17 active slides + 3, target 20m + panel

What energy can teach us about water

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Water Resources Review Committee
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FOREIGN AFFAIRS

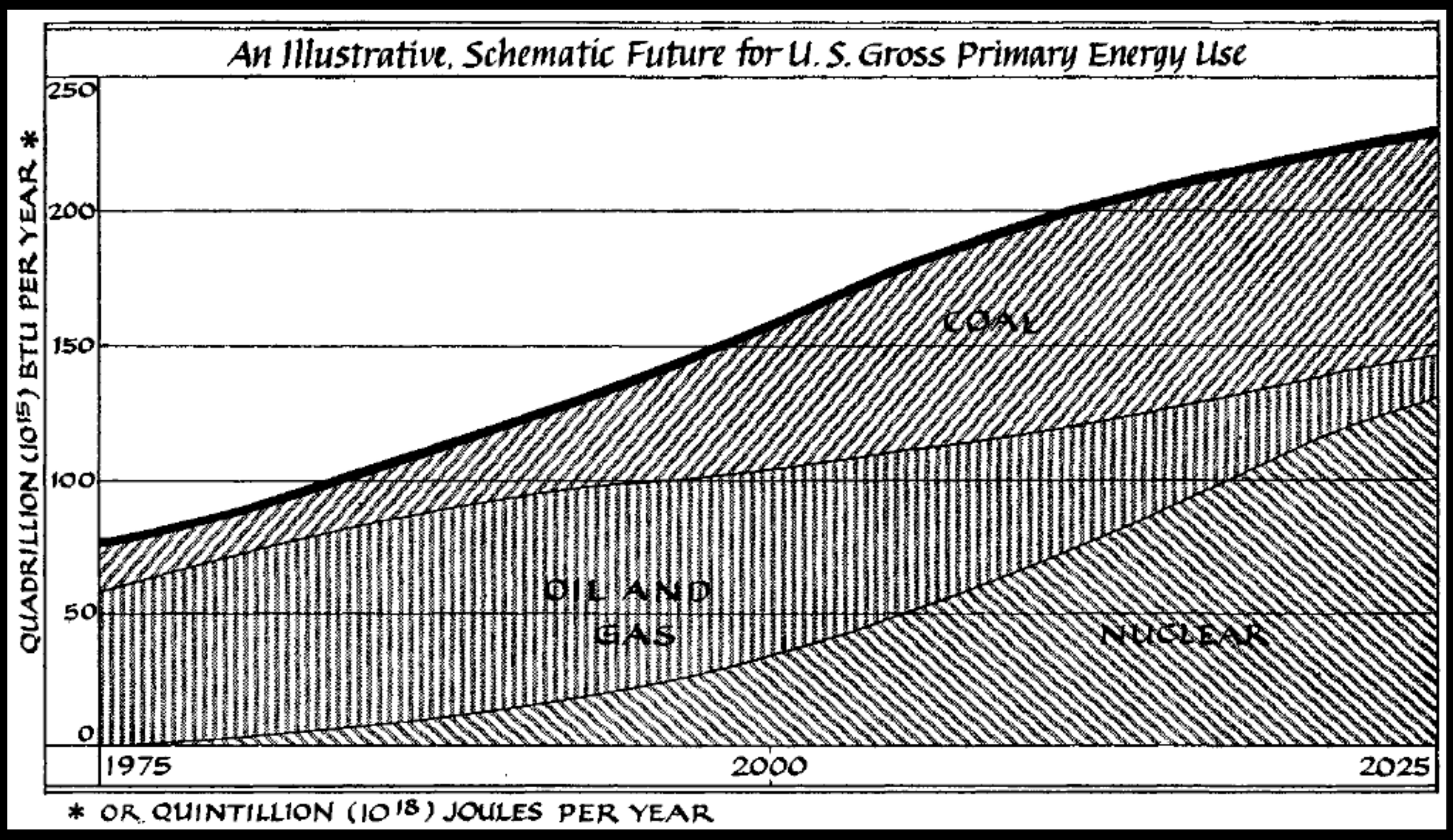
October 1976

Energy Strategy: The Road Not Taken?

Amory B. Lovins

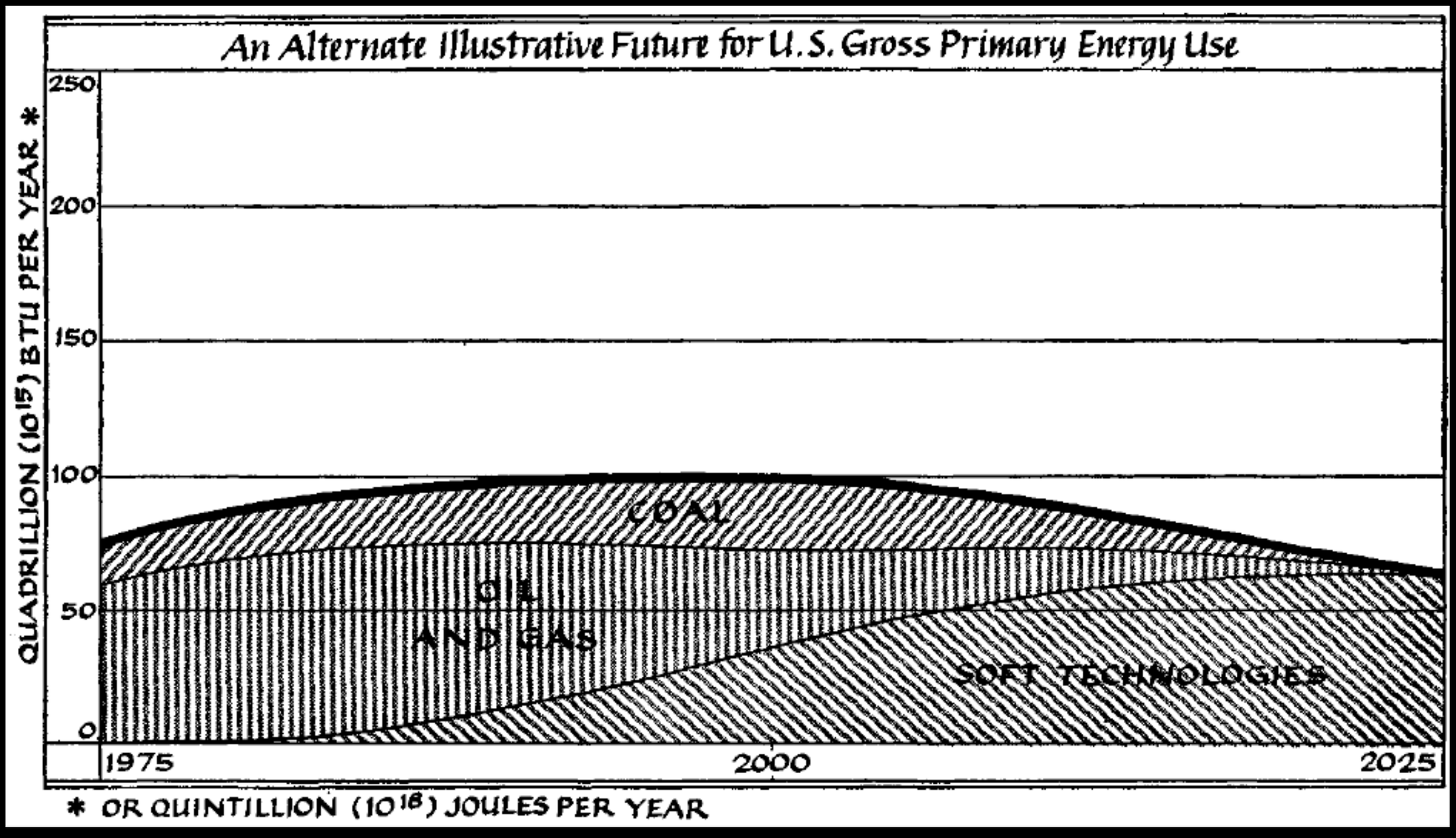
Volume 55 • Number 1

A “hard energy path”



[explain]
A prominent feature of such futures is that inexorably growing demand keeps outrunning supply, causing supposed Gaps that must be filled by one or another form of supply. There is no end to this except when we run out of money, fuel, sites, political tolerance, or other critical ingredients.

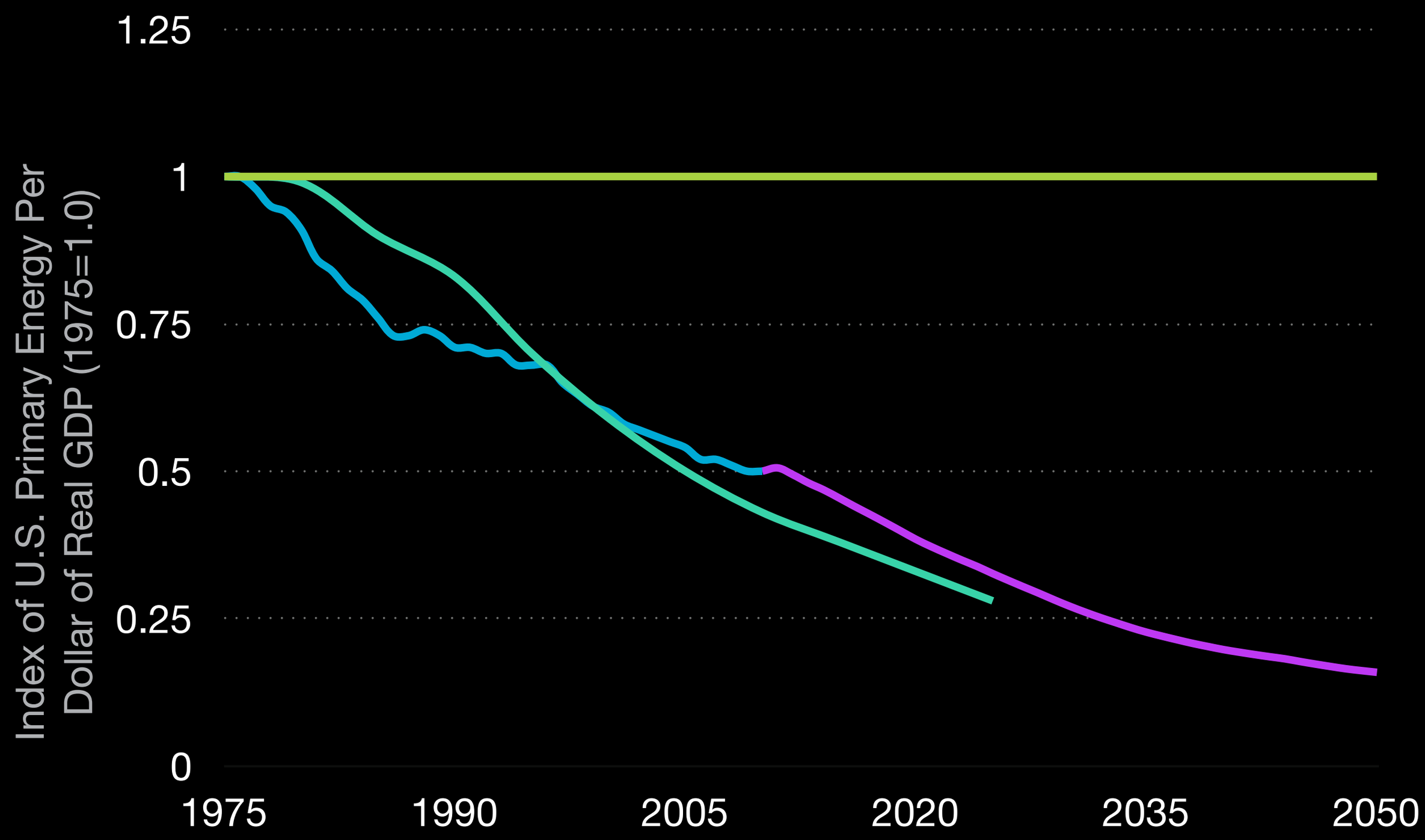
A “soft energy path”



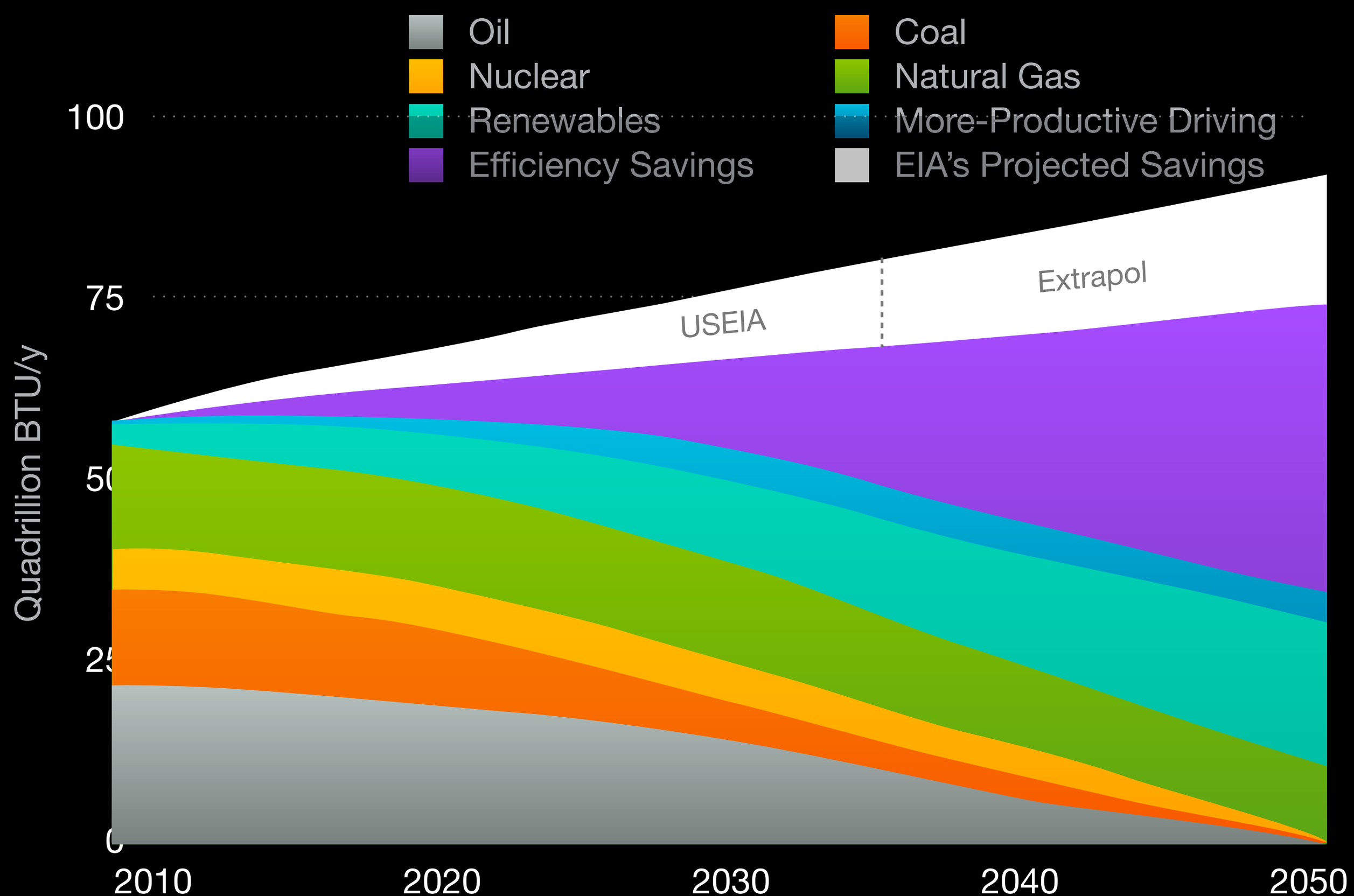
[explain]
A third of a century into this future, we’ve learned that taking economics and security seriously, ahead of environmental and equity priorities, generally gives the same answer—efficiency and benign supplies win just on economics and resilience—but may command a wider consensus.

Heresy Happens

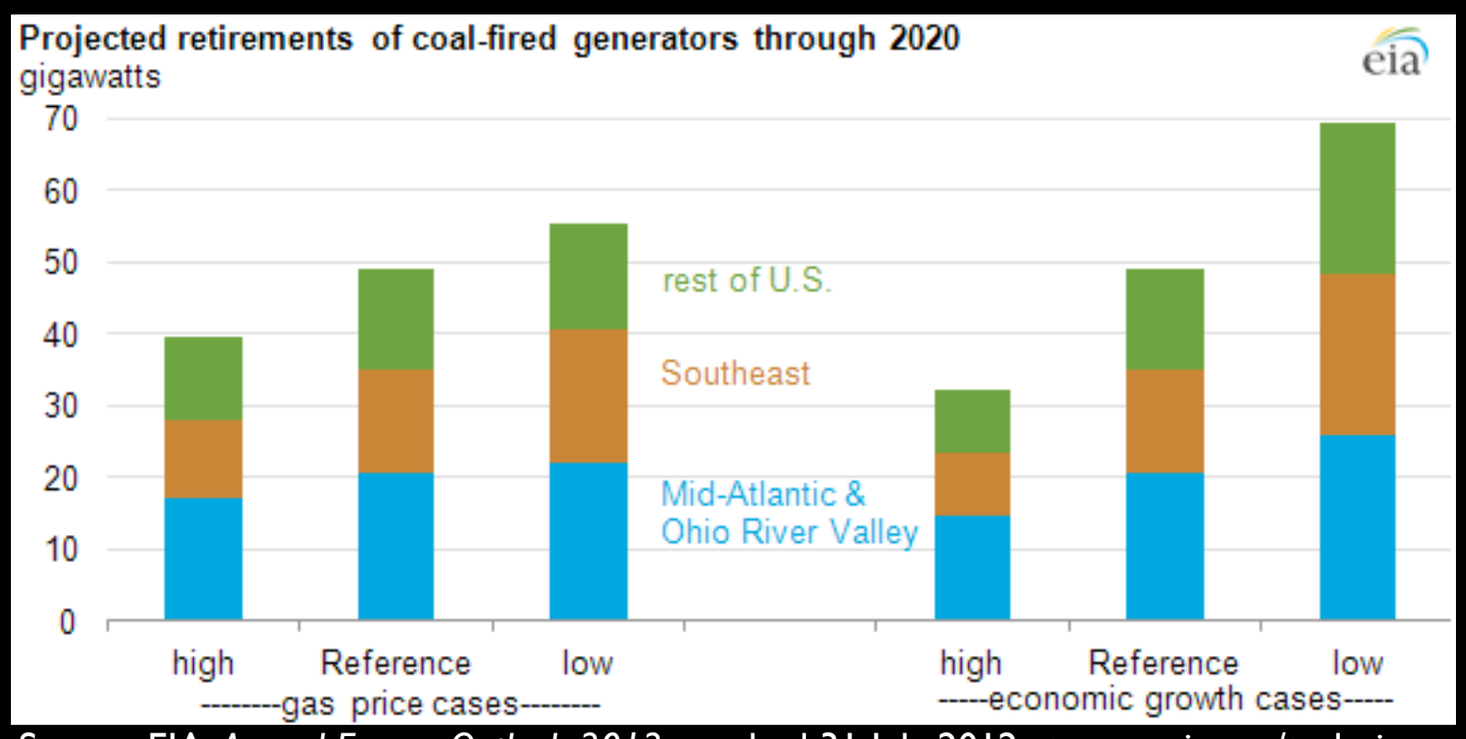
U.S. energy intensity



Reinventing Fire (2011): tripled efficiency, 3/4 renewables

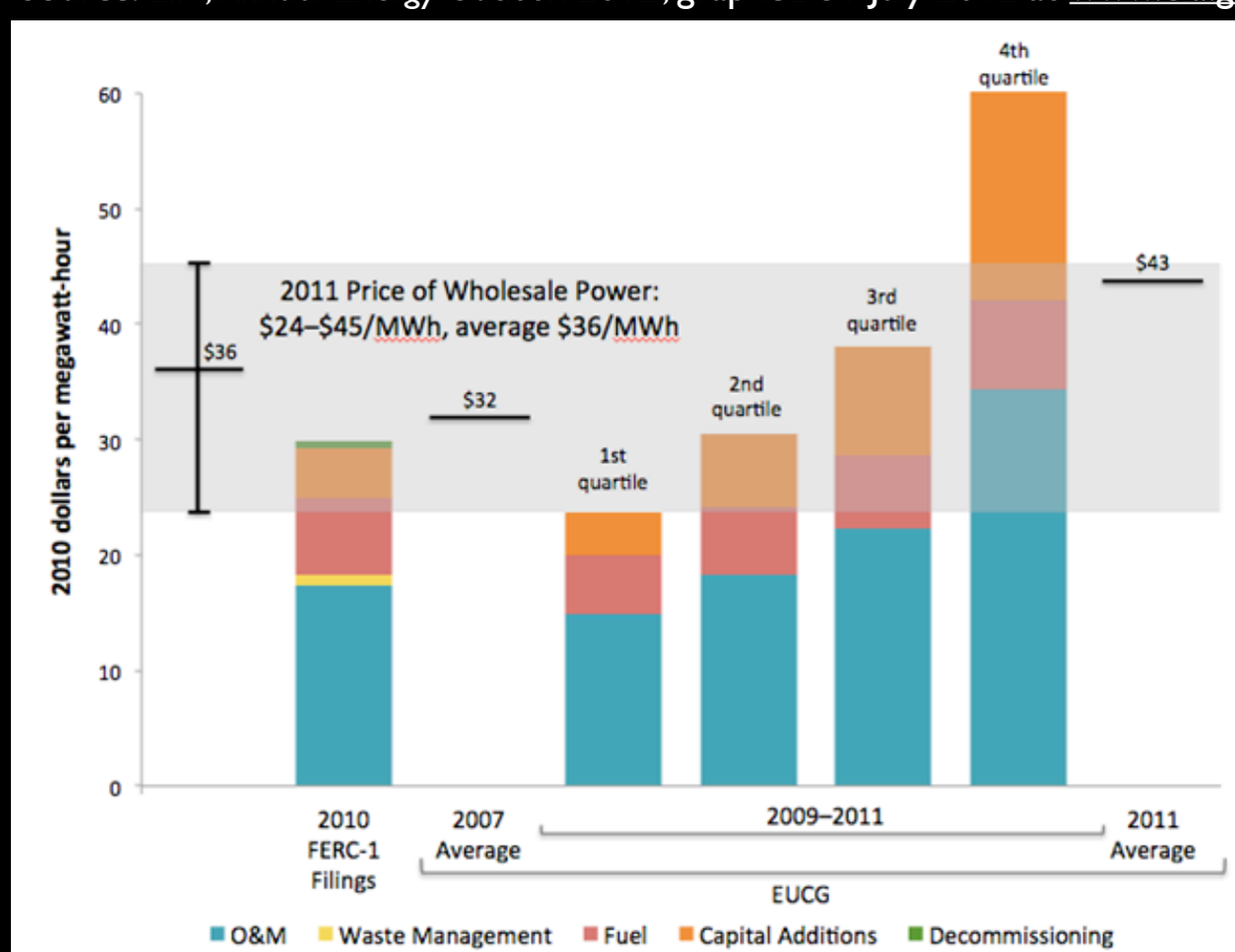


Many US thermal power plants have become too costly to *operate*



Source: EIA, *Annual Energy Outlook 2012*, graphed 31 July 2012 at www.eia.gov/todayinenergy/detail.cfm?id=7330

Coal lost 19% of its US market share just in the past two years —partly to gas, but efficiency was nearly twice as important in 2012. Big shifts away from coal, now underway in China, India,..., are softening exports. Many more coal plants will shut.



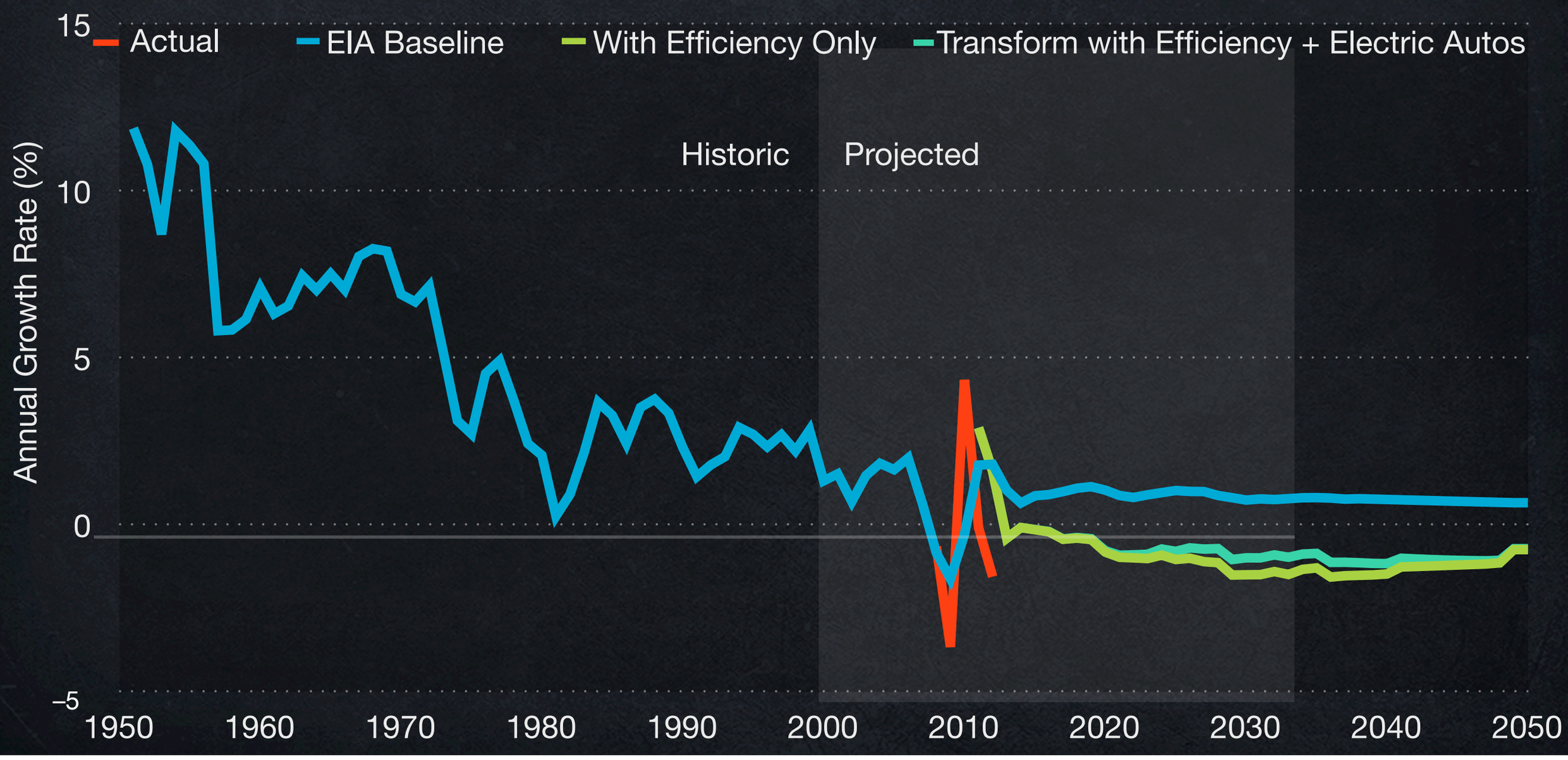
Source: A.B. Lovins, *Bulletin of the Atomic Scientists* **69**(2):44–65, Fig. 1, March/April 2013; RMI analysis; data from FERC, EUCG, DOE/EIA

Many if not most operating U.S. nuclear plants can no longer compete just on *operating* cost. Consistent with these industry data, 14 operating or planned U.S. reactors were terminated Jan–Aug 2013, with more to come. Yet official forecasts still assume only ~7 units will retire early, mainly after 2030.

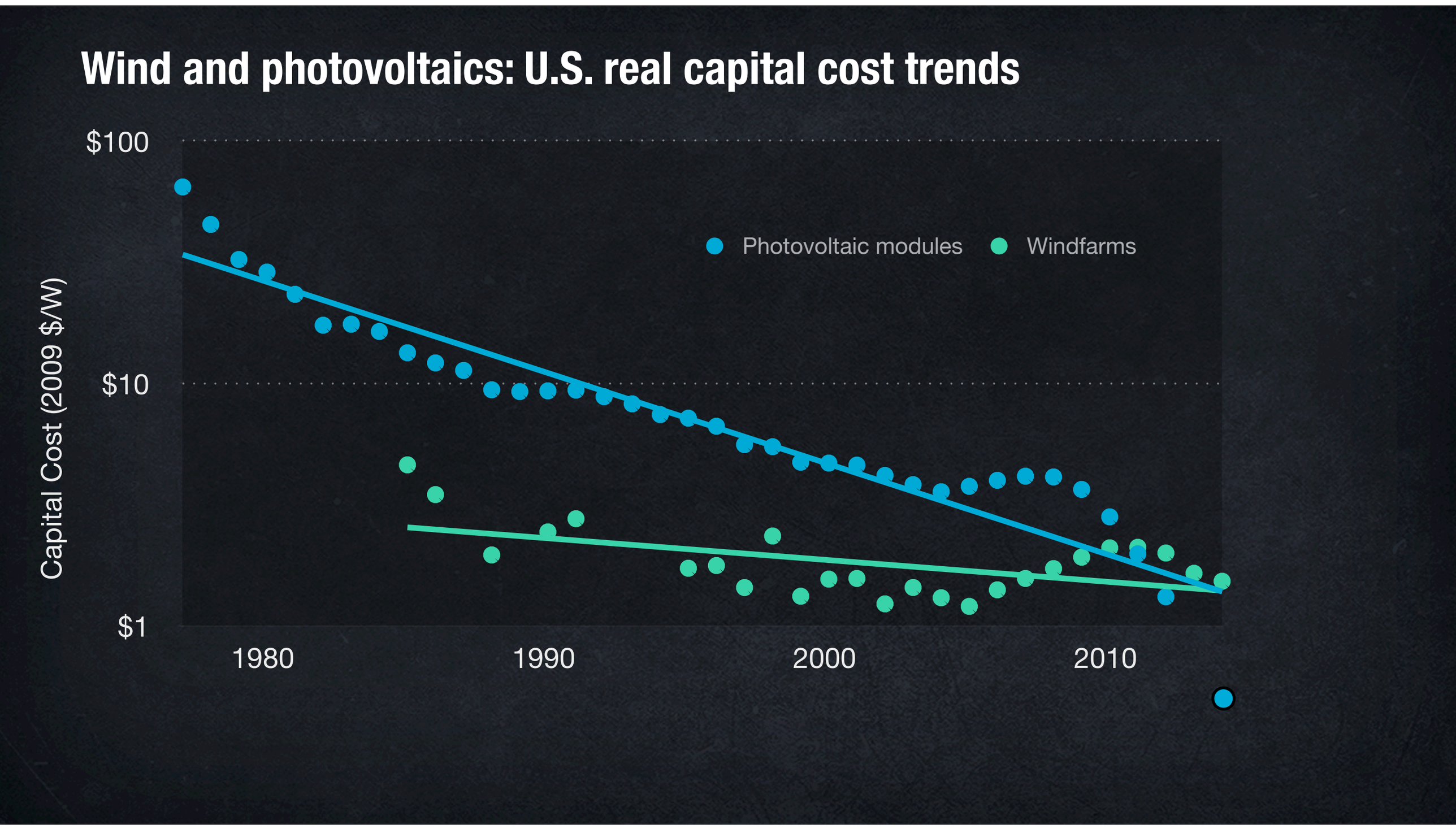
Competition from end-use efficiency: *Reinventing Fire* (2011)

- Buildings, which use 71% of U.S. *electricity*, could triple or quadruple their energy productivity (worth $1.4 trillion NPV) with a 33% IRR
- Industry, which uses 29% of U.S. electricity, could double its energy productivity with a 21% IRR
- These conclusions rest on very detailed National Academies and Lawrence Berkeley National Lab assessments, plus (mainly for buildings) conservatively assessed integrative-design savings they omitted
- U.S. electricity demand peaked in ’07 and has stagnated or begun to decline nearly nationwide despite economic growth, so the industry now considers this the “new normal”
- Resulting revenue erosion heightens incentives for decoupling and shared savings (as with gas earlier), now in 15 states for el., 20 for gas
- This will further accelerate utilities’ efficiency efforts ($6.9b in 2012)
- Efficiency cut U.S. 2012 CO_2 emissions by nearly twice as much as natural gas did
- Unbought “negawatt” reserves keep getting bigger and cheaper

Electric Needs Will Dwindle as Efficiency Gains Speed



Changing how we make electricity gets easier if we need less of it. Today, it's mostly wasted, and efficiency technologies keep improving faster than they're applied, making the potential savings ever bigger and cheaper. But as buildings and industry start to get efficient faster than they grow, * America's electricity use, instead of growing 1% a year as officially forecast, could start *shrinking* by 1% a year despite * electrified autos; in fact, electricity used (not yet weather-adjusted) per dollar of GDP * fell by an unprecedented 3.7% last year alone. And we can *keep* demand dropping by reasonably accelerating existing trends. This projection assumes that by 2030, U.S. average efficiency adoption will match what the Pacific Northwest states did in 2005. *

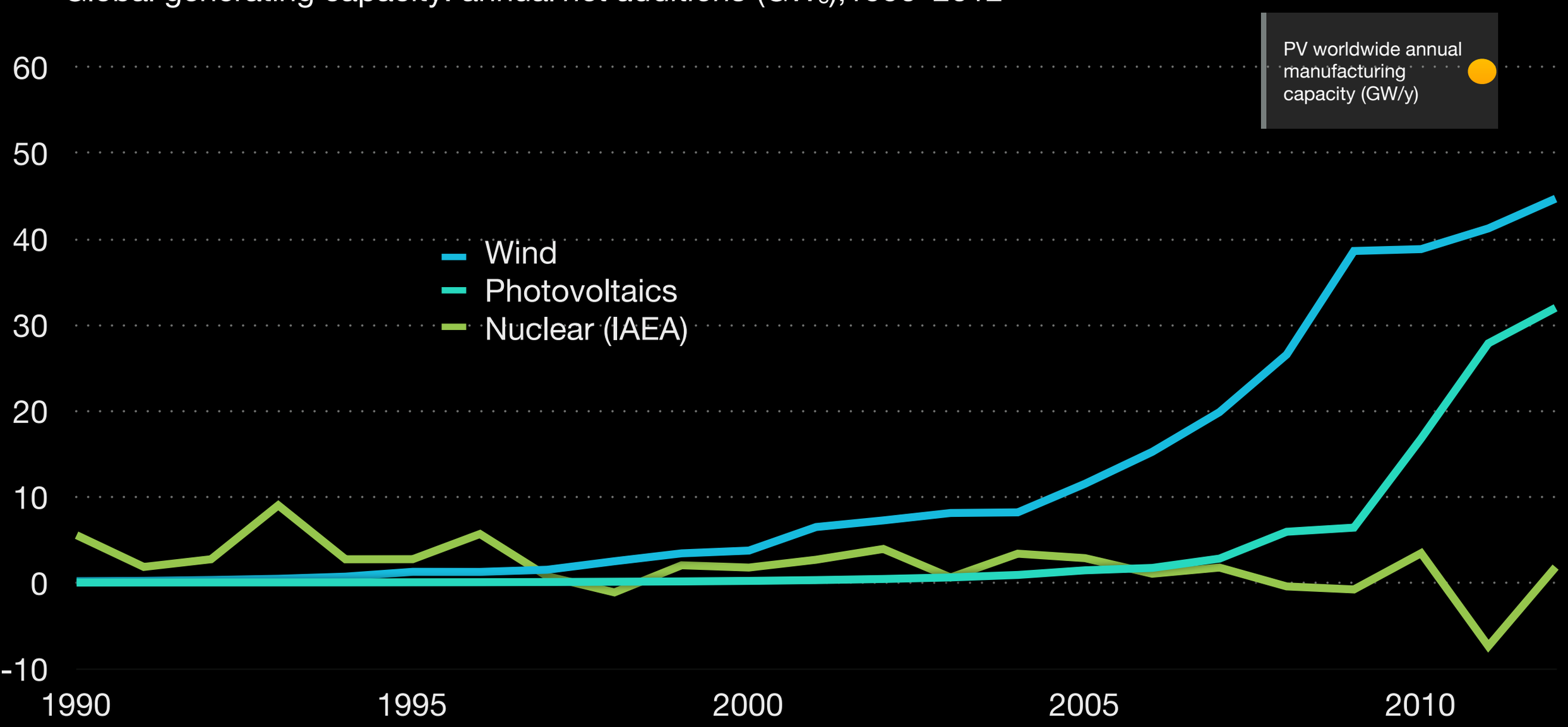


Needing less electricity would ease and speed the shift to new *sources* of electricity ... chiefly renewables. China leads their explosive growth and the almost nonvolatile, quite steadily plummeting costs shown here on a logarithmic scale: photovoltaic module prices, the blue dots, have fallen off the bottom of this logarithmic chart to today's 50–70¢/W. Well-sited solar and windpower are already marketplace winners: they're generally subsidized less than nonrenewables, but if new US windpower and solar power got *no* subsidies, their 2012 busbar prices would be respectively around 5–6¢ and 13¢/kWh, and falling.

In Germany, installed photovoltaic systems cost half as much as average American ones, even though they buy the same equipment, because Germany wrung out costs by scaling installations to 8 GW/y, adding more in one peak month than the US adds all year. Yet today in about 20 of the United States, private installers can put those photovoltaics on your home's roof with no money down and often guarantee to beat your electric bill. Such unregulated products could ultimately add up to a "virtual utility" that bypasses power companies just as cellphones bypassed wireline phone companies. That gives electricity executives nightmares and venture capitalists sweet dreams. Or incumbent electricity providers could turn that insurgency into a major business opportunity, and our e-Lab helps both sides to create value—separately or together. *

Global markets are rapidly shifting to distributed renewables

Global generating capacity: annual *net additions* (GW_e),1990–2012



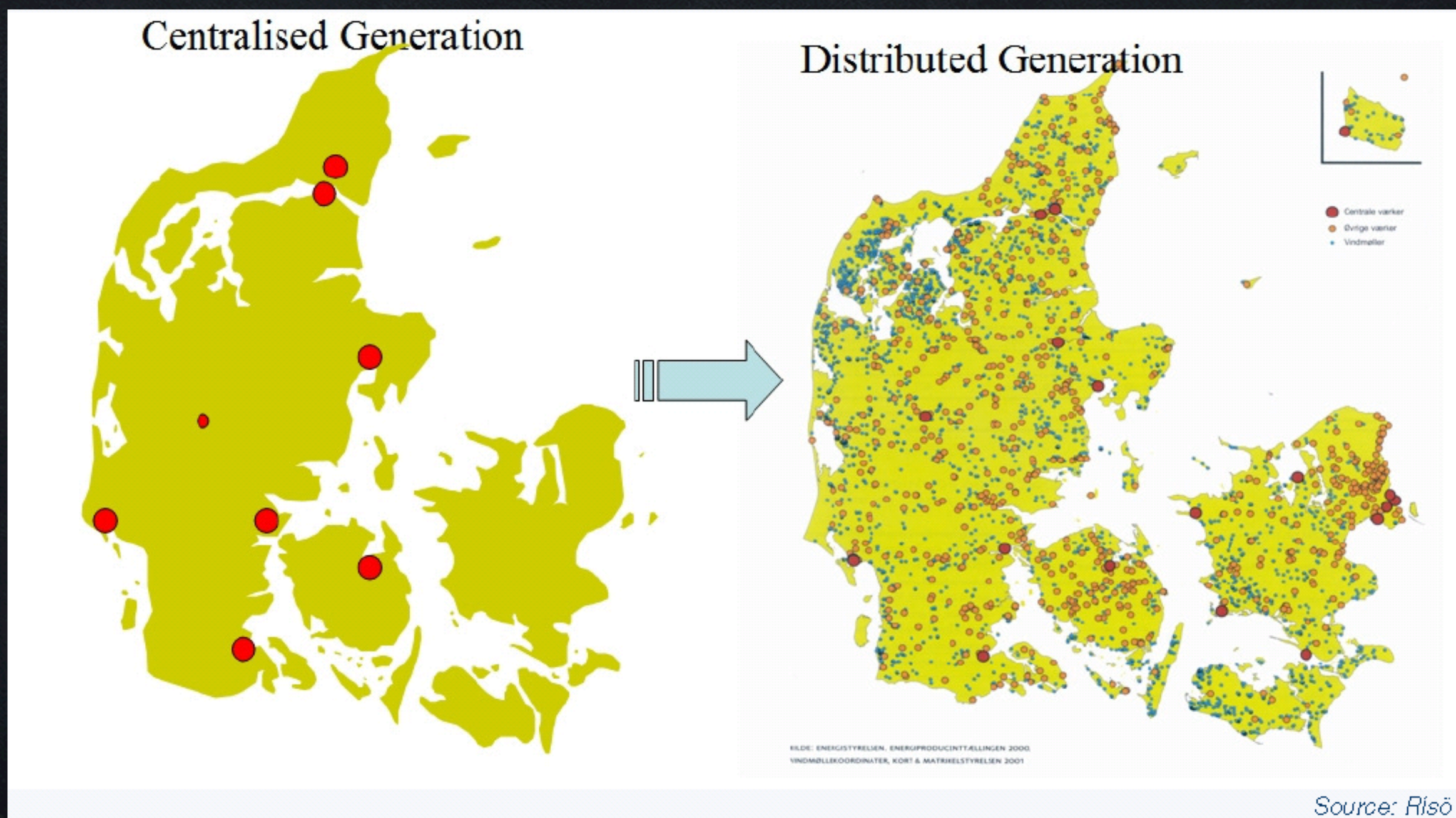
Output additions from nuclear fell behind PVs' since 2007 and will never catch up

Worldwide, starting in 2008, half of all new generating capacity has been renewable. This graph shows the amount of wind and photovoltaic generating capacity *added* worldwide each year. * Electricity production has become a scaleable manufactured product, more like making chips or mobile phones than like building cathedrals **[explain]**.

[The global clean-energy sector has brought Europe 1.1 million renewable-energy jobs, and created more American solar jobs than we have steel or coal jobs.]

Worldwide in 2011, renewable power *ex*cluding big hydro invested its trillionth dollar since 2004. They've surpassed the total global installed capacity of nuclear power, whose dwindling annual net additions * had turned negative even before Fukushima.

In contrast, global orders for nuclear *and* coal plants continue to fade because they *cost* too much and have too much *financial risk.* In the U.S., no merchant nuclear power plant is financeable despite nearly eight years of 100+% construction subsidies. Natural-gas prices too remain volatile, but renewables and efficiency have *no* fuel and *falling* capital costs. These modern competitors can displace the rest of today's coal plants and most of the nuclear plants too at below just their *operating* costs. *



Another key transition is illustrated by Denmark's 32-year journey from centralized power stations, mainly burning coal, to distributed wind turbines (86% owned by farmers and their communities) and cogeneration (often burning agricultural wastes). Denmark's conservative government plans 100% renewable energy by 2050 at essentially no extra cost.

Denmark is also reorganizing its grid in a "cellular" architecture that makes cascading blackouts impossible. [The same approach enabled Cuba to reduce its serious blackout days from 224 in 2005 to zero in 2007, and to sustain vital services in 2008 even when two hurricanes in two weeks shredded the eastern grid.]

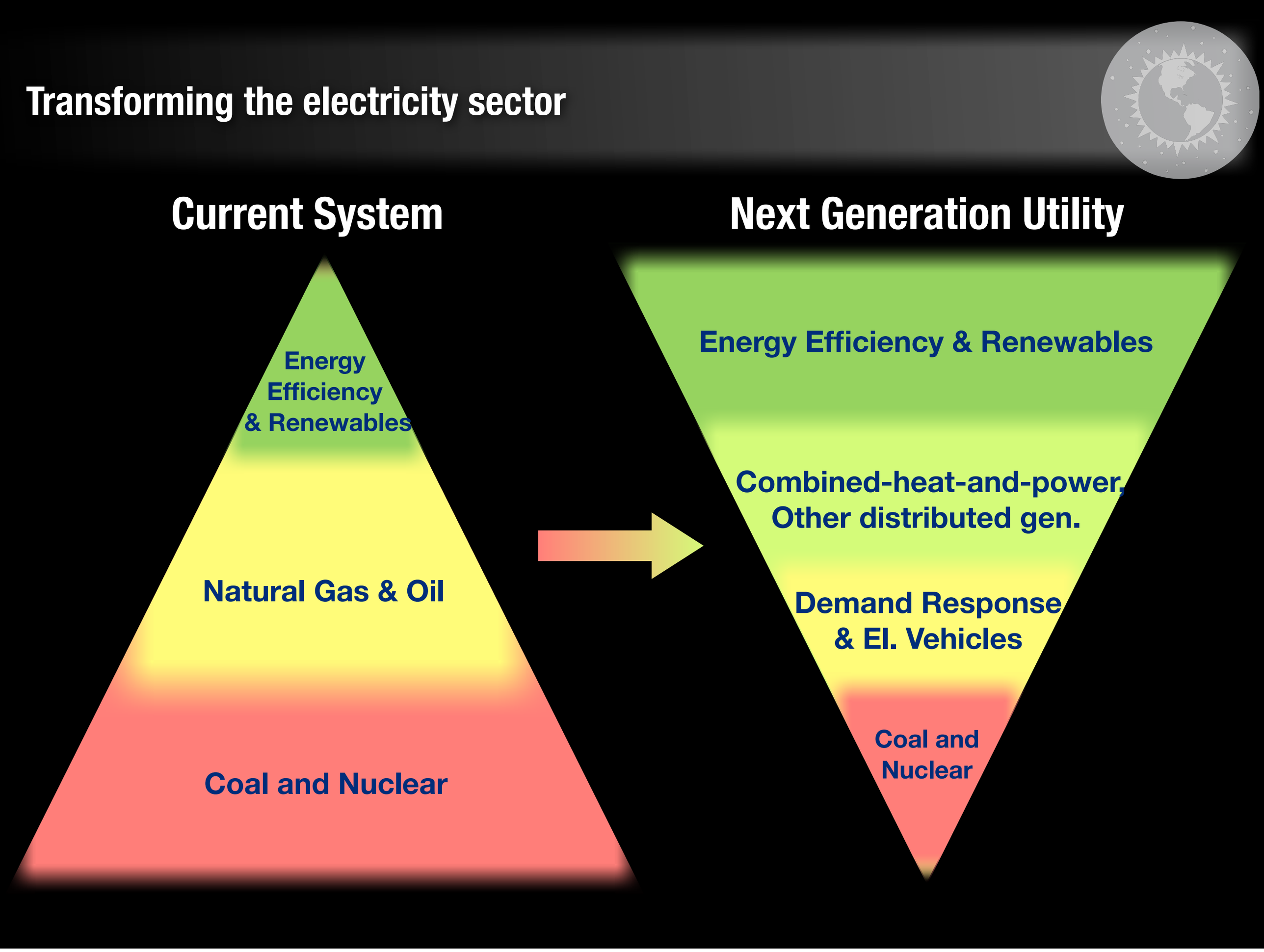
Those "small, limited, costly, unreliable" nonhydro renewables are winning

- *Business Week*, *Financial Times*, EEI: upending business models
- Getting >$250b/y private capital, adding >80 GW/y
- Exceed global nuclear power capacity and add >10x more/y
- Added 49% of 2012 new capacity in US, 69% in EU
- In 3 of the world's 4 top economies (China, Japan, Germany) and in India, produced more 2012 electricity than nuclear did
- Increased China's 2012 generation more than nuclear + *fossil*
- Produced 23% of 2012 electricity in Germany, 41% in Denmark, and in 1H13, 48% in Spain and 70% in Portugal (*vs.* 17% in 2005)

In good U.S. areas, wind *and* photovoltaic new capacity beat new combined-cycle gas at auction, and those areas are growing fast

So anyone who dismisses modern renewables as a serious competitor and the current winner, or who claims coal and nuclear plants will rule, ignores markets and forgets that arithmetic is not an opinion.

So whether or not we properly value water and water resilience, the power sources that use the most water are also the least economic, and the market is doing them in nicely. **[explain]**

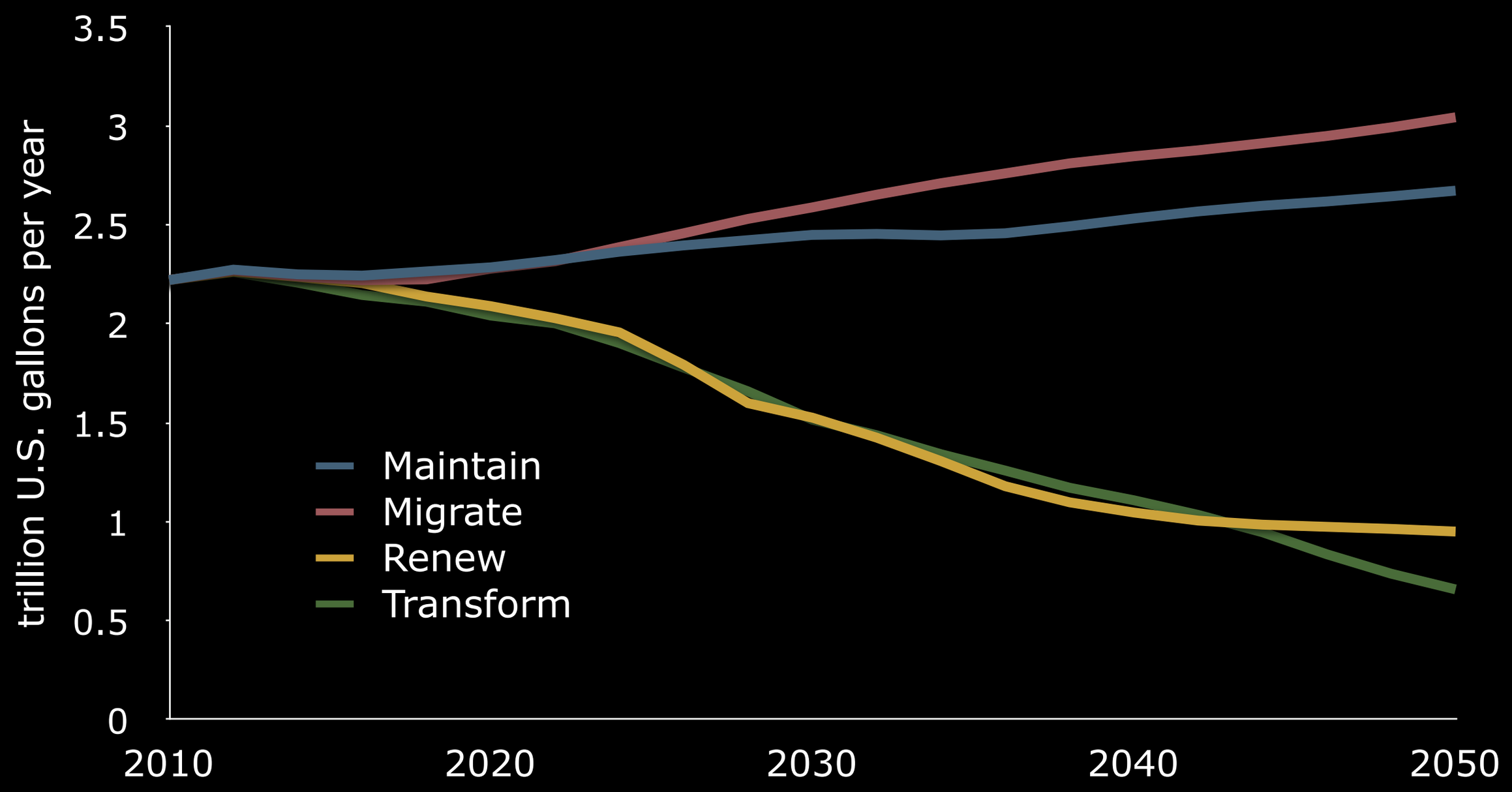


Together, these transformations in efficient use and diverse, dispersed, renewable supply are starting to flip the whole electricity sector on its head. * Traditionally, utilities relied mainly on giant coal and nuclear plants; augmented them with big gas plants; and bought a little efficiency and renewables. Those utilities were rewarded, as most still are, for selling more electricity. But now—especially where regulators reward cutting customers' bills— * the market is shifting massively towards efficiency, renewables, cogeneration, and ways to blend them all together reliably—with little or no need for bulk electricity storage.

These best buys save about 2–20x more carbon per dollar, 20–40x faster, than nuclear power, so the market winners are also the most effective climate solutions. They're also the best solutions to nuclear proliferation, energy insecurity, and energy poverty.

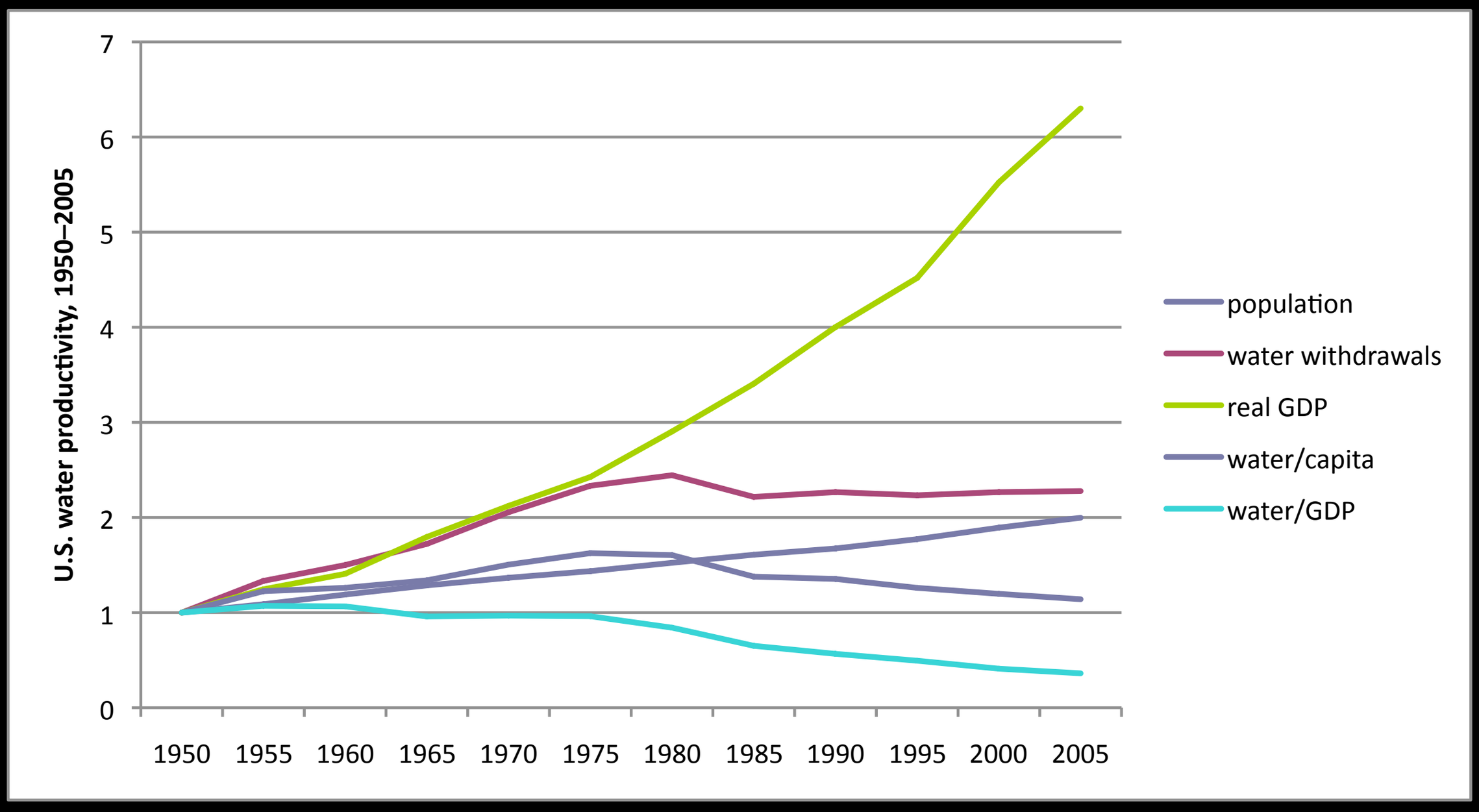
Now combine the electricity and oil revolutions, plus similar opportunities with natural gas and direct coal, and you have the really big story... *

RMI's *Reinventing Fire* scenarios (2011) for U.S. electricity evolution showed how 80%-renewable supply could cut the power sector's water consumption by two-thirds by 2050, at comparable cost, more resiliently, best managing all risks



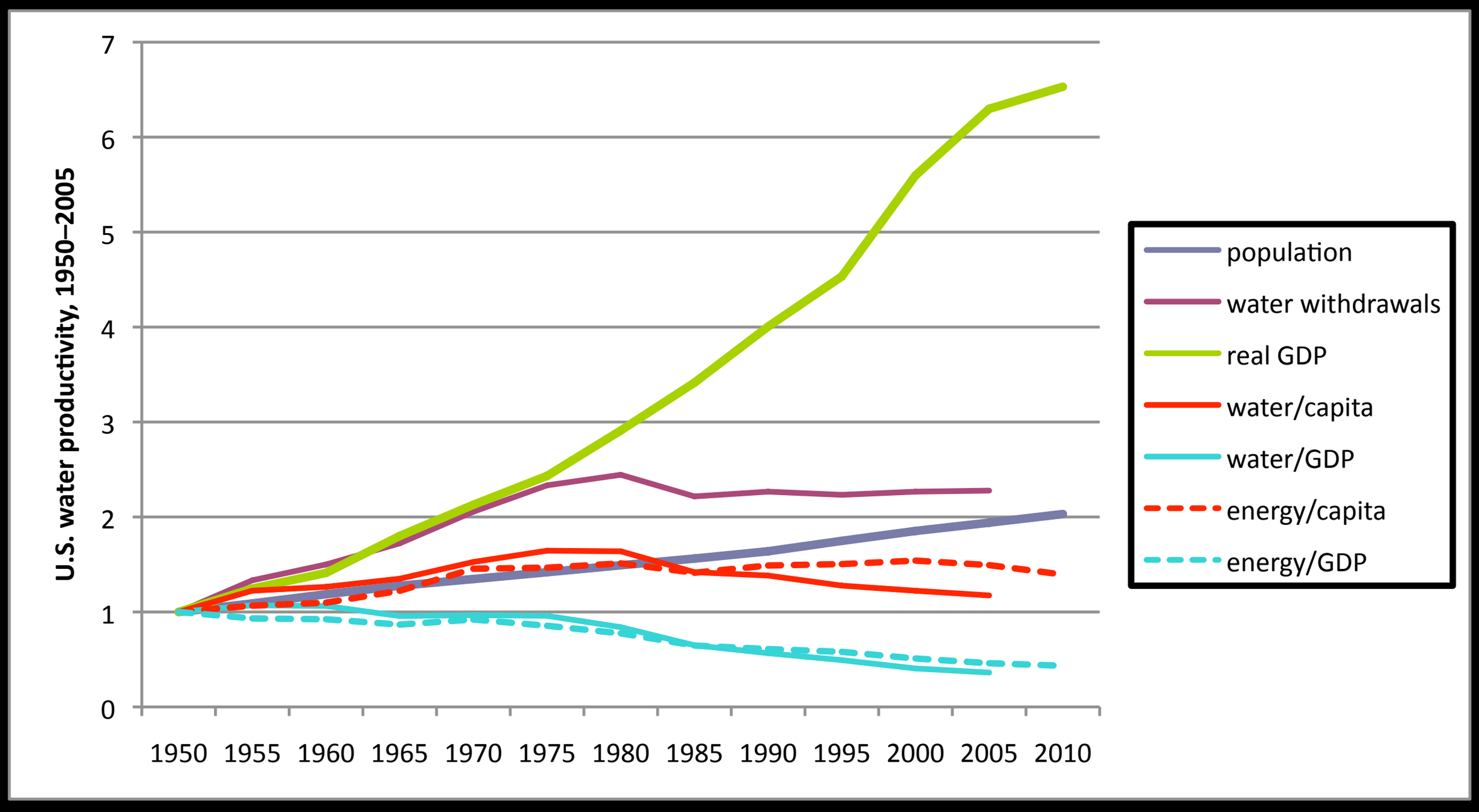
Such market-driven energy futures will use less water because the increasingly uneconomic thermal power generators will go away (they now use half of US water withdrawals) and because many ways to save energy also save water—even as simple approaches as high-performance showerheads and irrigation sprinklers.

Making a dollar of GDP took 64% less water in 2005 than in 1950



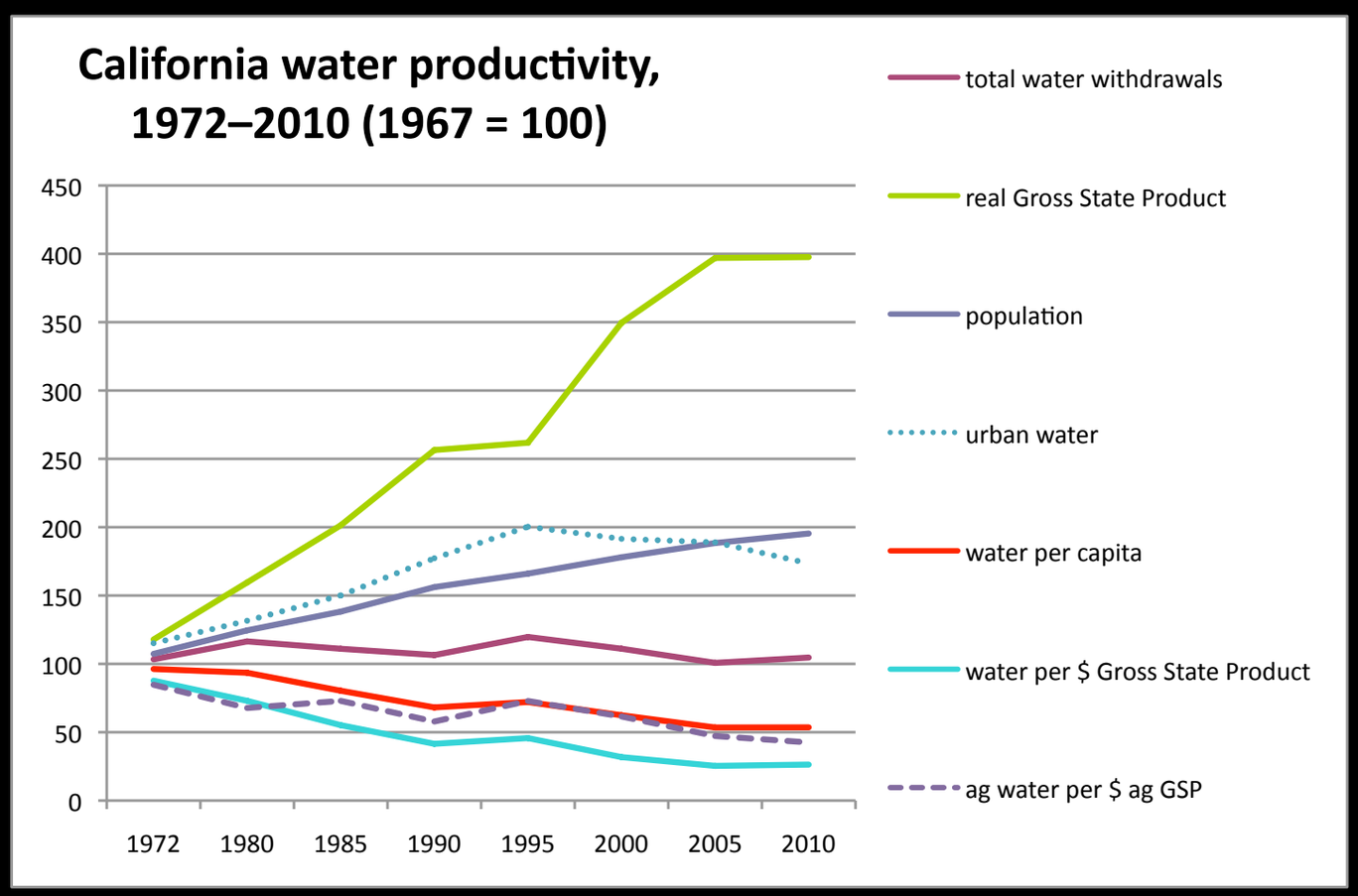
The biggest use, withdrawals for thermoelectric power plants, used 68% less water per kWh

Water productivity outpaced energy productivity—with almost no policy



That national average hides big variations. California, which has held per-capita electricity use flat for 30 years while per-capita real income rose >4/5, has since 1980 saved one-fourth more water per person or $ than the national average, mainly because of its more modern water-management and -trading policies

Yet we're only just scratching the surface of water *and* energy productivity—even in California, with the strongest policy framework



Source: "Water and the California Economy," 2012, www.ppic.org, updated to 2010 by Bob Wilkinson and Ellen Hanek, graphed by Amory Lovins

CA ag's water use peaked ~1980; by 2010, farms produced 32% higher value with 17% less water; yet only ~1/4 of '05 irrigation was precise (e.g. drip), half was flood, and just 38% of cropland grew high-value crops

Households, which use >2/3 of CA's urban water, have mainly adopted moderately improved fixtures, but done little with the *out*door ≥1/2 of their water use (Israel, Spain, and some Australian cities are >2x as efficient in irrigating landscape)—yet urban use drifted down since 1995

The next big frontier is capturing synergies—CA's water system uses 1/5 of its electricity—and tapering down the use of water for uneconomic thermal power generation (which uses half of all U.S. water withdrawals)

During 1985–2005, the only two data points I could readily find, Colorado raised its water productivity (GDP per gallon withdrawn) by 123%, vs. 79% for the U.S. average.

Colorado, like many states, doesn't yet let water efficiency compete head-to-head (or at all) with enhanced water supply

- RMI's 1989 comparison found that full use of simple, commercially available water-efficiency equipment in Denver households would save more water than the Two Forks Dam would supply, at a fifth of its cost per acre-foot (the full efficiency potential is much larger)—in effect, giving Denver the same water services as the dam plus $2/3 billion of savings
- Denver Water Board critiqued RMI's study; RMI fully responded; weeks later, EPA launched its veto process, leading to the dam's cancellation
- Denver and many others (some as intensively as Las Vegas) have since begun adopting basic water efficiency improvements
- Yet such then-novel comparisons to help us pick the best buys first remain sporadic, administrative (not market-based), and relatively rare
- Why? Poorly defined and measured water rights make a Water Court change case costly and risky, especially for the 85%-ag users, so nobody wants to go there, so antiquated policy is more comfortable to keep; and water-saving tends to be penalized, not rewarded, because saved water can't be traded (has no market), risks abandonment, hence has small, no, or negative value

Standard arguments against using water efficiently

Faced with a choice between (1) efficient use, (2) ag dryup, and (3) more Colorado River diversions, most of the water establishment, being comfortable with and good at present arrangements, chooses #3, because:

- "We've already done it." (Nonsense. We've barely begun in CO.)
- Cities fear losing water rights. (True. Solution: trade saved water.)
- We're not forced to, and we don't like the state to cram stuff down communities' throats. (Is that equally true of diversions and dryups?)
- If we save now, we can't tighten our belts later. (Complete confusion.)
- We can't set savings targets because it's hard to estimate current usage. (And water rights! Actually usage is not hard to measure, and a *process* to buy cost-effective efficiency matters much more than setting a *target*.)
- We can't physically move saved water between cities. (Do so virtually.)
- Utilities won't share saved water. (They will if they can trade or sell it.)
- Utilities need revenue from robust water sales. (For what—since efficiency will be bought only when it's cheaper than supply?)
- Water efficiency unfairly burdens the poor. (Not with proper design.)
- The public isn't involved. (Right: needs governance and engagement.)

Re saving now/later, our 1989 Two Forks analysis correctly stated: "Water saved is exactly the same as water supplied [except, I'd add, it's steady, not fluctuating with rainfall]. One person's reduction in water use makes water available for someone else to use. A temporary reduction in use is equivalent to a temporary increase in supply, a permanent reduction in use equivalent to a permanent increase in supply. Temporary reductions and those requiring lifestyle changes are generally useful only during temporary shortages, after which they can readily reverse; but permanent, reliable reductions which do not require or depend upon lifestyle changes can permanently disable alternative, reliable supplies." It follows that permanent water savings through efficient end-use do not interfere with temporarily curtailments in a later shortage, but can make that shortage much less likely by stretching limited supplies to cover greater needs for services.

Some basic elements of modern water strategy

- Neutrality between more supply and efficient use.
- Best buys first: end-use / least-cost.
- Let all ways to save or supply water compete fairly, at honest prices, regardless of their type, technology, size, location, seniority, or ownership.
- Therefore make robust and diverse markets in saved water so market mechanisms (including futures and options) can anticipate, manage, and resolve imbalances and reward those who provide least-cost solutions.
- Quantify water rights, make them fungible, eliminate abandonment risk.
- Thus transcend current reluctance to change, basically caused by terror of going into Water Court and coming out with less.
- Help water lawyers reskill and repurpose themselves as water traders.
- Nurture new statewide water-efficiency industries and livelihoods.
- Start by understanding what citizens want: efficiency and agriculture.
- Do not assume that historic patterns of overdiversion from the Western Slope are fair, acceptable, or politically sustainable. (Fortunately, they're also increasingly uneconomic under all-resources competition.)
- Be mindful of timing—the hydroillogic cycle
- Say what you mean—efficiency, not ambiguous "conservation". No Gap!

Colorado has an effective water management system founded in 19th-century principles. It is increasingly inadequate to the needs and unable to grasp the opportunities of a 21st-century market economy. This is a problem we have inflicted on ourselves. For the sake of a dynamic and resilient economy supported by a healthy citizenry and environment, we must solve this problem. I'd therefore like to presume to suggest some lessons from the past 30+ years of energy evolution that I believe can also inform your water deliberations...

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/

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 ISO, PJM, MISO)

Fungible savings (with grid credit)
- Morro Bay example for saving water
- Wheeling savings between customers, utilities, States, even countries (Québec/Vermont)
- 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/simulations

Bootstrap operational savings *in utility* (motors…)

Morro Bay: When Morro Bay, California, ran short of water in the late 1980s, it simply required any developer wanting a building permit to save, at some other site in town, twice as much water as the new building would use. Developers then discovered what saved water is worth, because the town had established a market in it. One- third of the houses in Morro Bay got retrofitted with efficient plumbing fixtures in the first two years and two-fifths in the first four years. This plan could as well have been implemented in a larger area, via water- savings brokers. Fantasy? It's already happening. A few states — notably California, Oregon, and Montana — have reformed their "use-it-or- lose-it" water laws to allow saved water to be sold or leased without penalty. Brokers are now emerging to handle those save-and-resell deals.

In Goleta, California, drought and the threat of a multimillion-dollar expenditure to meet EPA sewage-treatment standards spurred a $1.5-million municipal program that provided information and incentives to the town's 74,000 citizens to reduce water waste. Technical improvements, plus some emergency drought measures (peak-season surcharges and a little rationing), cut citywide water consumption within the single year from 1989 to 1990 by 30 percent, from an average of 135 to 90 gallons per person per day — twice the targeted savings. Sewage flow fell by over 40 percent, enabling the existing plant to run within its rated capacity and EPA secondary standards.[109] The proposed plant expansion was indefinitely deferred. The total water savings later grew to 40 percent. In the dry summer of 1990, while some nearby communities were forced to cut their water use by 30–45 percent, Goleta had only to set a 15 percent goal, avoiding disruption or hardship. This illustrates how prior efficiency can actually *reduce* the hardship and increase the effectiveness of temporarily curtailments in a water emergency.

New methods (continued)

- C&I load-management coops (CA, NY, MA, IL, S)
- Efficiency cross-marketing (electricity/gas/water/sewer)
- 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 and 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), whilst 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

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 ACT^2s
  - Carefully reward utility personnel for audited savings
  - Strongly emphasize whole-system design synergies