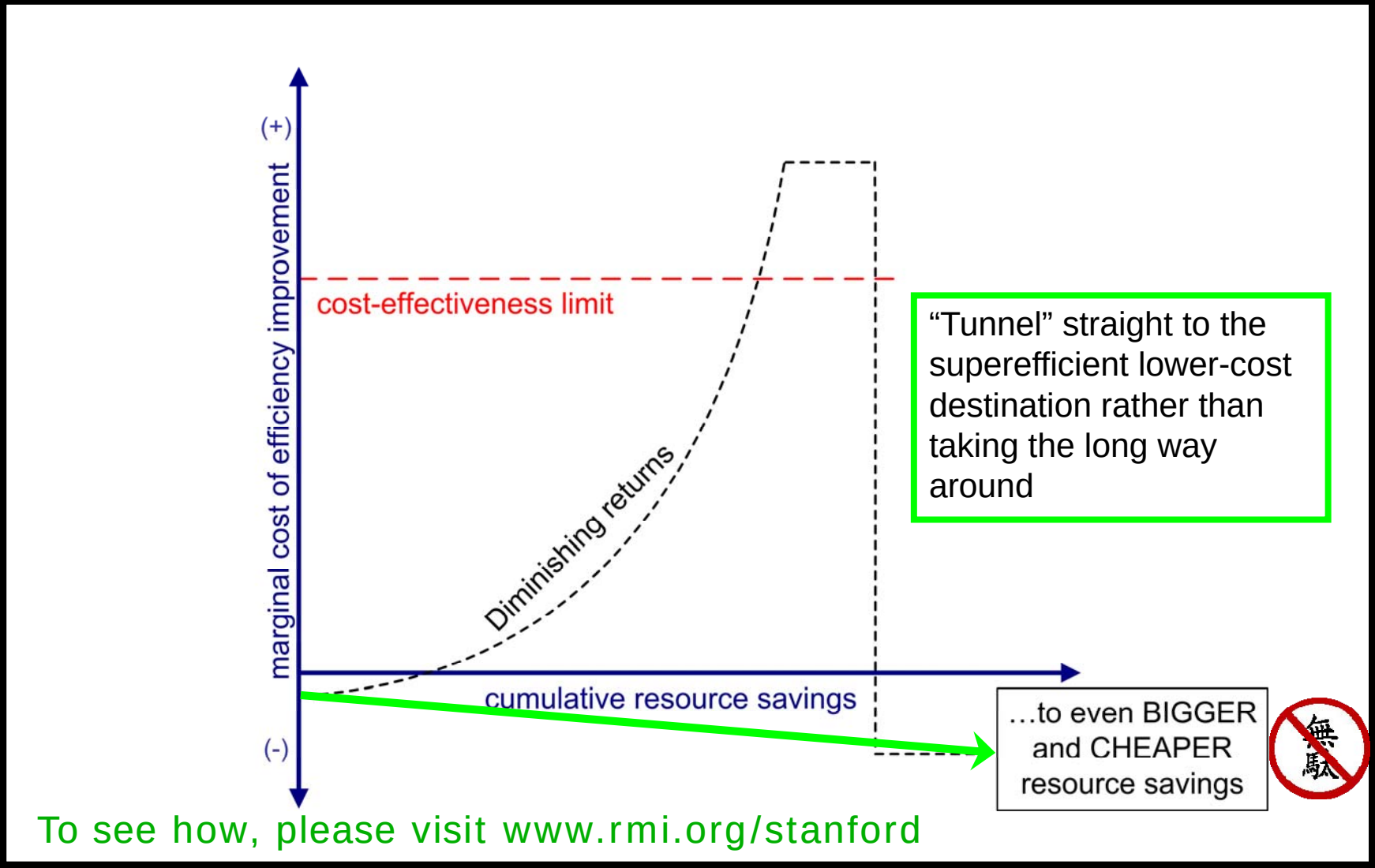
New design mentality: expanding returns, "tunneling through the cost barrier"



Two ways to tunnel through the cost barrier

1. Multiple benefits from single expenditures

- Save energy *and* capital costs...10 benefits from superwindows, 18 from efficient motors & lighting ballasts,...
- Throughout the design: *e.g.*, RMI HQ building's central arch has 12 functions but only one cost

Tunneling through the cost barrier through integrative design: Grand Forks (ND) office

Incremental costs

Windows	$67,500
Daylighting	$18,000
Insulation	$17,200
Lighting	$21,000
HVAC	-$160,000
Total	-$36,300

Energy savings: $75,000/year

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2. Piggyback on retrofits

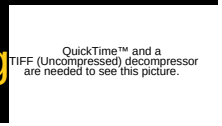
- Coordinate a whole-building retrofit to occur at the same time as big changes that are being made anyway, such as renewing the façade or the mechanical equipment of a building

Cost can be negative even for *retrofits* of big buildings

- 19,000-m^2, 20-year-old curtainwall office near Chicago (Kansai-like summer, very cold winter)
- Dark-glass 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^2_{glass} more
- Add deep daylighting, plus very efficient lights (3 W/m^2) and office equipment (2 W/m^2)
- 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

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

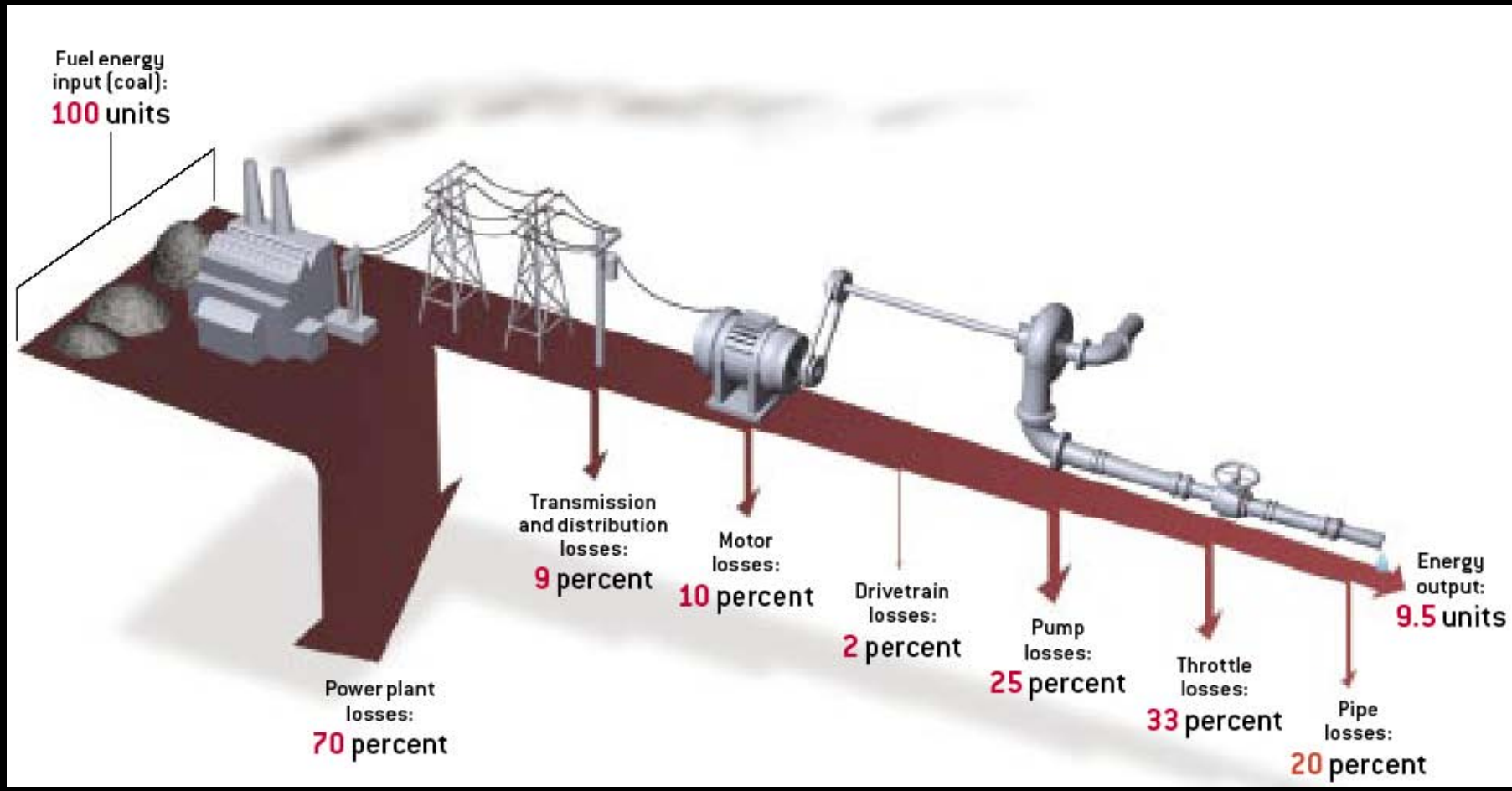
- Save half of motor-system electricity; retrofit payback typically <1 y
- Similar ROIs with 30–50+% retrofit savings of chip-fab HVAC power
- Retrofit very efficient oil refinery, save 42%, ~3-y payback
- Retrofit North Sea oil platform, save 50% el., get the rest from waste
- Retrofit USNavy *Aegis* 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



New design mentality

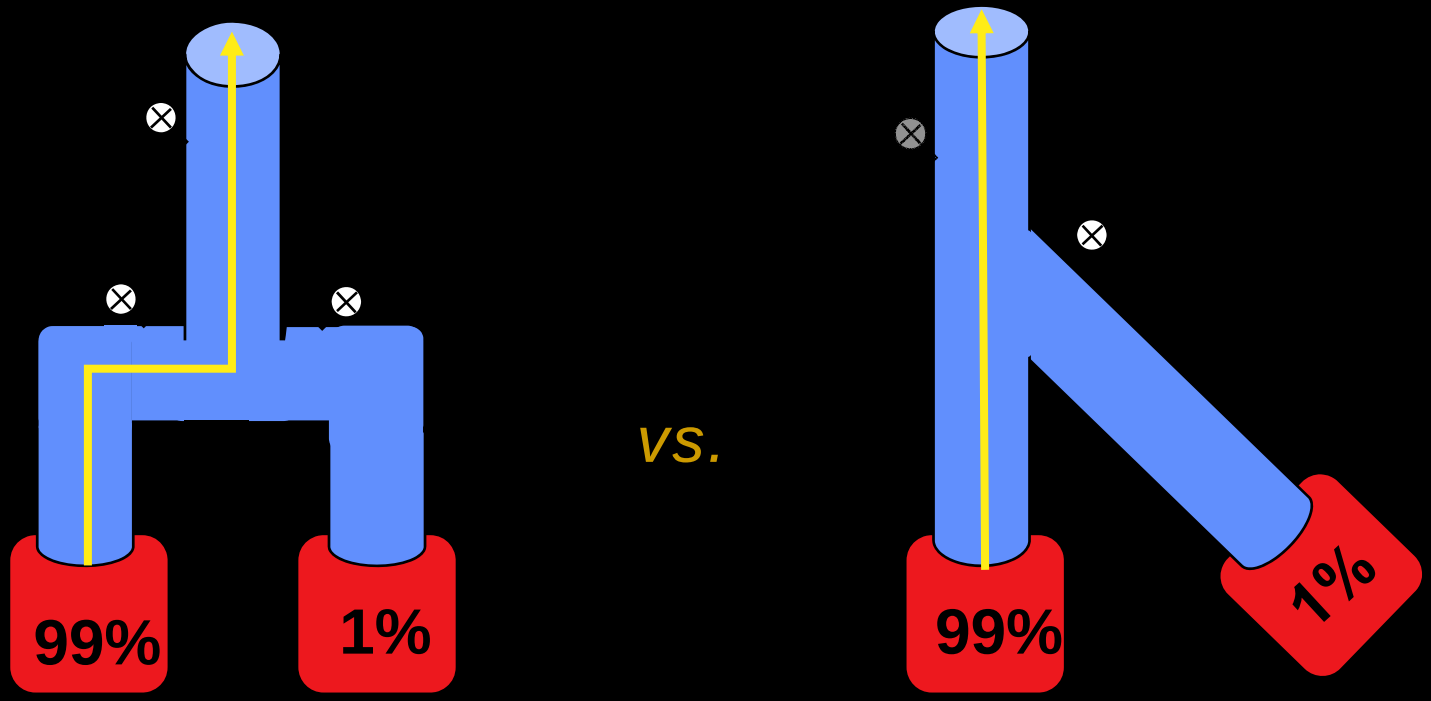
- Pumps and fans use half of motor energy; motors use 3/5 world electricity
- Redesigning a standard (supposedly optimized) industrial pumping loop cut its power from 70.8 to 5.3 kW (–92%), cost less to build, and worked better
- Just by specifying fat, short, straight pipes—not (as usual) thin, long, 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



Boolean pipe layout

hydraulic pipe layout

High-efficiency pumping / piping retrofit

(Rumsey Engineers, Oakland Museum)

Notice smooth piping design – 45^{o}s and Ys

Downsized condenser-water pumps, ~75% energy saving