An Eight-Fold Way Towards Faster Energy Efficiency

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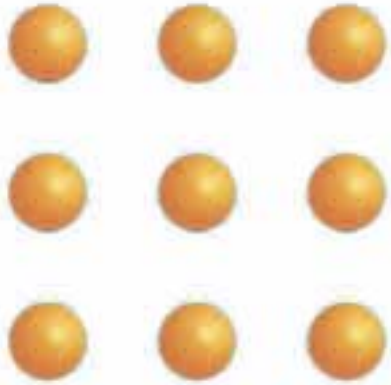
Edwin Land

"People who seem to have had a new idea have often just stopped having an old idea"

The Nine Dots Problem



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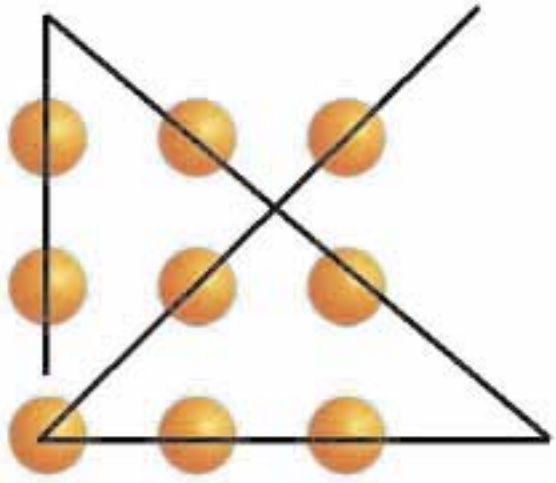

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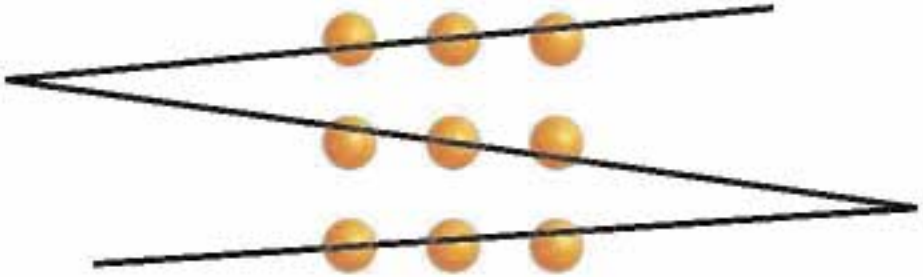
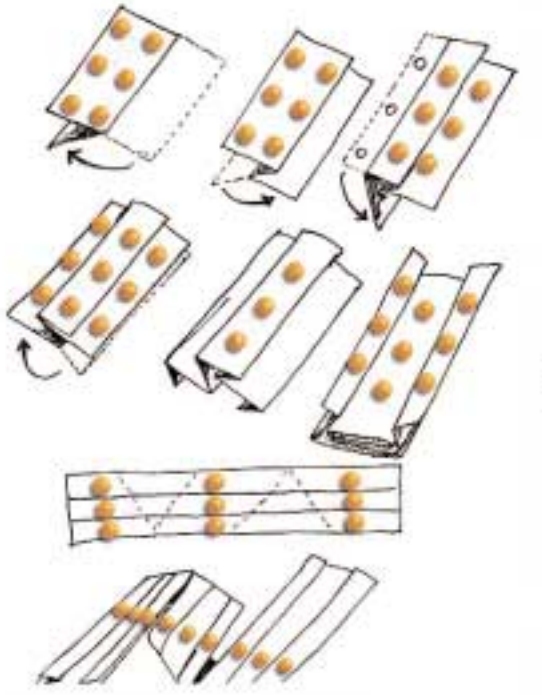
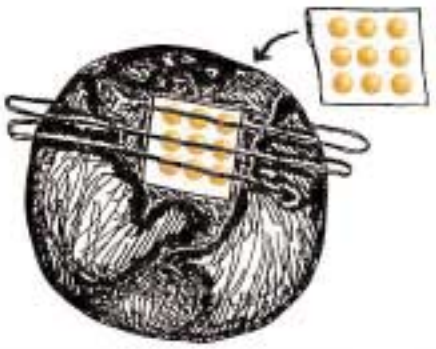




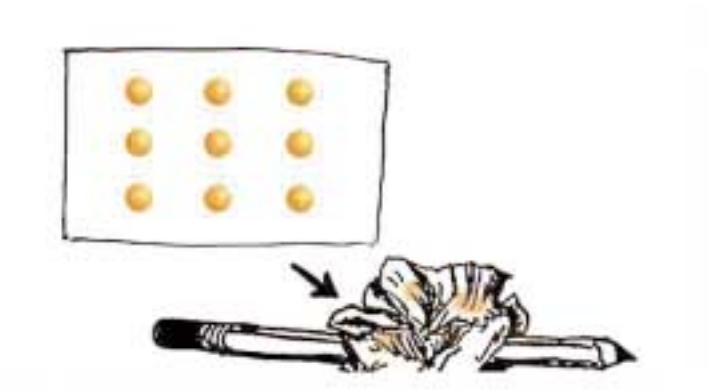
origami
solution

geographer's solution



mechanical engineer's solution

statistician's
solution



wide line
solution

Conventional policy instruments for turning ideas and goals into actions

- Regulation
  - Standards, mandates, results (Kyoto),...
- Innovation + laissez-faire
  - RD&D, "golden carrots", targeted devel't.
  - Labeling, information, and public education
  - Liberalization, "competitive" restructuring
- Taxes and prices
  - Energy, carbon, and other Pigouvian taxes
  - Tariffs and tariff structures
- These all work; choice is a matter of taste

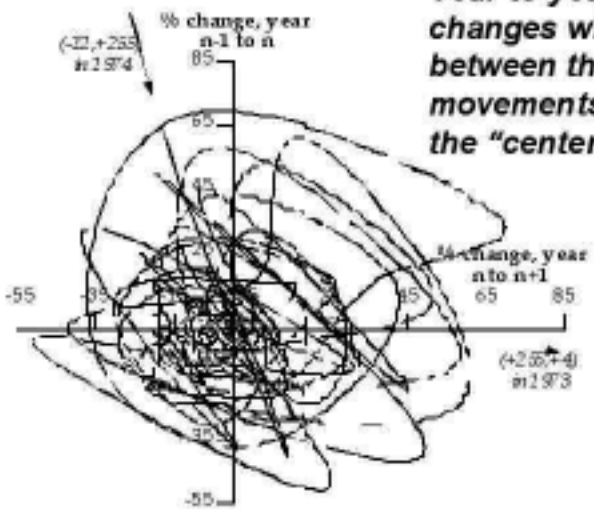
What drives energy savings?

- Prices do matter, and should be correct, but ability to respond can matter more
  - Seattle in 1990–96 paid half Chicago's electricity price, yet saved kW_p 12× as fast and kWh 3 640× as fast, due to utility differences
- Price is only one of many ways to get attention: e.g., US E/GDP 1996–99 fell 3,2%/y during record-low & falling prices
- Prices without barrier-busting do little
  - DuPont's European factories are as inefficient as US ones despite long exposure to prices 2× as high

Price May Well Become Less Important

- On the demand side, end-use efficiency will be bought mainly for qualitatively improved services (joint products)
- On the supply side, distributed and renewable resources will be bought mainly for distributed benefits
- Outcomes will therefore become decreasingly predictable from economics
- Disruptive technologies may be driven by factors other than price and regulation
- In any case, price should reflect ecological tax-shifting (from goods to bads)

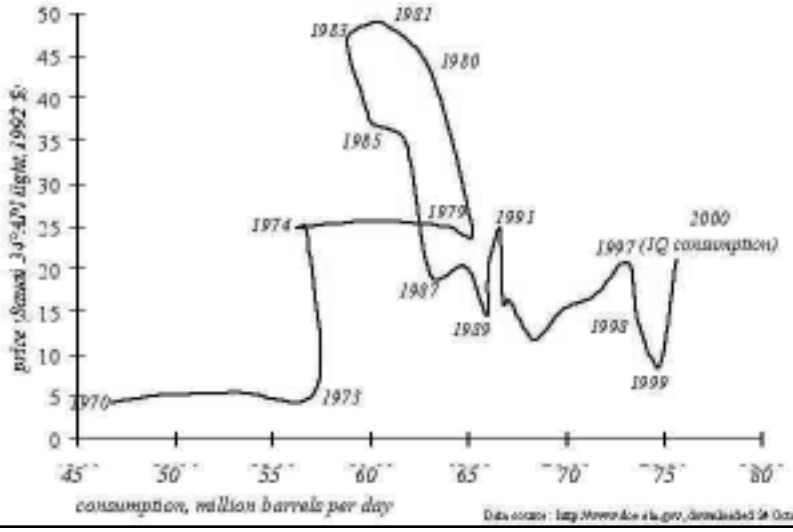
The Brownian Random Walk of World Real Oil Price, 1881–1993



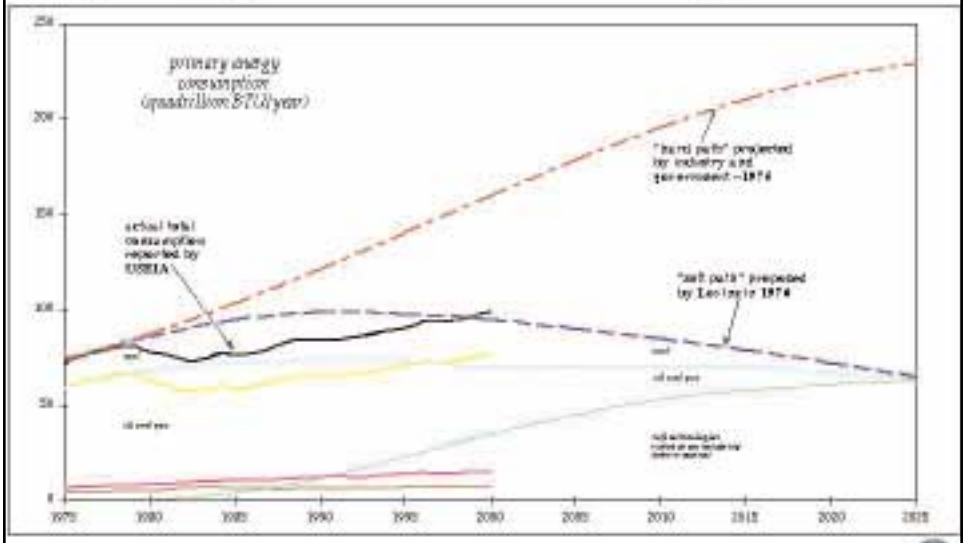
Year-to-year percentage price changes with a one-year lag between the axes. If the price movements showed a trend, the "center of gravity" would favour a particular quadrant. All that happened after 1973 is that volatility trebled; changes stayed perfectly random, just as for any other commodity.

Graph devised by R.R. Nelli, USDOE

Market surprise: world crude-oil real price vs. oil consumption, 1970–1Q2000



US energy use/$ GDP already cut 40%, to very nearly the 1976 "Soft Energy Path"



Conventional policy instruments are not the only ones and may not be the most effective. Here are eight more. Change...

1. *Ability to respond to price*
2. *What competes, what is rewarded*
3. *What benefits are marketed and sought*
4. *Technologies vs. negatechnologies*
5. *How designers think*
6. *How quickly we deploy*
7. *How business is done*
8. *What drives underlying demand for energy services*

1. Ability to respond to price

- *60–80 specific market failures of 8 types:*
  Capital misallocation, value-chain risks, organizational and informational failures, regulatory failures, perverse incentives, false or absent price signals, absent markets
- *Proven methods can turn each of these obstacles into lucrative business opps.**
- *"Barrier-busting" to create that alchemy should top the public policy agenda*

**Pp. 11–20, "Climate: Making Sense and Making Money," RMI, 11/97, free download, www.rmi.org/images/other/C-ClimateMSMM.pdf*

2. What competes, what is rewarded

- Efficiency should compete fairly and comprehensively with supply in all administrative and market processes
- Energy distributors should be rewarded for reducing customers' bills, not for selling more energy
  - Decoupling + shared savings (9, now 2, U.S. states; widely adaptable methods)
- Designers should be rewarded for savings achieved, not expenditures
- Rules should be neutral as to scale and ownership — just count results

3. What benefits are marketed & sought

- Side-benefits are often worth ≥10× more than direct energy savings
  - ~6–16% higher labour productivity from better visual, acoustic, & thermal comfort
  - Big gains in industrial output/quality, +40% sales in well-daylit shops, 20–26% faster learning in well-daylit schools,...
- Integration with other goals: Curitiba
- Distributed benefits: ~125 effects often raise economic value of distributed electric resources by ~10×
- Breakthrough performance: Hypercar℠

Order-of-magnitude typical value increase from distributed benefits

- *Financial-economics benefits: often nearing ~10× renewables, ~3–5× others*
- *Electrical-engineering benefits: normally ~2–3×, far more if the distribution grid is congested or if premium power reliability/quality is required*
- *Miscellaneous benefits: often around 2×, more with thermal integration*
- *Externalities: indeterminate but may be important; not quantified here*
- *Result: PVs often cost-effective* now

Four Times Square, NYC
(Condé-Nast Building)

- *150,000 m²; 47 storeys*
- *non-toxic, low-energy materials*
- *50% energy savings/m² despite doubled ventilation rates*
- *Gas absorption chillers*
- *Fuel cells*
- *Integral PV in spandrels on S & W elevations*
- *Ultrareliable power helped recruit premium tenants at premium rents*
- *Fiber-optic signage (signage required at lower floor(s))*
- *Experiment in Performance Based Fees rewarding savings, not costs*
- *Market average construction cost*

A 5×-efficiency midsize sport-utility vehicle

An illustrative, uncompromised, manufacturable, production-costed concept car (11/2000) developed for a few million dollars in 8 months by Hypercar, Inc. (www.hypercar.com), on time and on budget, with attributes never before combined in one vehicle

- 5 big adults, up to 1,96 m^3 of cargo
- Hauls 460 kg up a 44% grade
- 857 kg (47% mass of Lexus RX300)
- Head-on wall crash @ 56 km/h won't damage passenger compartment
- Head-on collision with a car twice its mass, each @ 48 km/h, meets U.S. safety std. for 48 km/h barrier crash
- 0–100 km/h in 8,3 seconds
- 2,38 L/100 km equivalent (5× RX300)
- 532 km on 3,4 kg of 345-bar H_2
- 89 km/h on just normal a/c energy
- Zero-emission (hot water)
- Body >2× as stiff as a good sportsca
- Fast all-wheel digital traction contro
- Ultrareliable; flexible, customizable; wireless diagnostics/upgrades
- 320 000-km warranty, no dent or rust
- Undamaged by 10 km/h collision
- Competitive cost expected @ ~50k/y
- Decisive manufacturing advantages — 10× lower capital, parts, assembly

Hypercars will ultimately...

- save as much oil as OPEC sells; exit Iron Age
- decouple driving from climate and smog
- permit a rapid, profitable hydrogen transition
- become immense electricity generators: cars are parked ~96% of the time, and a full US fleet of 150 million light vehicles, @ 20–45 kW each, would be 3–6 TW — 5–10× as much generating capacity as all utilities now own

WHEN? Within current planning horizons!

- ~$10 billion committed during 1993–2000
- Hypercars could be widely available in ~5 y, dominant in ~10 (www.rmi.org/sitepages/pid414.asp)
- The old way of making cars — and electricity — could be toast in 20 y

Note unusual features...

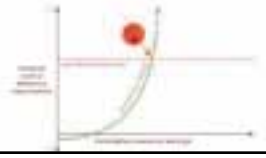
- *Uncompromised cars at comparable cost — no tradeoffs, no extra costs (CDs)*
- *They'll sell because they're* better, *not because they're clean and efficient*
- *No oil price, fuel tax, climate regulation, mandate, or subsidy needed — an "end-run" around the policy gridlock*
- *Business model rests* solely *on value to the customer and competitive advantage to the manufacturer*
- *Quick entry, formidable new entrants*
- *Hard to stop; basic work in public domain*

4. Technologies vs. *negatechnologies*

- *We customarily deploy more efficient devices*
- *We too seldom buy and scrap the old, very inefficient devices*
  - *They're often worth more dead than alive*
  - *Take them out back and shoot them*
  - *Offer "bounties" to "hunters"*
- *We do not track, label, stigmatize, or penalize trade in inefficient devices*
  - *"Negative technology transfer"*
  - *Retards global development*

5. How designers think

- *Almost all technical systems have been designed by optimizing components for single benefits (pessimizing the system)*
- *Designing by optimizing whole systems for multiple benefits typically yields dramatic resource savings at lower costs*
- *"Tunneling through the cost barrier" now demonstrated in buildings, fan/pump/hot-water/HVAC/motor/lighting systems, computer design, other technical systems*



Edwin Land

Invention is "… a sudden cessation of stupidity"

New design mentality, an example:

- Jan Schilham's redesign of a supposedly optimized standard industrial pumping loop cut power from 70,8 to 5,3 kW (–92%), cost less to build, and worked better

No new technologies, just two design changes

- Fat, short, straight pipes — not skinny, long, crooked pipes!
- Benefits counted
  - 92% less pumping energy
  - Lower capital cost
- "Bonus" benefit also captured
  - 70 kW lower heat loss from pipes
- Additional benefits not counted
  - Less space, weight, and noise
  - Clean layout for easy maintenance access
  - But needs little maintenance—more reliable
  - Longer equipment life

Why this example matters

- Pumps are the biggest use of motors
- Motors use 3/5 of the world's electricity
- Every unit of flow or friction saved in the pipes saves ~10 units of fuel, cost, and pollution at the thermal power plant
- This is an archetype for whole-system redesign: optimizing whole systems for multiple benefits, not individual components for single benefits, typically raises efficiency ~3–10×, reduces capital cost, and improves performance

6. How quickly we deploy

- Why assume routine turnover of stocks?
- We seldom consider accelerated scrappage, e.g. incentivized by car feebates
- We seldom implement mass retrofits
  - Despite many great European examples
- We seldom even coordinate e.g. building superoutsulation with routine façade renovation or HVAC installation/renewal
- Rely more on "vernacular" technologies, as fast as mobile phones / informatics?
- "Ready, fire, aim"; "just do it, keep trying"; leadership vs. management

7. How business is done (beyond structural changes from E-commerce)

- Industrial capitalism treats only money and goods; but natural capitalism also productively uses and reinvests in people and nature, thus making far more profit
- Being rapidly adopted (www.natcap.org)
- Integrates radical resource productivity, closed-loop nontoxic production, a "solutions economy" business model that rewards both (profiting from doing more & better with less for longer—like www.mobility.ch), and reinvestment in nat. capital
- Profound implications for demand

8. What drives underlying demand for energy services

- Population
- Affluence and its metric(s)
- Distributional (in)equity
- Hedonic / functional efficiency (how much human happiness / satisfaction come from each unit of energy services delivered)
- "Homo œconomicus" / "vanity"
- Markets make a great servant, a bad master, and a worse religion
- Meeting nonmaterial needs by non-material means

By 2050, an affluent world could meet or beat a 3–4× C reduction goal

× 2 × 3–4 ÷ 2–4

$$C_{energy} = \frac{population \times affluence\ per\ capita \times carbon\ \text{intensity}}{\text{conversion eff.} \times \text{end-use eff.} \times \text{hedonic eff.}}$$

× 1,5 × 4–6 × 1–2?

or ~1,5–12× lower CO_2 emissions despite assumed 6–8× growth in GWP. (A 1993 UN study* found 1,35× and 8× respectively, 1985–2050.) Great flexibility is thus available. The future is not fate but choice.

*Johansson, Kelly, Reddy, Williams, & Fenhann, *Renewable Energy* 1179 pp., Island Press, Washington D.C.
This analysis, though not the smallest on the supply side, assumed relatively weak end-use efficiency opportunities.

So if we have at least ten ways to deploy efficiency, not just two...

Can't we become efficient much faster by combining most or all of this rich menu of options? (Anyway, such an "assiette" tastes better!)

Success will depend on our…marketing!

Fortunately, the many flavours on the new menu of ≥10 items have far more transideological appeal than just regulation and/or prices

For more than these hors d'oeuvres...

- ***Informal tech. session 1530–1630+ Wed.***
  - ***How to tunnel through the cost barrier***
  - ***Hypercars, fuel cells, & the H_2 transition***
  - ***Distributed utilities & distributed benefits***
  - ***Profitable business-led climate protection***
  - ***Making markets in saved energy***
- ***Informal session 1430–1530 Thu.***
  - ***Natural Capitalism — also www.natcap.org***
- ***Joint informal session 1530–1730 Thu.***
  - ***What happened to California electricity?***

Thank you! And please visit...

- *www.rmi.org (general information, many publications; Transportation section gives public Hypercar information)*
- *www.hypercar.com (the new private technology-development company)*
- *www.naturalcapitalism.org or www.natcap.org for short (the wider context—making business far more profitable by behaving as if nature and people were properly valued): see* **Natural Capitalism** *(Little Brown, NY, & Earthscan, London)*