natural gas; total U.S. oil, coal, and energy use *fell* in 2006. Far more *could* happen if we paid attention
- "Solutions must await global agreement"
- "Pricing carbon is the essential first step"
  - Internalizing carbon costs will be valid and helpful, but not essential, sufficient, nor probably very important (because efficient carbon markets will clear at low or negative prices)
  - *Ability to respond* to price ("barrier-busting") matters more
- "Public policy = taxes, subsidies, and mandates"
  - Other instruments, such as car feebates and utility decoupling-and-shared-savings, are more effective and attractive
- "Public policy is the only, or the strongest, key"
  - Innovative competitive strategy, technology, and design, all from *business* coevolving with civil society, are more dynamic

The two biggest public-policy levers to support the business logic

1. *Reward electricity and gas distribution companies for reducing customers' bills, not for selling more electricity*
   - Decouple profits from sales volumes using a balancing account
   - Let distributor keep a small part of the savings it achieves for its customers
   - Unanimously endorsed by US state utility 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, www.raponline.org supports Commissions
2. *Use size- and revenue-neutral "feebates" to widen the price spread between less and more efficient light-duty vehicles (of a given size)*
   - Within a given size class, fees on inefficient and rebates on efficient models, so buyers will consider the full 14-year lifecycle savings, not just the first year or two
   - Encourages choice of efficient vehicles of the desired size, not of a different size
   - ~90% of feebates' effect comes from automakers' shifting their offerings to try to move from fee zone to rebate zone; this *increases* their (& dealers') profit margins
   - Reverse proposed EU policy: we must base efficiency standards on size not weight!

- These and other innovative policies are more effective, and far more politically attractive, than traditional ones (like stds. and fuel taxes)
- A ripe opportunity for *Länder*-level leadership and experimentation

Implementation reality: Compete to win…via efficiency

- Boeing’s crisis in 1997 was like Detroit’s today
  - Wrenching changes instituted at BCA, including TPS (*e.g.*, moving assembly); mfg. & costs brought back under control; but what next?
- In 2003, Airbus for the first time outproduced Boeing
  - “This is really a pivotal moment…could be the beginning of the end for Boeing's storied airplane business,” said Richard L. Aboulafia, a Teal Group aerospace analyst, in 2003
- Boeing’s bold, efficiency-led 2004 response: *787 Dreamliner*
  - ≥20% more fuel-efficient than comparable modern aircraft, *same price*
  - 80% advanced composite by volume, 50% by mass →
    - Bigger windows, higher-pressure cabin
  - 3-day final assembly (*737* takes 11 days)
  - 885 orders (857 firm + 28 pending) + 430 options & rights
  - Sold out into 2016—fastest order takeoff of any jetliner in history
  - Now rolling out *787*’s radical advances to *all* models (Yellowstone)

- Airbus: Ultra-jumbo *A380*, 2 years late, ~€5b over budget
  - Response? Efficient, composite *A350*—probably too late
- Boeing’s breakthrough strategy flipped the sector in 3 years

What are we waiting for?
We are the people we have been waiting for!

"Only puny secrets need protection. Big discoveries are protected by public incredulity."

—Marshall McLuhan

Your move…

www.oilendgame.com, www.fiberforge.com, www.rmi.org (Publications), www.natcap.org