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



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### What is the energy problem?

#### Pre-1976 view, still held by some governments.

- Where can we get *more energy*, from any source, at any price?
- That energy will increasingly be electricity, from giant stations
- Only fossil fuels and nuclear will be important, not renewables

#### Post-1976 view, held by many energy companies

- What do we want energy *for*, and how much energy, of what quality, at what scale, can do each of those "end-use" tasks at least cost?
- All ways to save or produce energy should be allowed to compete fairly, at honest prices, no matter which kind they are, what technology they use, how big they are, where they are, or who owns them
- The question you ask determines the answer you get —but some questions are more useful than others

## U.S. energy/GDP already cut 48%, to very nearly the 1976 "soft path"





### U.S./Japan energy: different prices; other similarities are more important than differences

Attribute energy efficiency oil consciousness oil resources renewable energy resources policy coherence tech. innovation main strength main weakness



Poor but +3-4%/y

rising fast

big, old, dwindling

huge, diverse, *badly underused* but rising

nationally poor, states often good

individualistic

entrepreneurial

dysfunctional, gridlocked national policy—but many workarounds

better but uneven high none big, diverse, largely unknown nationally strong, but mixed & opaque corporate cohesive belief (not fact) that Japan is poor in energy and can't get much more efficient



### 2007 McKinsey Global Institute (MGI) potential for abating global greenhouse gases (technically *very* conservative)

Global cost curve of GHG abatement opportunities beyond business as usual





### Two "different but likely" Japanese societies in 2050

Matsuoka Yuzuru-sensei Kyoto University, "Modeling Activity to Support Japan 'LCS Toward 2050' Project," 14 June 2006, Tokyo

Scenario A	Scenario B		
Bustling, Technology-driven	Slow, Natural-oriented		
Urban concentrated/ Individualistic	Decentralized, Community- oriented, Self-sufficient		
Centralized production /recycle	Produce locally, consume locally,		
Convenient and Beneficial	Social and Cultural Values		

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National Institute for Environmental Studies 2005–
~60 diverse experts
Consistent with existing long-term government plan (such as nuclear power)
GDP growth per capita is 2%/y (A) or 1%/y (B)
Both scenarios assume a vibrant society with much technological progress (though more in A)
Some innovative but no speculative technologies

"Japan has the technological potential to reduce its  $CO_2$  emissions by 70% compared to the 1990 level, while satisfying the expected demand for energy services in 2050."

Akemi Imagawa



### NIES 2050 Japan energy scenarios

NIES, "Japan Scenarios Towards Low-Carbon Society (LCS): Feasibility Study for 70% CO<sub>2</sub> emissions reduction by 2050 below 1990 level," February 2007



 Secondary energy demand decreases by 40-45% Thus secondary energy/GDP falls by 78% (A) or 66% (B) Based on careful analysis of how people spend their time and how they travel, urban design, industrial structure,.... Service demand improvements cut  $CO_2$  11–21%, fuelswitching in end-use sectors 19-48% and in power sector 15–34%; end-use efficiency cuts emissions only 24–41% Low-carbon energy supply 2050 extra cost ~¥0.7–1.8 trillion/y, ~0.1% of 2050 GDP Can we save more cheaper?



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

 A. Both got messed up by a sign error—a confusion between "+" and "-"

	Saving energy is cheaper than buyin firms are starting to buy energy effi- whether or not they worry about cli	ng it, ciend mate	so cy e
$\diamond$	IBM and STMicroelectronics		
	o CO <sub>2</sub> emissions –6%/y, fast paybacks		
$\diamond$	DuPont's 2000–2010 worldwide goals		IIIII
	<ul> <li>Energy use/\$ -6%/y, add renewables, cut absolut greenhouse gas emissions by 65% below 1990 lev</li> <li>By 2006: actually cut GHG 80% below 1990, \$3b</li> </ul>	e rel profit	bp
$\diamond$	Dow: cut E/kg 42% 1990–2005, \$3.3b profit		
$\diamond$	BP's 2010 CO <sub>2</sub> goal met 8 y early, \$2b profit		60
$\diamond$	GE pledged 2005 to boost its eff. 30% by 207	12	(36)
♦ air	Interface: 1996–2006 GHG –60% (–9.2%/y) ns to eliminate <i>all</i> waste by 2020 (\$0.34b pro	, fit by	0 Interface '06)
$\diamond$	TI new chip fab: -20% en., -35% water, -30	)% Ca V Texas In	
Po	pliticians debate "costs," smart firms pocket p	rofits!	



The climate problem is caused by one percentage point (after Hoffert *et al., Nature* 395:881–884 (1998))

The "Kaya identity" (Kaya Youichi-sensei) shows that: Emitted  $CO_2/y = N \times GDP/N \times \dot{E}_{primary}/GDP \times C/E_{primary}$ 1990 - 2100 %/y: +0.69 + 1.6 - 1.0 - 0.26 = + 1.0That +1%/y causes C growth from ~6 to ~20 Gt/y Supply-siders debate the -0.26%/y (no-C energy) term But let's examine the 4× bigger energy-intensity term... because  $-1\%/y \rightarrow -2\%/y$  flattens  $CO_2$  emissions (or saves ~30 TW of no-C supply required for 550 ppm), and reducing energy intensity slightly faster, say 3%/y, would stabilize Earth's climate...still at a profit

So how plausible is a 2–3%/y, or even faster, reduction in energy used per unit of GDP?



- The U.S. has spontaneously saved >2%/y since '97, 3.4%/y in '81–86, 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—it saved >5%/y for >20 y, 7.9%/y 1997–2001 (then reversed '02–06); energy efficiency is *the* top strategic development priority; 11<sup>th</sup> 5-Year Plan sets 20% (4.5%/y) savings 2005–10
- Attentive companies profitably save ~6–9%/y
- So why should 3%/y be difficult—or costly?
- Japan's E/GDP fell 0.7%/y 1977–2004; government's New National Energy Strategy (Jan. 2006) calls for 1.5%/y to 2030; NIES would be 1.7–2.4%/y to 2050



## So could the vision of contraction & convergence be feasible *and profitable*?





### An all-too-common belief

"Japan's energy efficiency level is unlikely to improve much, since it is already the best in the world." *—Yomiuri Shimbun*, 7 January 2006
But doesn't kaizen apply also to energy?
Isn't Japan still the world's best at kaizen?
Japan can lead this global hiyaku (飛躍)!

Japanese frogs jump too!

-Bashô

The old pond frog jumps in plop 古池や 蛙飛び込む 水の音



Let's see how, focusing on oil (42% of global  $CO_2$  emissions) and electricity (40%)



Some of Japan's impressive CO<sub>2</sub> achievements so far...

- ♦ Toyota cut CO<sub>2</sub> per car produced by 15%, 2002–05
  - Single line / multiple models cuts energy as much as 40%
  - New 2003– welding system cuts CO<sub>2</sub> 50%, cuts time & cost
- $\diamond$  Nissan aims to cut CO<sub>2</sub> by 2007 to 2000 10%
- Honda during 1Q2001–07 cut CO<sub>2</sub> mfg. emissions in Japan by 9.5%/car and 29.3%/motorcycle; also raised average car fuel economy 31% 1995–2005
- ♦ Ricoh expects to cut 2010 CO<sub>2</sub> to 1990 12%
- ♦ Kirin's 2010 goal (1990 25%) was reached in '06
- And many more
- But outside leading firms, the picture is less rosy...



#### Per capita electricity consumption



Source: EMBARQ, the World Resources Institute (WRI) Center for Sustainable Transport (Dr. Lee Schipper, Director of Research), from official data sources

# U.S. cars & light trucks were long the least efficient, but Japan's have become similar



Source: EMBARQ, the World Resources Institute (WRI) Center for Sustainable Transport (Dr. Lee Schipper, Director of Research), from official data sources



## If we got serious, what more could fully-adopted end-use efficiency do?

- Save more than half of US oil at an average cost of \$12/bbl (2000 \$)—1/6 its recent world price
- Save at least half of US natural gas at an average cost <\$0.9/GJ—1/8 its US price</p>
- ♦ Save at least three-fourths of US electricity at an average cost ≤1¢/kWh—1/8 its US price
- Total *marginal* cost of achieving such savings overnight in 2006 would be only of order \$94b/y (2006 \$), or \$1.2 trillion (20-y present value)—1/6th their value
- Such savings would also cut prices and volatility, keep supplies cheaper for longer, slash CO<sub>2</sub> emissions, improve security, and buy precious time
- But these techniques' *percentage* savings potential is not so very different in Japan, which has better industry, worse buildings, and broadly similar vehicles



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





Key: integrative design—multiple benefits from single expenditures



#### Lovins house / RMI HQ, Snowmass, Colorado, '84

- Saves 99% of space & water heating energy, 90% of home el. (372 m<sup>2</sup> use ~120 W<sub>av</sub> costing ~\$5/month @ \$0.07/kWh)
- 0 10-month payback in 1983
- PG&E ACT<sup>2</sup>, Davis CA, '94
  - Mature-market cost -\$1,800
  - Present-valued maint. -\$1,600
  - 82% design saving from 1992
     California norm, ~90% from US

Prof. Soontorn Boonyatikarn house, Bangkok, Thailand, '96

- 84% less a/c capacity, ~90% less a/c energy, better comfort
- No extra construction cost



### Old design mentality: always diminishing returns...





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

Due to its shape, I call this the 'kyû curve' (九).





#### 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



Cost can be negative even for retrofits of big buildings



- 19,000-m<sup>2</sup>, 20-year-old curtainwall office near Chicago (hot and humid summer, cold winter)
- Dark window units' edge-seals were failing
- Replace not with similar but with superwindows
  - Let in nearly 6× more light, 0.9× as much unwanted heat, reduce heat loss and noise by 3–4×, cost \$8.4/m<sup>2</sup><sub>glass</sub> more
- Add deep daylighting, plus very efficient lights (3 W/m<sup>2</sup>) and office equipment (2 W/m<sup>2</sup>)
- Replace big old cooling system with a new one 4× smaller, 3.8× more efficient, \$0.2 million cheaper
- That capital saving pays for all the extra costs
- ♦ 75% energy saving—*cheaper* than usual renovation



### Pumps are the biggest use of motors, which use 3/5 of global electricity



♦ Redesign of a supposedly optimized standard industrial pumping loop cut its power from 70.8 to 5.3 kW (-92%\*), cost less to build, worked better

Simply change design mentality: use fat short straight pipes rather than thin long crooked pipes

Better optimization would save ~98%, cost less

Such integrative design can save 75–80% of *all* el.

\*The designer's spreadsheet contains an error whose correction indicates an 84% saving, but he told me the measured saving confirmed the original 92% estimate. He has retired; we are trying to track down this discrepancy.



Compounding losses...or savings...so start saving at the *downstream* end to multiply the fuel and equipment savings upstream



So each unit of avoided flow or friction at the pipe saves ten units of fuel at the thermal power station



layout

hydraulic pipe layout

### High-efficiency pumping / piping retrofit (Rumsey Engineers, Oakland Museum)

15 "negapumps"

Notice smooth piping design  $-45^{\circ}$ 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  $\diamond$ Similar ROIs with 30–50+% retrofit savings of chip-fab HVAC power  $\diamond$ Retrofit very efficient oil refinery, save 42%, ~3-y payback  $\diamond$ Retrofit North Sea oil platform, save 50% el., get the rest from waste  $\diamond$ Retrofit USNavy *Aegis* cruiser's hotel loads, save ~50%, few-y paybacks  $\diamond$ Retrofit big LNG plant,  $\geq$ 40% energy savings; ~60%? new, cost less  $\diamond$ Retrofit giant platinum mine, 43% energy savings, 2–3-y paybacks  $\diamond$ Redesign \$5b gas-to-liquids plant, -\$1b capex, save >50% energy  $\diamond$ Redesign new data center, save 89%, cut capex & time, improve uptime  $\diamond$ Redesign next new chip fab, save  $\sim 67\%$ , cut capex  $\sim 50\%$ , no chillers  $\diamond$ Redesign new supermarket, save 70–90%, better sales, ?lower capex  $\diamond$ Redesign new chemical plant, save  $\sim 3/4$  of el., cut time and cost  $\sim 10\%$  $\diamond$ Redesign cellulosic ethanol plant, save 50% steam, 60% el., ~2/3 capex  $\diamond$ Redesign new 58m yacht, save 96% potable  $H_2O \& 50\%$  el., lower capex  $\diamond$ "Tunneling through the cost barrier" now observed in 29 sectors  $\diamond$ None of this would be possible if original designs had been good  $\diamond$ Needs engineering pedadogy/practice reforms; see www.10xE.org  $\diamond$  $10 \times e$ FACTOR 10



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







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 PLANES: save 20% free,

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





250 km/h, 40 km/L

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



savings; often *lower* capex



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

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



BLDGS/IND: big, cheap



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

13% tractive load



- o 6% accelerates the car, 0.3% moves the driver
- Three-fourths of the fuel use is weight-related
- $\circ$  Each unit of energy saved at the wheels saves  $\sim7-8$  units of gasoline in the tank (or  $\sim3-4$  with a hybrid)
- o So first make the car radically lighter-weight!



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



• Immaterial damage when Tboned by *Golf* 

7 kg of carbon crush cones
(0.4% of car's weight) can absorb all crash energy @ 105 km/h



- Carbon-composite crush structures can absorb 6–12x as much energy per kg as steel...and more smoothly
- This can make cars lighter *but* bigger *and* safer... *and* simpler and potentially cheaper to manufacture



### Migrating innovation from military/ aerospace to high-volume vehicles

- 1994–96: DARPA/IATA\* Skunk Works<sup>®</sup> team designed an advanced tactical fighter airframe
  - made 95% of carbon-fiber composites
  - o 1/3 lighter than its 72%-metal predecessor
  - o but 2/3 cheaper...
  - because designed to be made from carbon, not from metal

\*Integrated Technology for Affordability (IATA)

- Finding no military customer for something so radical, the team leader left. I hired him to lead the 2000 design of a halved-weight SUV with two Tier Ones, Intl. J. Veh. Design 35(1/2):50–85 (2004)
- Manufacturing method for competitive carbonfiber structures is being rapidly commercialized

Midsize Revolution midsize SUV, 5 adults in comfort, 2 m<sup>3</sup> cargo Ultralight (-53%, 857 kg) but ultrasafe 0–100 km/h in 8.3 s (later 7.2) 28.1 km/L with gasoline hybrid (-85 gCO,/km) 48.6 km/"L" with H<sub>2</sub> fuel con-~99% lower tooling con No body shop, optional paint shop 40% lower mfg capital mensity

> "We'll take two." — Automobile magazine World Technology Award, 2003

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

#### Can U.S. automakers use efficiency as a competitive strategy (as Japanese ones just did)?



- Boeing's crisis in 1997 was like Detroit's today
  - Wrenching changes instituted at BCA, including TPS (*e.g.*, moving assembly); manufacturing and costs brought back under control
  - But what about growth? What was in the pipeline after 777?
- 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" — analyst Richard L. Aboulafia, 2003

Boeing's bold, efficiency-led 2004 response: 787 Dreamliner

- ≥20% more 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)



- 817 orders (710 firm + 107 pending), 396 additional options.
- Sold out into 2015—fastest order takeoff of any airliner 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
- ♦ Might U.S. automakers do this to Toyota, Nissan, and Honda?



#### Toyota's 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

This design, the closest yet shown by a major automaker to RMI's Hypercar<sup>®</sup> concept, was announced 10 Oct 07—a day after Toray was reported to be planning a ¥30b plant to mass-produce carbon-fiber autobody panels and other components for Toyota and others



### 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
  - UAW 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
  - Competition, at a fundamental level and at a pace last seen in the 1920s, will change automakers' managers or their minds, whichever comes first
  - RMI's two transformational projects and "feebate" promotion will help too



### The emerging automotive [r]evolution: beyond *WTOE*

- An excellent hybrid, properly driven, doubles efficiency
  - o Considerably more if diesels or digital engines can meet air regs
- Ultralighting (+ better aero and tires) redoubles eff'y.
- Cellulosic-ethanol E85 quadruples oil efficiency again
  - Biofuels can make driving a way to protect, not harm, the climate
- A good plug-in hybrid (such as Toyota is to road-test Nov 07 and may sell in MY08) redoubles fuel efficiency again, and could be attractive if the power grid buys its electric storage function via a "smart garage"
  - Precursor of "vehicle-to-grid" fuel-cell play—power plant on wheels
  - So far, these stages can save 97% of the oil/km used today
- Hydrogen fuel cells also compete via cheaper ¢/km and 2–6× less CO<sub>2</sub>/km (or zero CO<sub>2</sub> if renewable)



### Big, fast changes are possible

- US automakers switched in six years in 1920s from 85% open wood bodies to 70% closed steel bodies—and in six months from making 4 million light vehicles/y to making the weapons and munitions that won World War II
- In eight years, 1977–85, US cut oil/GDP by 5.2%/y—equivalent, at a given GDP, to a Gulf every 2.5 years; the 47% (4.9%/y) gain in new US-made cars was the key
- Boeing launched 787 4/04, scheduled in-service 5/08—built on prior work, but still all in the lab in 03; so a very complex and highly regulated product was transformed in four years
- ♦ GM's small team took EV1 launch-to-street in three years
- Major technological transformations take 12–15 years to go from 10% to 90% adoption in the product stock, but innovative business strategies and public policies can get to the first 10% years earlier, & greatly steepen adoption curve



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, <u>www.fas.org/irp/agency/dod/jason/fossil.pdf</u>), 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 graphics 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



To scale from U.S. alternatives-to-oil potential in Mbbl/d achievable by the 2040s (at average cost \$16/bbl in 2004 \$: <u>www.oilendgame.com</u>) to world potential over 50 y, multiply the U.S. Mbbl/d × 146,000: 365 d/y × 50 y × 4 (for U.S.  $\rightarrow$  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 ~3 Tbbl averts >1 trillion tonnes of carbon emissions and saves tens of trillions of dollars





#### Efficiency is a rapidly moving target





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



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



Best 1989 commercially available, retrofittable technologies

EPRI found 40–60% saving 2000 potential; difference was largely methodological

Similar S, DK, D, UK...

Savings get bigger & 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)



### Electric shock: low-/no-carbon decentralized sources are eclipsing central stations



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

• Two-thirds combined-heat-andpower (cogeneration)\*, ~60–70% gas-fired,  $\geq$ 50% CO<sub>2</sub> reduction

\*Gas turbines  $\leq$ 120 MWe, engines  $\leq$ 30 MWe, steam turbines only in China

### - One-third renewable (including hydropower only up to 10 $\text{MW}_{\rm e})$

- 1/6 of global el, 1/3 of <u>new</u> el
- 1/6 to >1/2 of all electricity in 13 industrial nations
- Negawatts appear comparable

 In 2005, these low- or no-carbon electricity generators added 4× as much output and 11× (excl peaking & standby units, 8×) as much global capacity as nuclear power added

• Micropower is winning due to lower costs & financial risks, so it's financed mainly by private capital (only central planners buy nuclear)





### 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:

- O 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 20% 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

### Renewable Energy Cost Trends Levelized sent-out cost of energy in constant 2005 US\$, excluding subsidies<sup>1</sup>



<sup>1</sup>These graphs are reflections of historical cost trends NOT precise annual historical data. DRAFT November 2005

*NB:* These graphs, and the previous cost comparisons, *ignore* the 207 "distributed benefits" that typically increase decentralized resources' value by ~10×...as markets are starting to recognize





### Bundling PVs with end-use efficiency: a recent example



- Santa Rita Jail, Alameda County, California
- PowerLight 1.18 MW<sub>p</sub> project, 1.46 GWh/y, 1.2 ha of PVs
- Integrated with Cool Roof and ESCO efficiency retrofit (lighting, HVAC, controls, 1 GWh/y)
- Energy management optimizes use of PV output
- ♦ Dramatic (~0.7 MW<sub>p</sub>) load cut
- Gross project cost \$9 million
- State incentives \$5 million
- Gross savings \$15 million/25 y
- IRR >10%/y (Cty. hurdle rate)
- Works for PVs, so should work better for anything cheaper



## These market shifts are good for climate and security

Lovins et al., Foreign Affairs, Summer 1980; Lovins, Nucl. Eng. Intl., Dec. 2005

- Micropower and efficiency profitably protect climate
- Free up money & attention for superior alternatives, with ~10,000× capital leverage to fund development; can provide energy for a decent life, for all, for ever
- Turn energy from a source of conflict to a peace path
- Change energy systems from brittle to resilient
- Stop the main facilitator, and source of disguise, for the spread of nuclear bombs (N. Korea, Iran,...)
  - Nuclear power makes widely and innocently available all the key ingredients of do-it-yourself bomb kits; new reactor types are worse
  - Without nuclear power, these ingredients would be harder to get, more conspicuous to try to get, and politically far costlier to be caught trying to get, because the reason for wanting them would be *unambiguously* military—no more pretenses of civilian purpose
  - Without nuclear commerce, proliferation is harder and more visible
  - Another way Japanese and US leadership can create a safer world



## Japan's energy achievements and opportunities

- Industrial efficiency ranges from #1 to more ordinary; even the best can improve markedly
- But 1970– transport & residential energy use more than doubled; trucks 2×, passenger cars >6×
- ♦ Car/truck fleet efficiency far below best exports; another ≥2× is available quickly at no extra cost
- Building efficiency unimpressive; needs mass retrofits, fully integrated new equipment & design
- Some excellent policies like "Top Runner", but need comprehensive barrier-busting, not just price
- Key: reward energy distributors not for selling more energy but for cutting customers' bills
- Japan is poor in fuels but rich in energy
- Biggest barrier: not realizing that opportunities for both efficiency and renewables are very large



We are the people we have been waiting for. Japan is the leader the world is waiting for.

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

Your move ...

ご静聴ありがとうございます

www.oilendgame.com,

-Marshall McLuhan

biofuel

<u>www.fiberforge.com</u>, <u>www.rmi.org</u> (Publications),

<u>www.rmi.org/stanford,</u> <u>www.natcap.org</u>