The Future of Engineering:

Is your guess as good as mine?

Thoughts on Engineering Progress From

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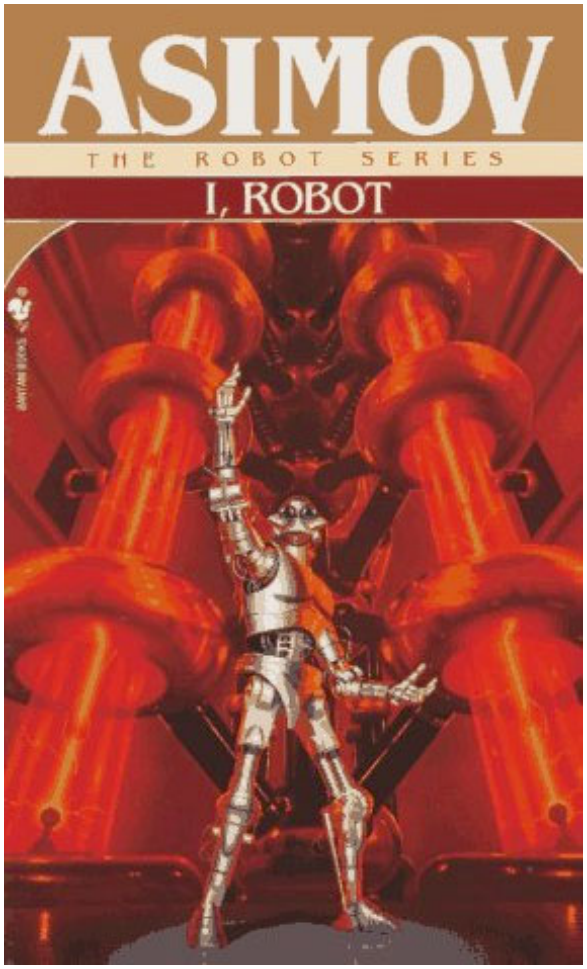
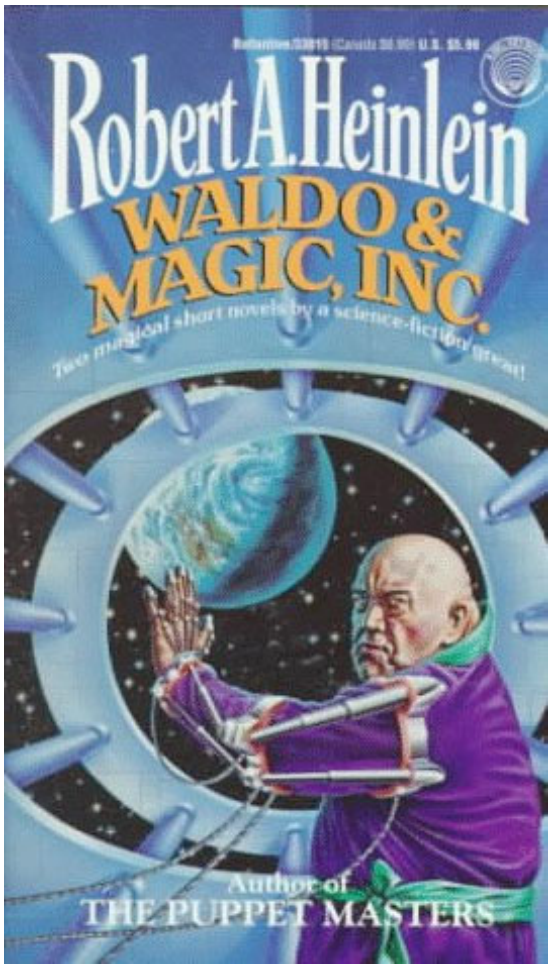
Today's Topics

- Progress in Engineering
  - Fantasies
  - Faith
  - History
  - Que sera sera — or not?
- My Story
  - Clean energy to save the world ☺

FANTASIES from the Golden Age of Science Fiction



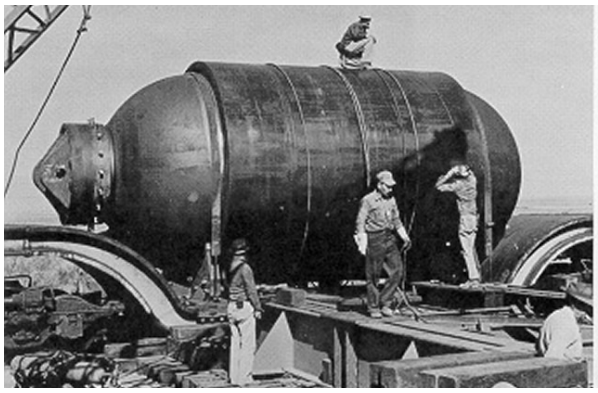


Technology of 1940s

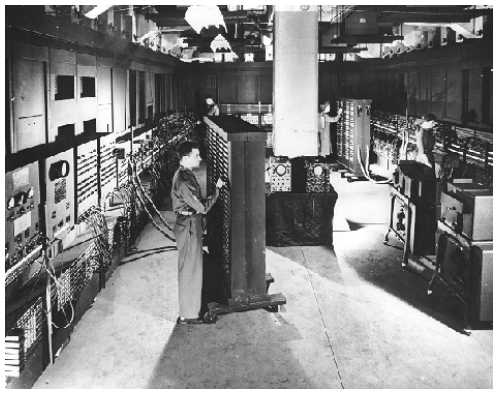
- Age of
  - Rockets (e.g. Werner Von Braun's V2)
  - Atomic bombs (Manhattan Project)
  - Large, slow computers (ENIAC)

Captured V2 Rocket

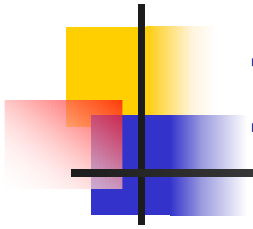
"Jumbo" (unused bomb)



ENIAC Computer



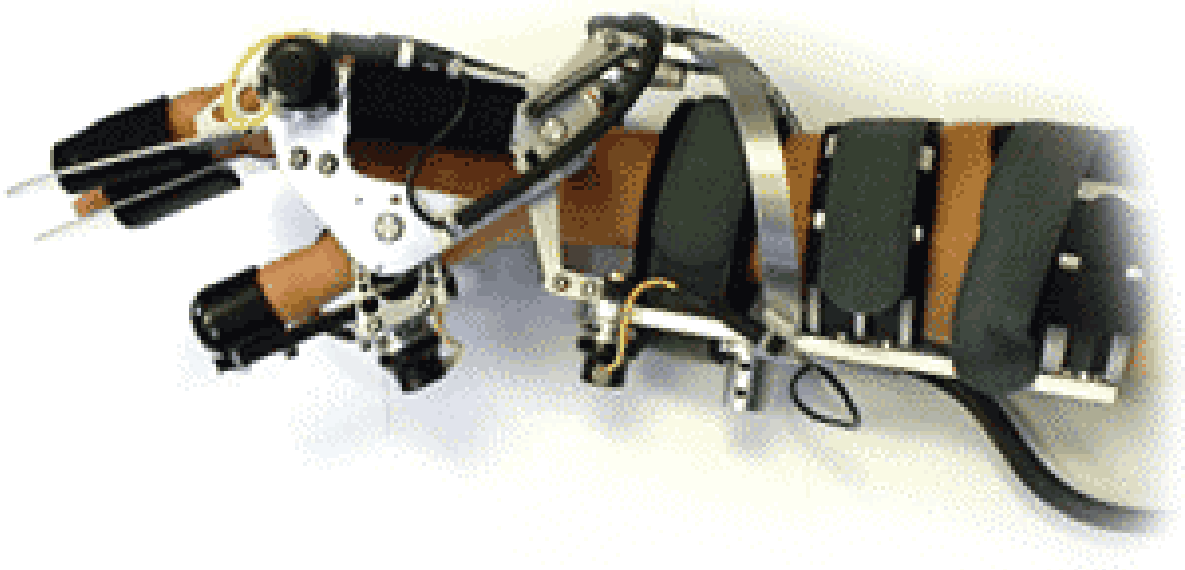
Outlook of Science Fiction, 1940-1950



- Extrapolated 1940s technology
  - Interplanetary travel
  - Portable atomic power
  - Huge computers
- Missed revolutions in electronics
  - Microcomputers
  - Lasers

What Came True: Heinlein's Waldos

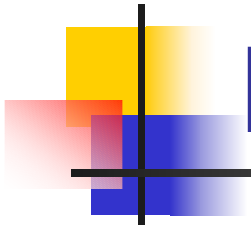
- Remote controls for tools



Still Far Off: Asimov's Intelligent Robots

- Today's industrial robots do not obey Asimov's "3 laws of robotics"

  - (1) A robot may not injure a human, or allow a human to be injured.
  - (2) A robot must follow any order given by a human that doesn't conflict with the First Law.
  - (3) A robot must protect itself unless that would conflict with the First or Second Laws.

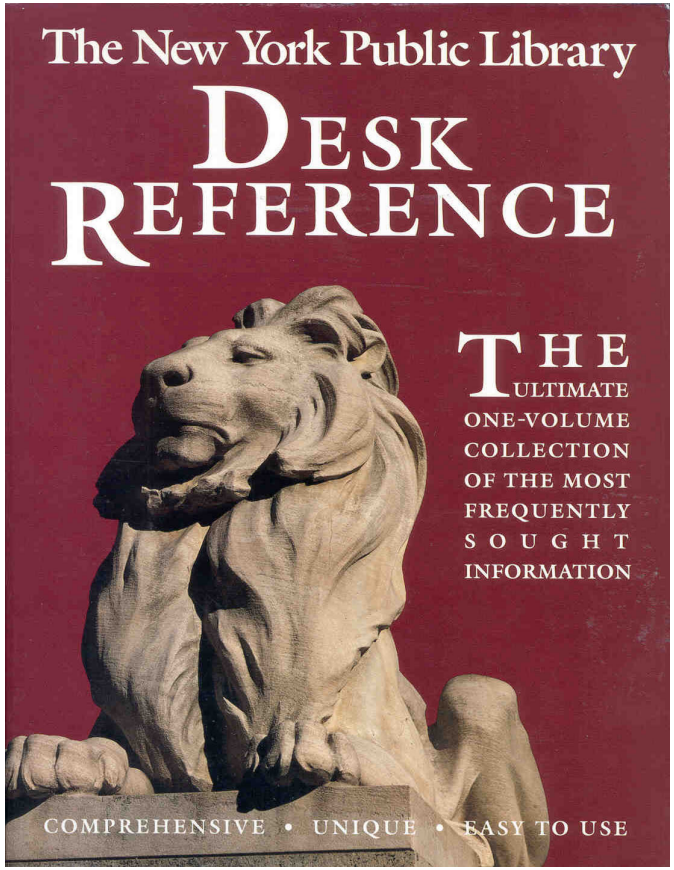


FAITH in Progress

- How little we know...
  - "Prediction is very hard, especially when it's about the future" — Yogi Berra
- Intuition shaped by
  - history (time horizon)
  - education (what we've been taught)
  - experience (what we've found out for ourselves)

HISTORY of Progress

- New York Public Library Desk Reference lists significant inventions and scientific discoveries from 12,000 B.C. to now



Significant Discoveries and Inventions of the 1940s

Science

Year	*Discovery*
1940	Plutonium
	Vitamin H (biotin)
1943	LSD
	Streptomycin
1944	Americium
	Curium
1947	Coenzyme A
	Vitamin B_{12} as cure for pernicious anemia
	Radiocarbon dating
1949	Berkelium

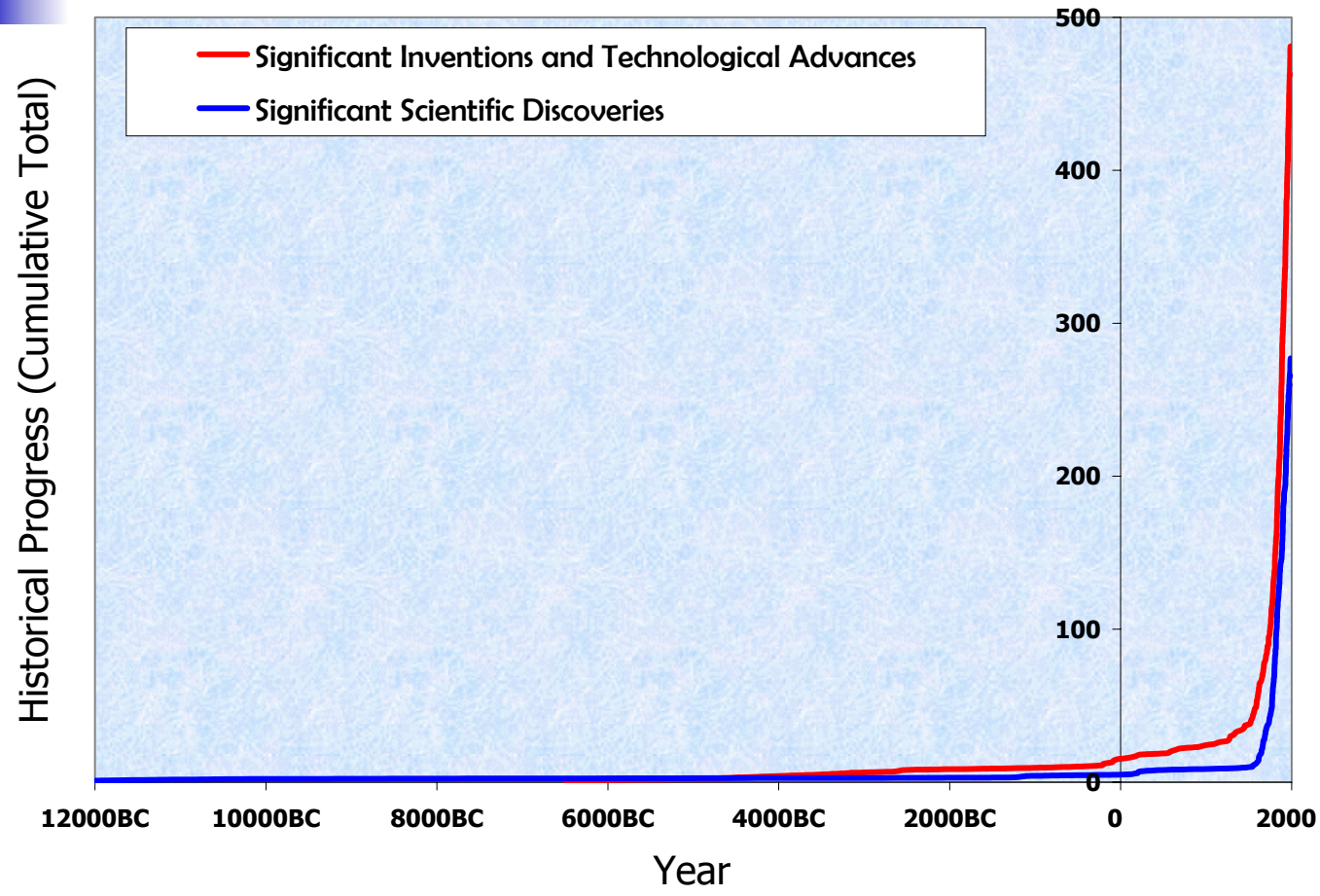
Engineering = Applied Science

Engineering

Year	*Invention or Achievement*
1940	Radar
	Automatic transmission
1941	Microwave Radar
	Darcon
1942	Manmade atomic reaction (Manhattan Project)
1943	Teflon
1944	Pyrex telescope lens
1945	Artificial kidney
	Atomic bomb
	Tupperware
	Vinyl floor covering
1946	Electronic vacuum tube computer (ENIAC)
1947	Holography
	Supersonic aircraft
1948	Transistor
	Atomic clock
	Cybernetics
	Long-playing phonograph record (microgroove record)
	Solid electric guitar
	Velcro
1949	Jet airliner

data: New York Public Library Desk Reference (1989)

Advances Since 12,000 B.C.



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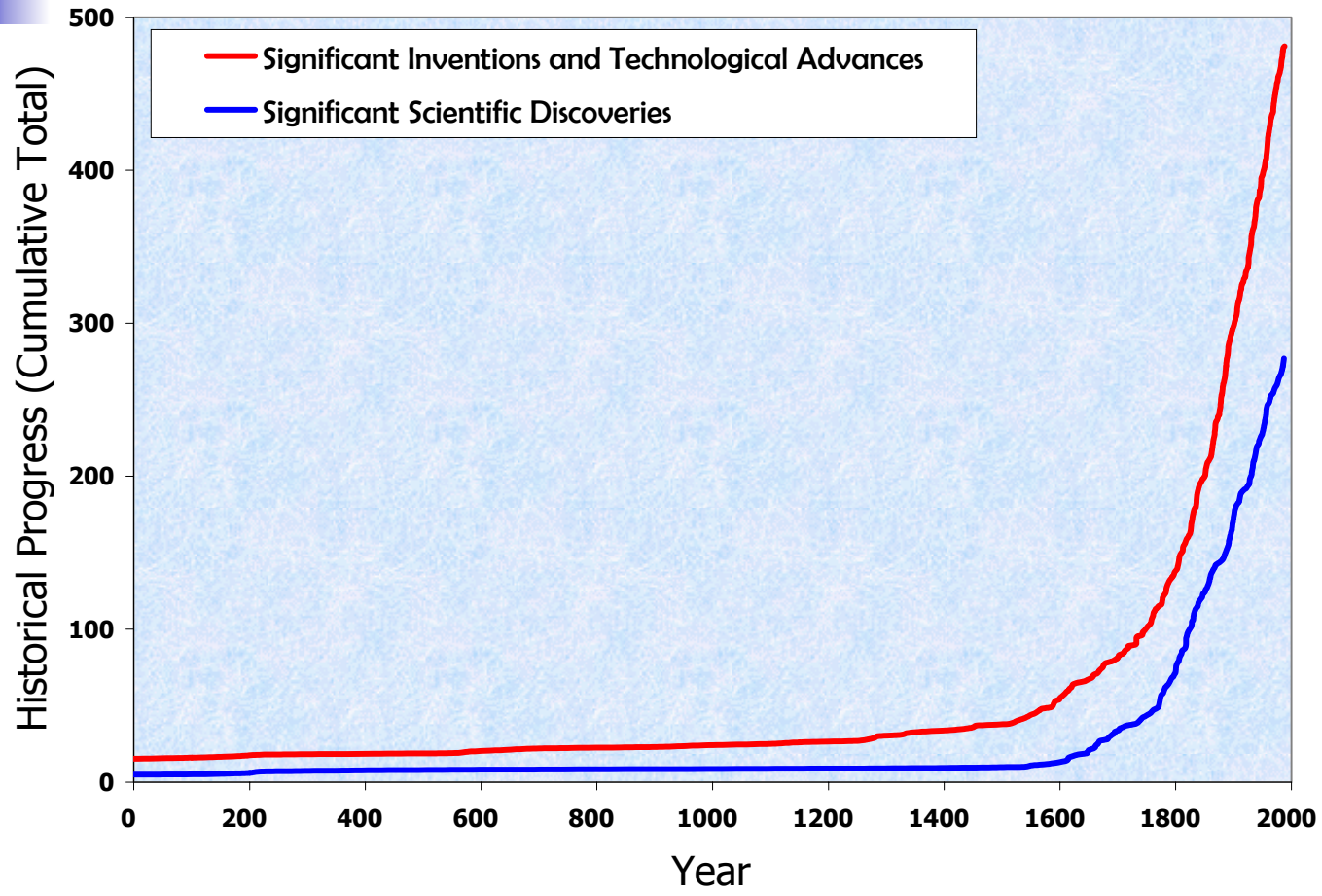
Advances Since 0 A.D.



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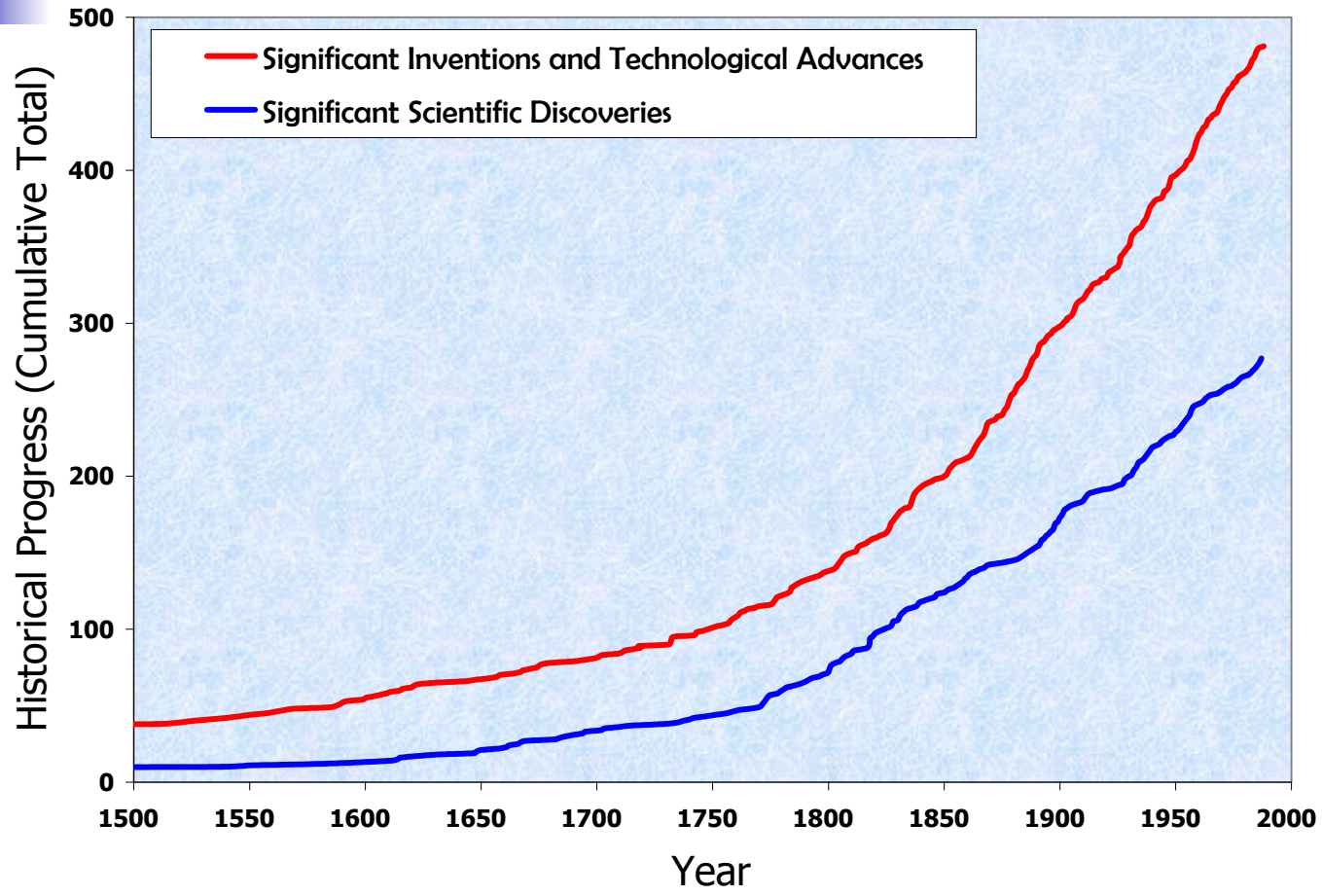
Advances Since 1500 A.D.



data: New York Public Library Desk Reference (1989)

Stories of the Inventors and Inventions

- Recommended: American Heritage of Invention & Technology

http://AmericanHeritage.com/it

QUE SERA SERA?
Or Not?

- What will the future bring?
  - Ask the experts, or
  - Make an educated guess
- For example, consider...

Question: Are Solar-Powered Cars Practical?

- Approach: compare energy in sunlight to energy needed to propel car

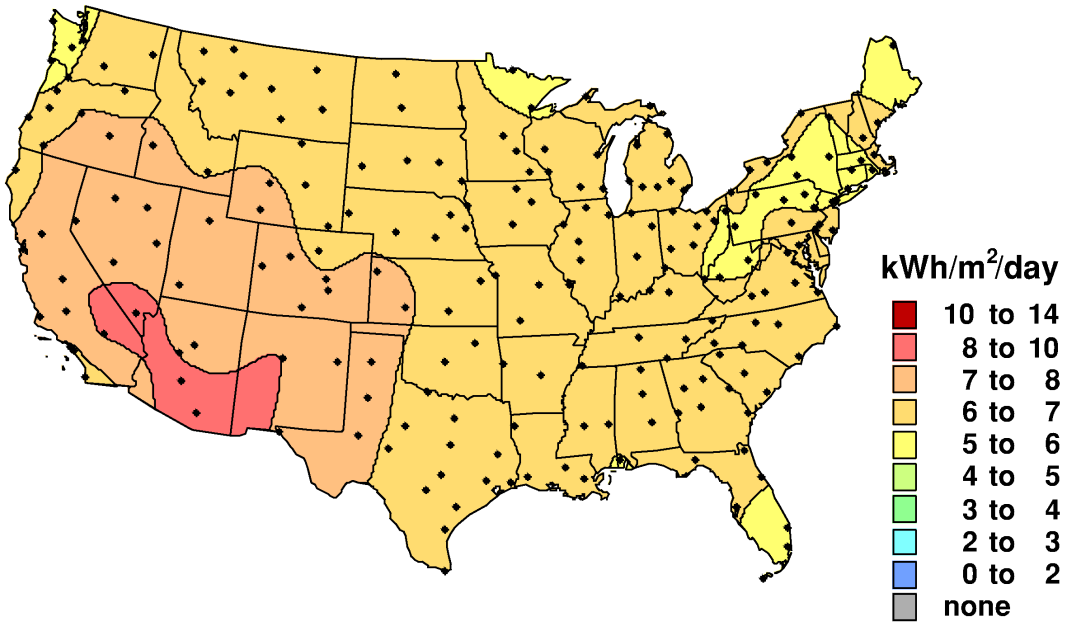
Formula Sun Solar Race Car

?

Honda Civic Sedan

Solar Energy

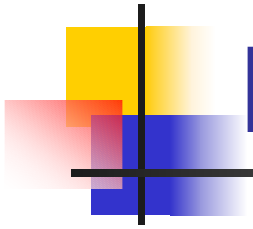
- On a typical June day in California, daily solar energy intensity is 8 kWh/m^2
- 1 kWh = 100-watt light bulb x 10 hours



Engine Energy

- Engine power measured in horsepower (HP), where 1 HP = 0.75 kW
- Typical compact car has 100 HP engine
- 1 kWh = 80 HP engine x 1 min

How Long Can an 80-HP Car Engine Run on Solar Energy?



- With 1 m^2 of solar cells on car
  - 100% efficiency $\rightarrow$ 8 min/day
  - 25% efficiency $\rightarrow$ 2 min/day
- With 100 m^2 of solar cells on building
  - 100% efficiency $\rightarrow$ 800 min/day
  - 25% efficiency $\rightarrow$ 200 min/day

Answer

- Solar cars require charging station

An EV1 charging under a Solar Charging array - Santa Monica Civic Center, Santa Monica, CA

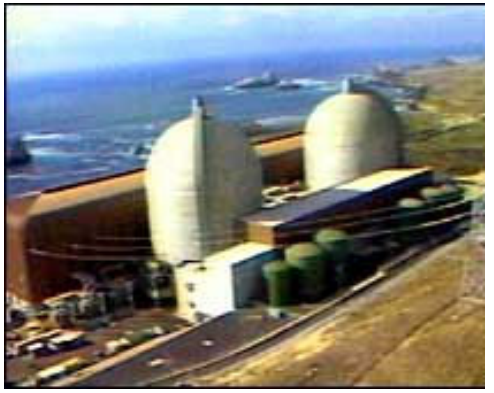
Role of Energy In Human Progress

- Abundant energy fundamental to meeting our physical needs
  - Short-term (< 500 yr): fossil fuels
  - Long-term: renewables, nuclear

oil

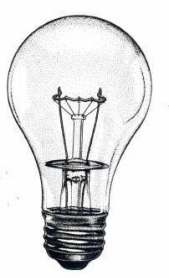
solar

nuclear



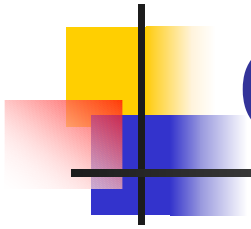
Energy Budget: Match Supply, Demand

- Meet long-term energy needs via
  - increasing production (renewables, nuclear)
  - decreasing demand (energy efficiency)
- Example: replacing 100-W incandescent light bulb with 25-W compact fluorescent light bulb saves
  - ~ 2 kWh of electrical energy per day
  - ~ 6 kWh of fossil fuel energy per day (generators are only about 1/3 efficient)



MY STORY: Clean Energy And Energy Conservation

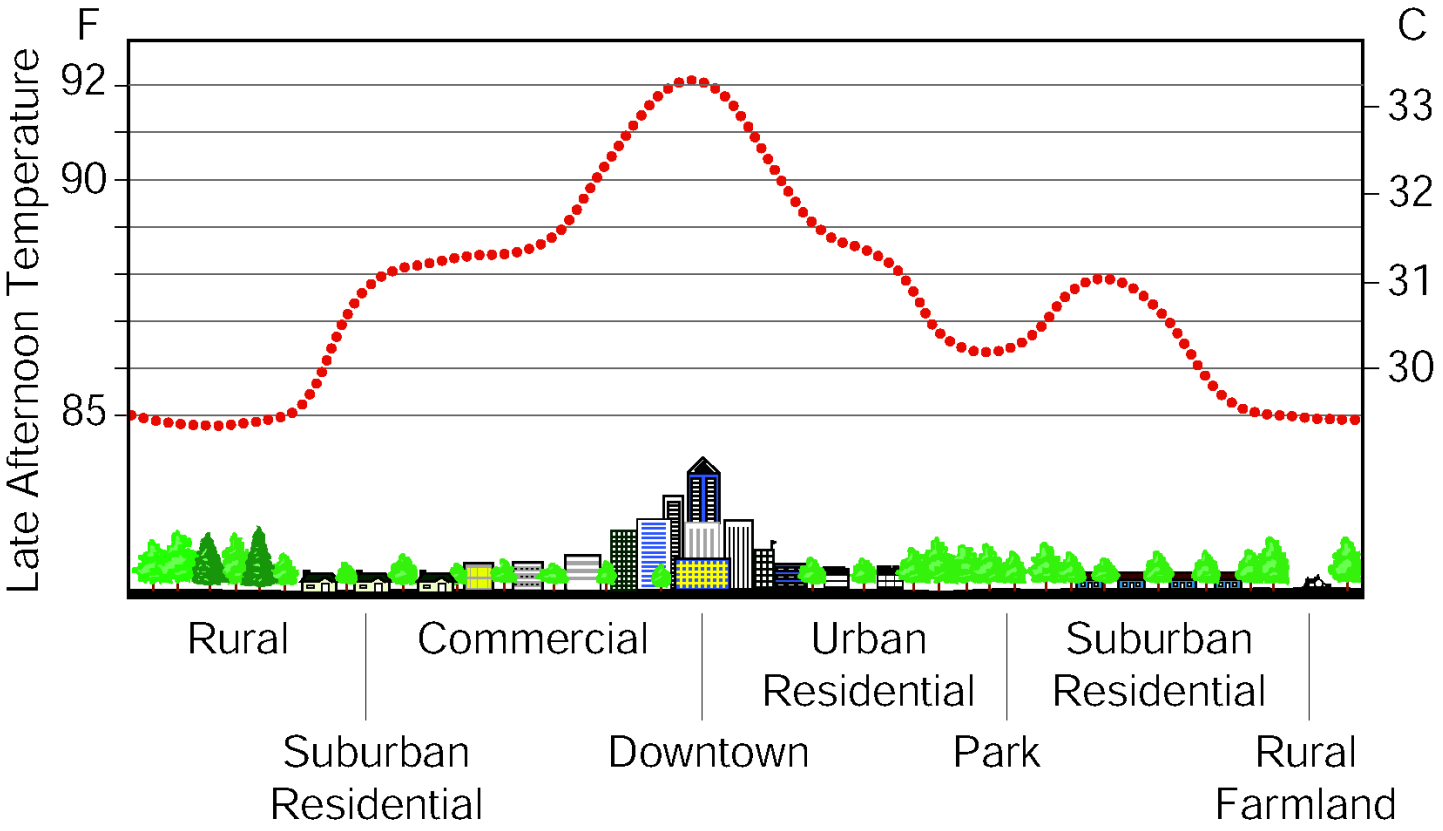
- Education
  - B.S. engineering physics (Cornell)
  - M.S., Ph.D. mechanical engineering (Cal)
- Mission
  - Improve the world through energy conservation ("negawatts"), clean energy production



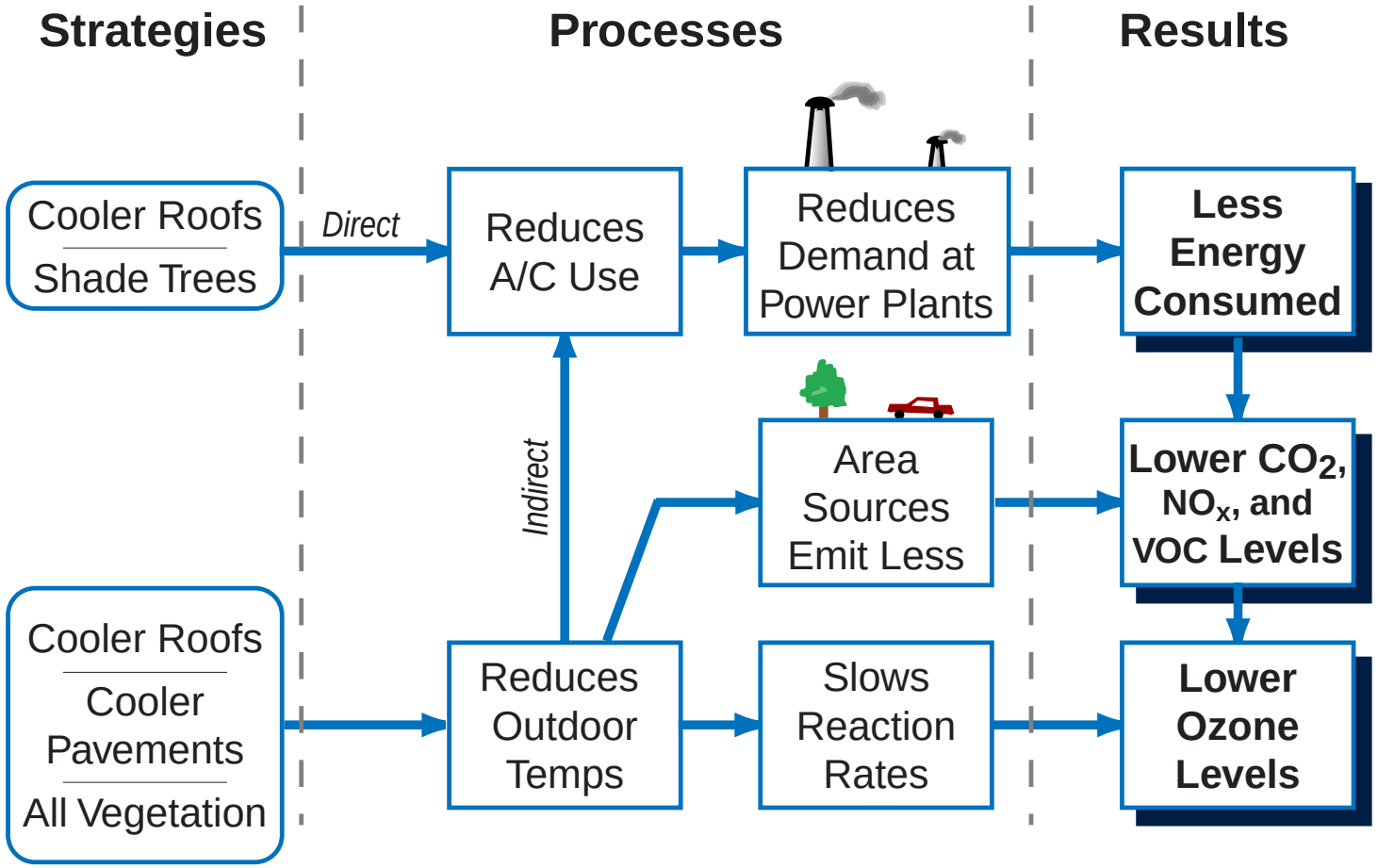
Current Research

- Scientist @ Lawrence Berkeley Laboratory
- Member of Heat Island Group
- Our goal: cool cities in summer
  - Reduce air-conditioning use (save power and energy)
  - Lower ambient air temperatures (cool the outdoors)
  - Improve air quality (reduce smog)

Hot City in the Summer



How To Cool Cities



Sample Project: Cool Colored Roofs

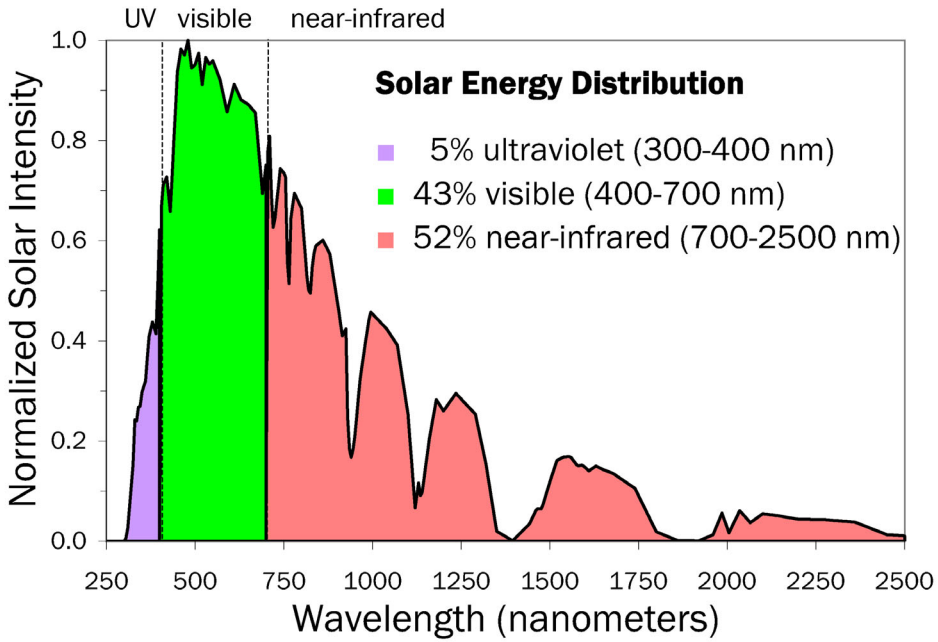
- Cool roofs (e.g., white roofs)
  - reduce air conditioning use
  - improve air quality
- But white roofs unpopular for houses

dark roof — typical

white roof — rare

What You Can't See...

- More than half of the energy in sunlight is invisible near-infrared (NIR) radiation
- NIR-reflecting dark colors can be cool



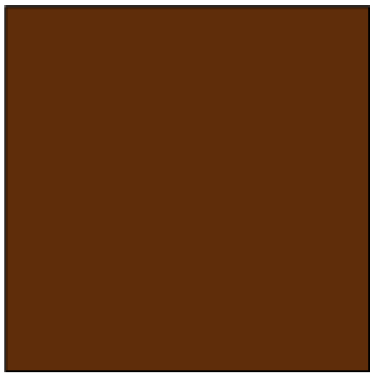
Cool Dark Metal Roofing

- "Cool" brown vs. standard brown
  - 3 times more reflective (0.27 vs. 0.08)
  - looks the same but 9°C (16°F) cooler

brown metal panel

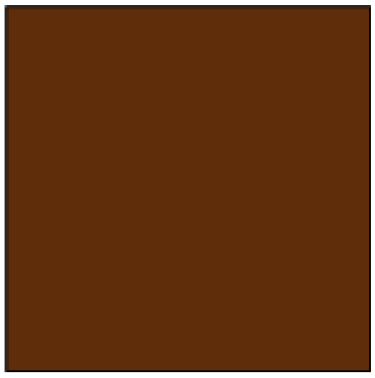
COURTESY BASF CORPORATION

cool

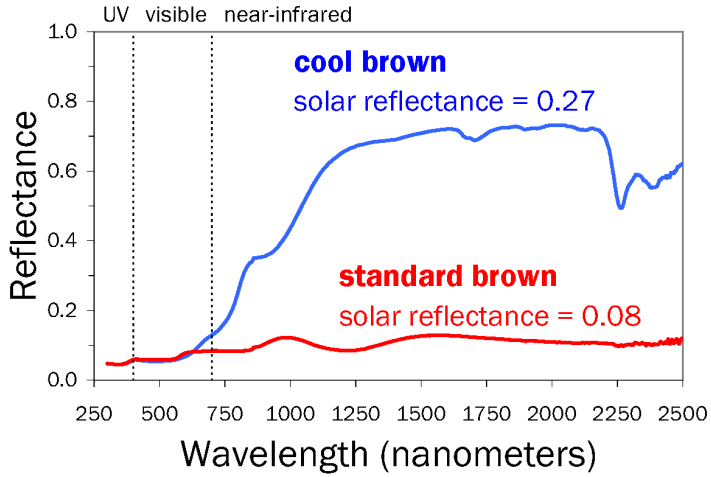


solar reflectance = 0.27
thermal emittance = 0.85
roof temp – air temp = 36°C (65°F)

standard



solar reflectance = 0.08
thermal emittance = 0.85
roof temp – air temp = 45°C (81°F)



Final Thoughts

- Your guesses about the future of engineering are as good as mine — if you do the math.
- Wise progress in science and engineering can make the world a better place.