PLANNING FOR A FUTURE WITHOUT OIL

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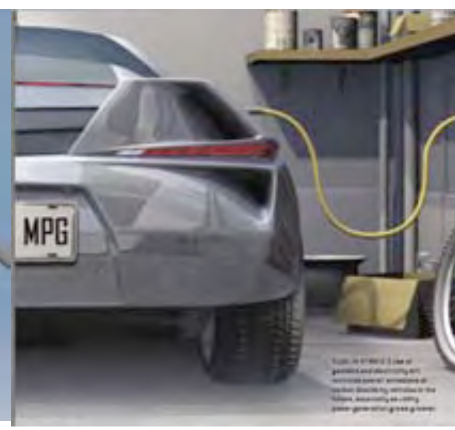
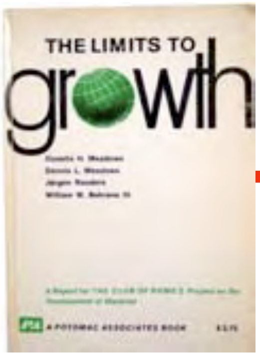
Stanford University

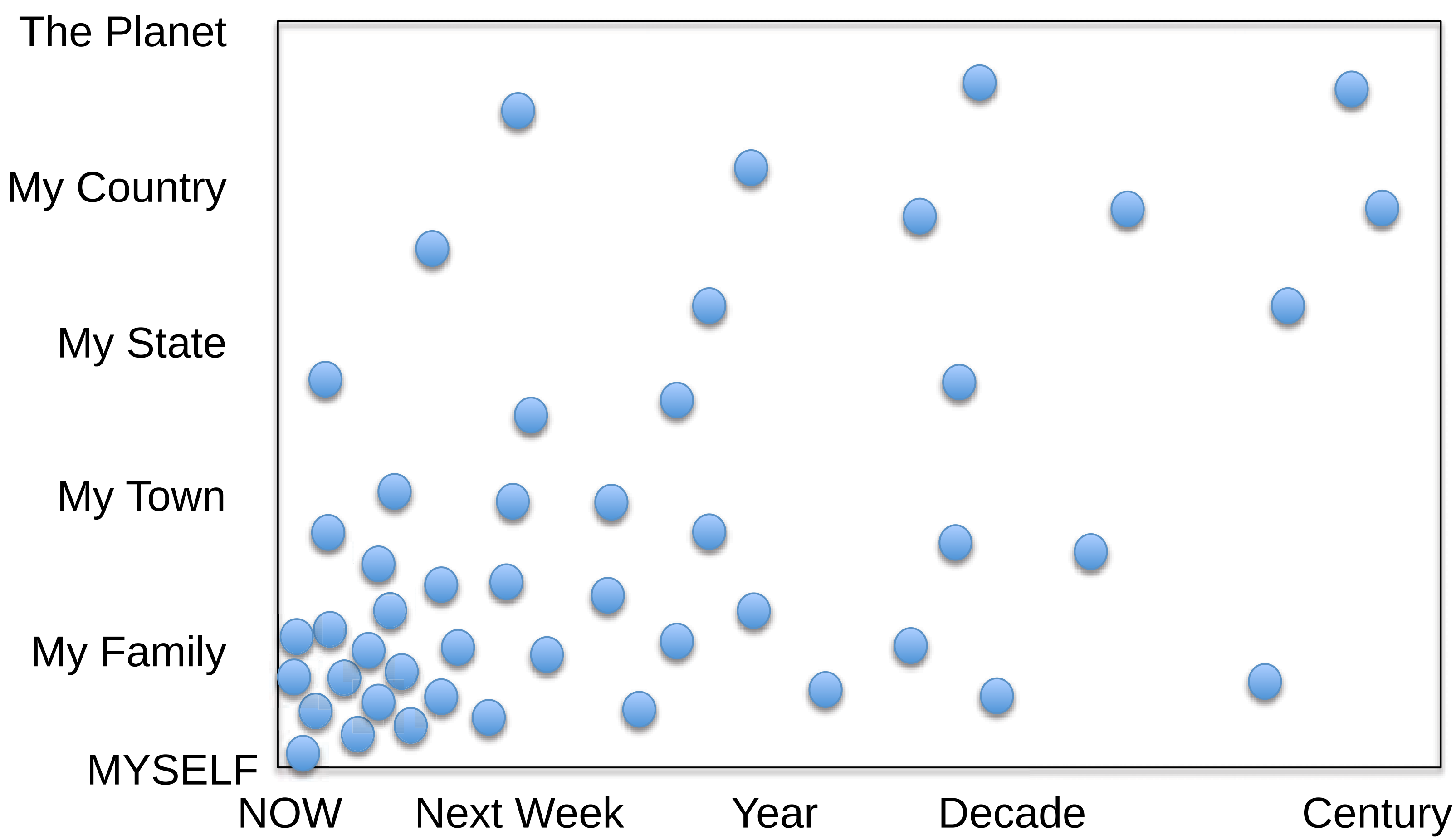
26th Pacific Islands Environment Conference
Climate of Change: Energizing a Sustainable Future for Pacific Islands

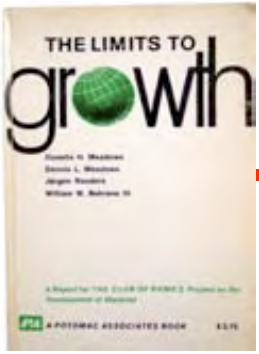
Saipan
June 23, 2009



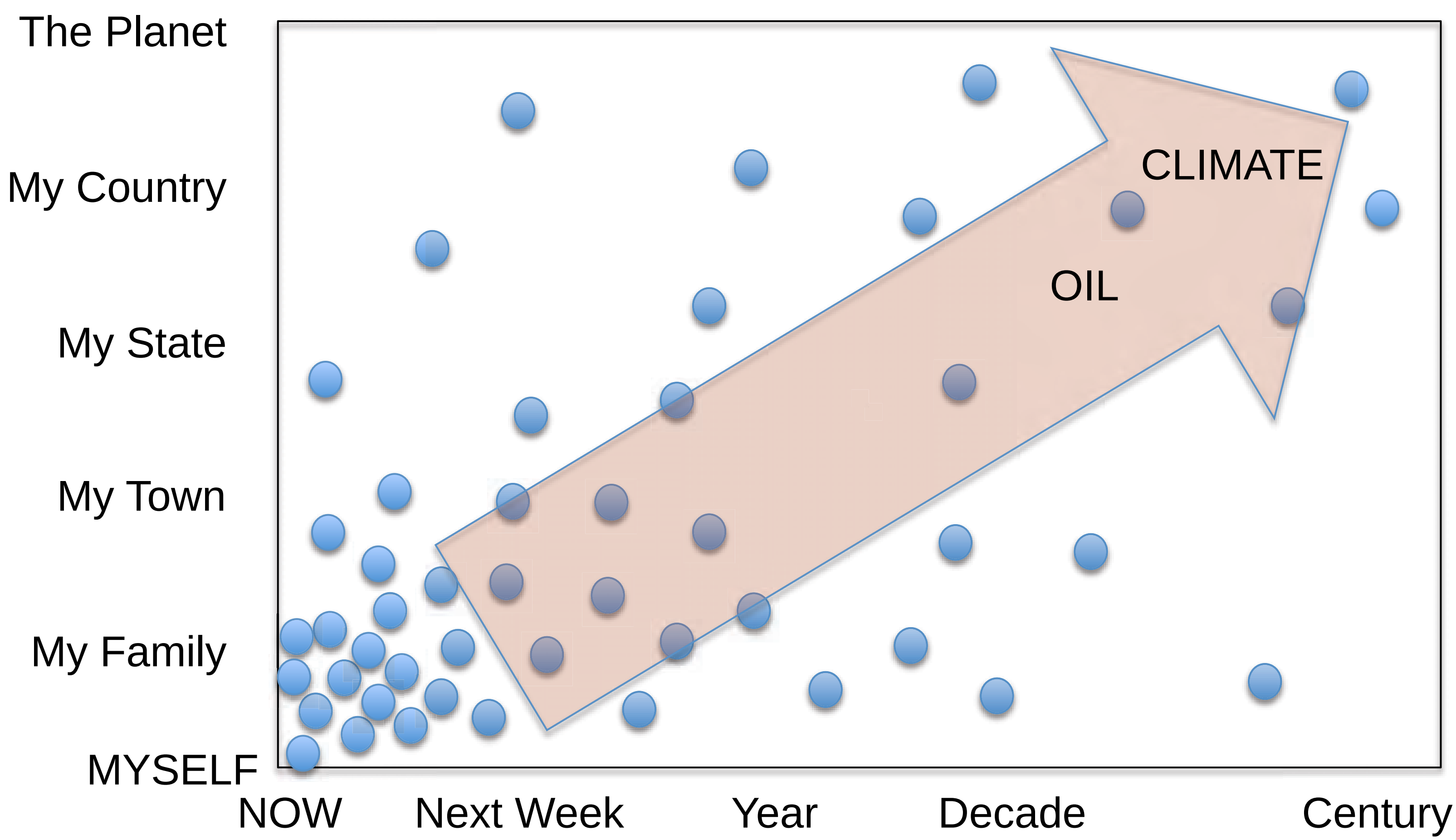
TIME SPENT THINKING ABOUT …



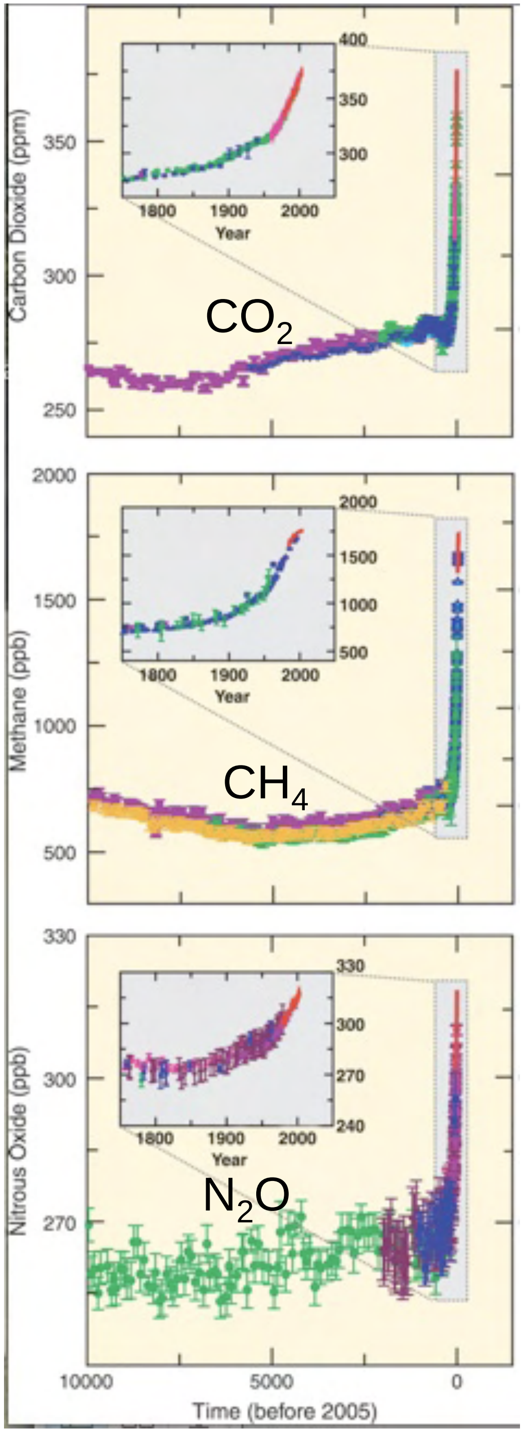


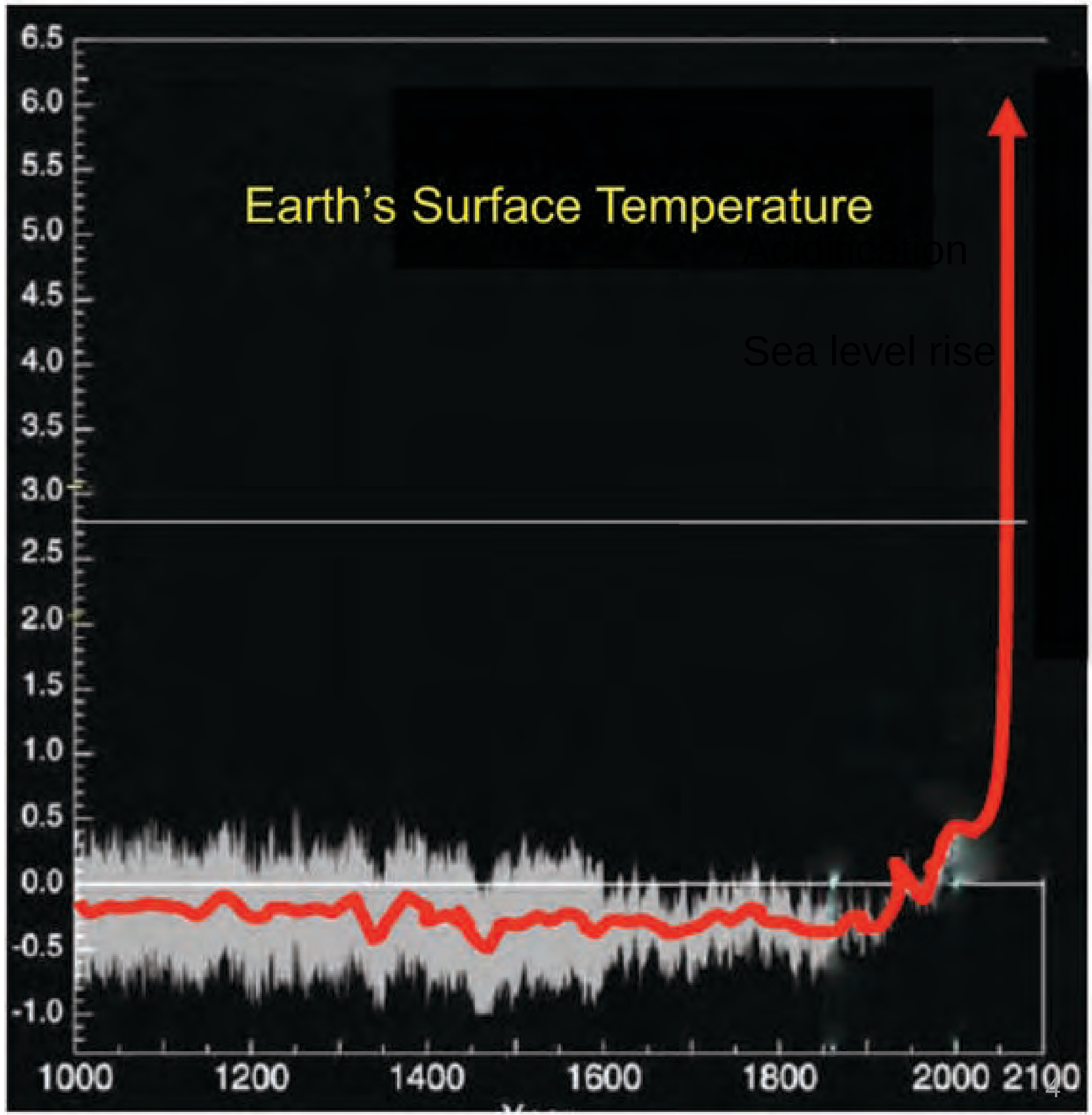
TIME SPENT THINKING ABOUT …

Climate of Change:
Energizing a Sustainable Future for Pacific Islands



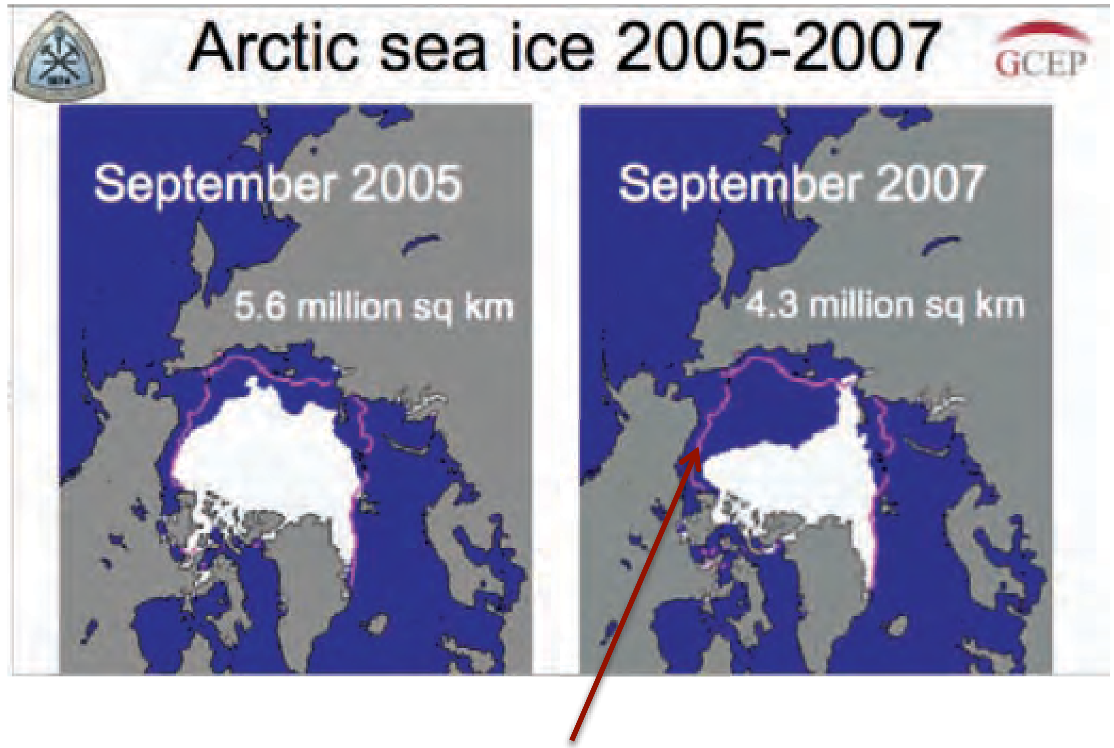
Stabilizing Climate: A critical challenge





"TIPPING POINT" and POSITIVE FEEDBACK:

Warming → Less Ice → Darker surface → More solar absorption → More warming



Summer 1979 boundary

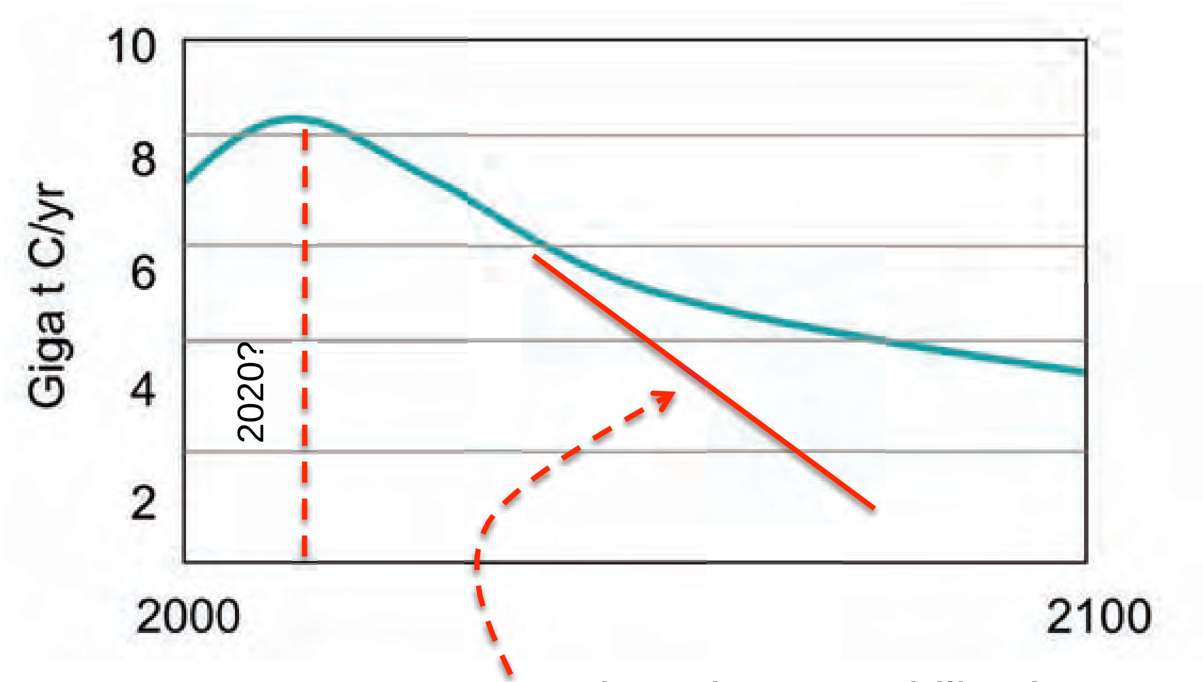
GLOBAL WARMING..
Are we already seeing the effects?

- Reduced Arctic ice cover
- Glacial melting
- Sea level rise
- Ocean acidification
- Wildfires
- Extreme weather events
  - Droughts
  - Floods
  - Tornadoes

Preventing *"Dangerous Anthropogenic Interference"* to climate

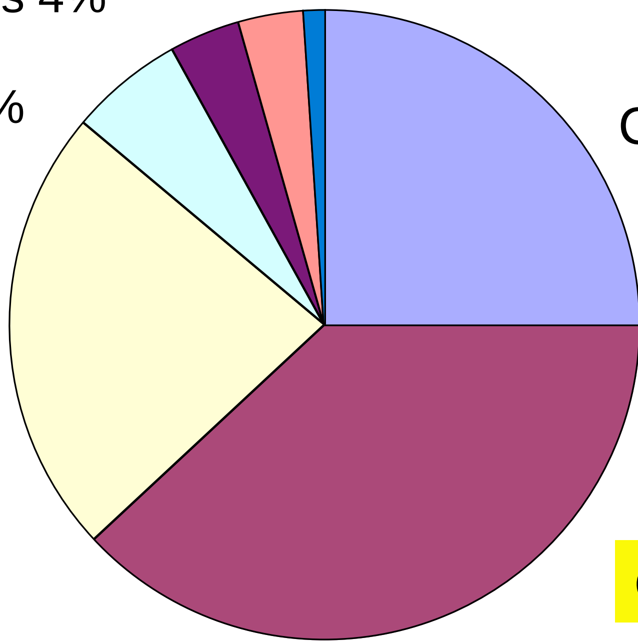
A commonly used estimate of climate goal…

To control warming to 2°C would require CO_2 to be stabilized at around 450 ppm CO_2 (it is now about 384 ppm)*.



*Hansen (2008) puts stabilization at 350 ppm

TWO FUNDAMENTAL PROBLEMS….. OIL AND CARBON



2006

GLOBAL ENERGY SUPPLY

Global Warming

There's "plenty" of coal..

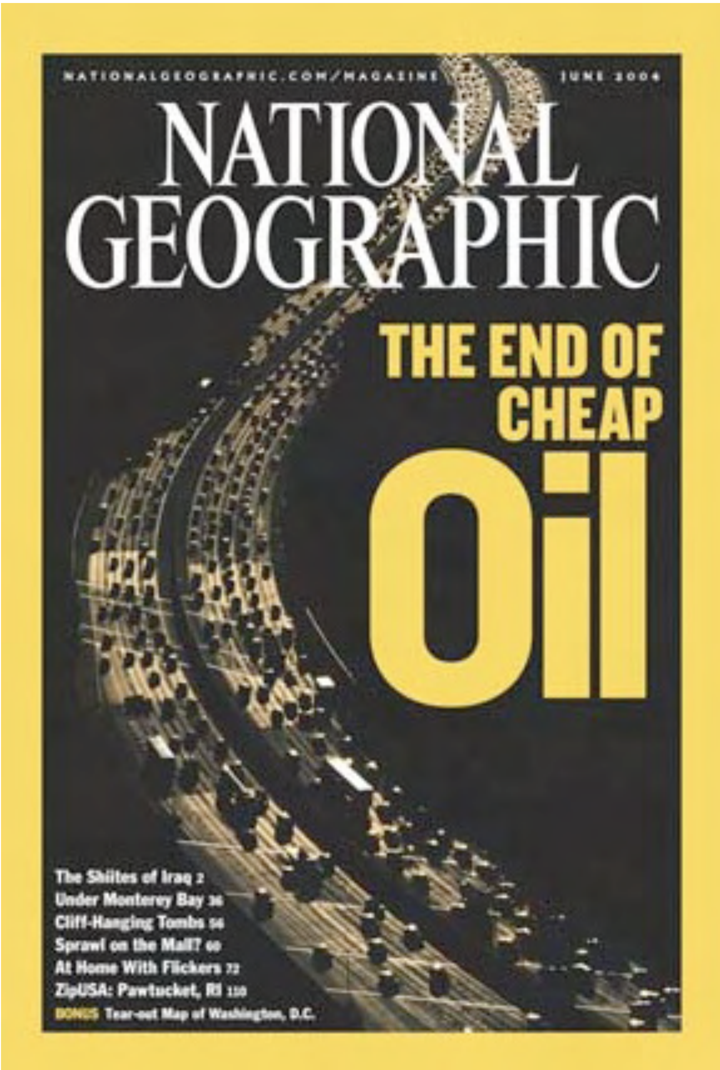
Can we control emissions?

Energy Security

Is there enough oil?

Can supply keep up with demand?

"PLANNING FOR A FUTURE WITHOUT [Cheap] OIL"



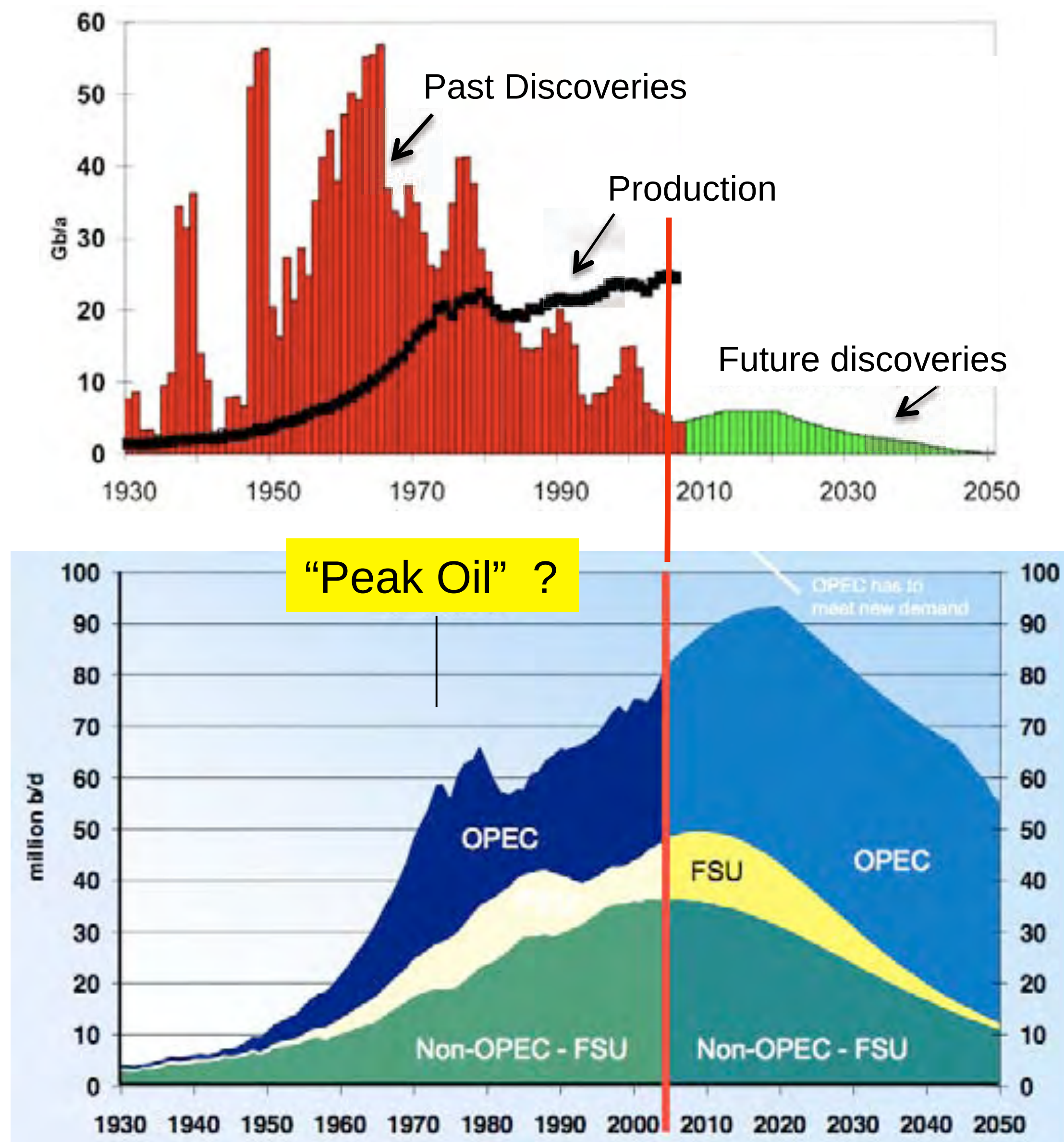
""The stone age came to an end ..not for a lack of stones…"

-- Sheik Yamani, former Saudi Oil Minister

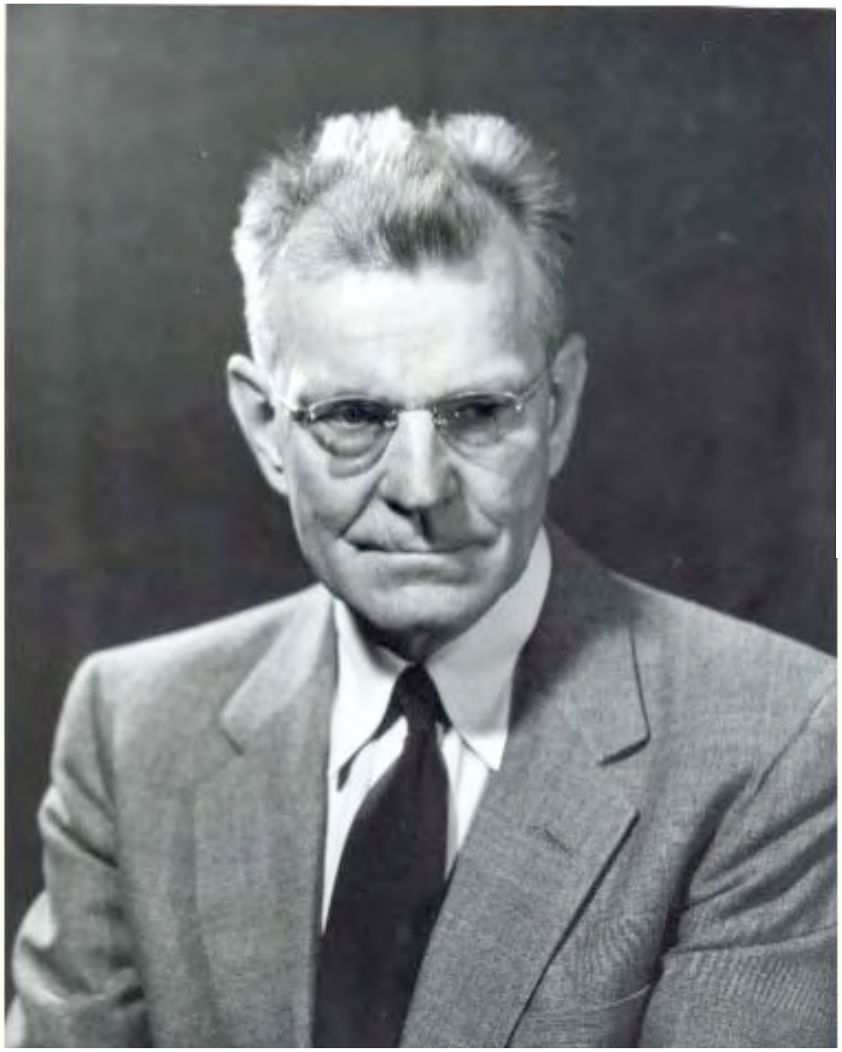
OIL discoveries aren't keeping up with increasing production…

Discoveries

Production



Oil prices may be stable as long as OPEC has competition.. Another 15 yrs… then what?



M. King Hubbert

“Nuclear Energy and the Fossil Fuels”
American Petroleum Institute, March, 1956

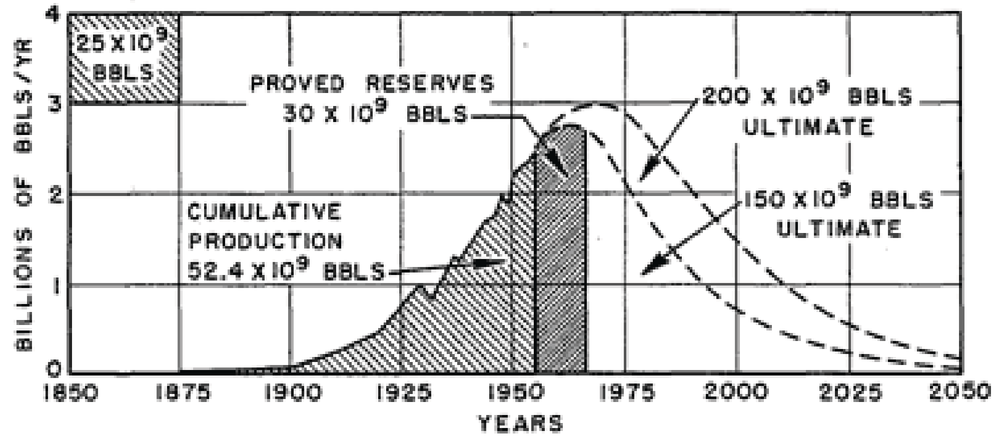


Figure 21 – Ultimate United States crude-oil production based on assumed initial reserves of 150 and 200 billion barrels.

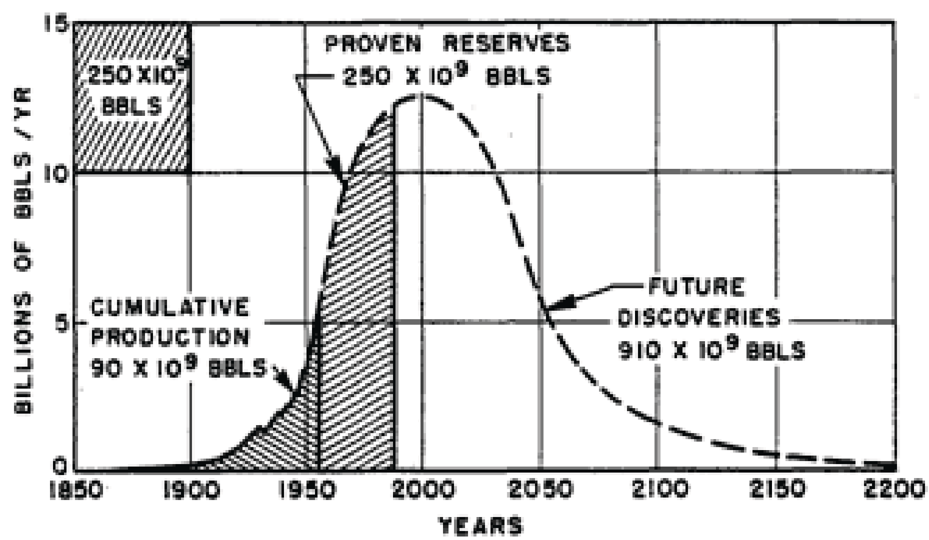
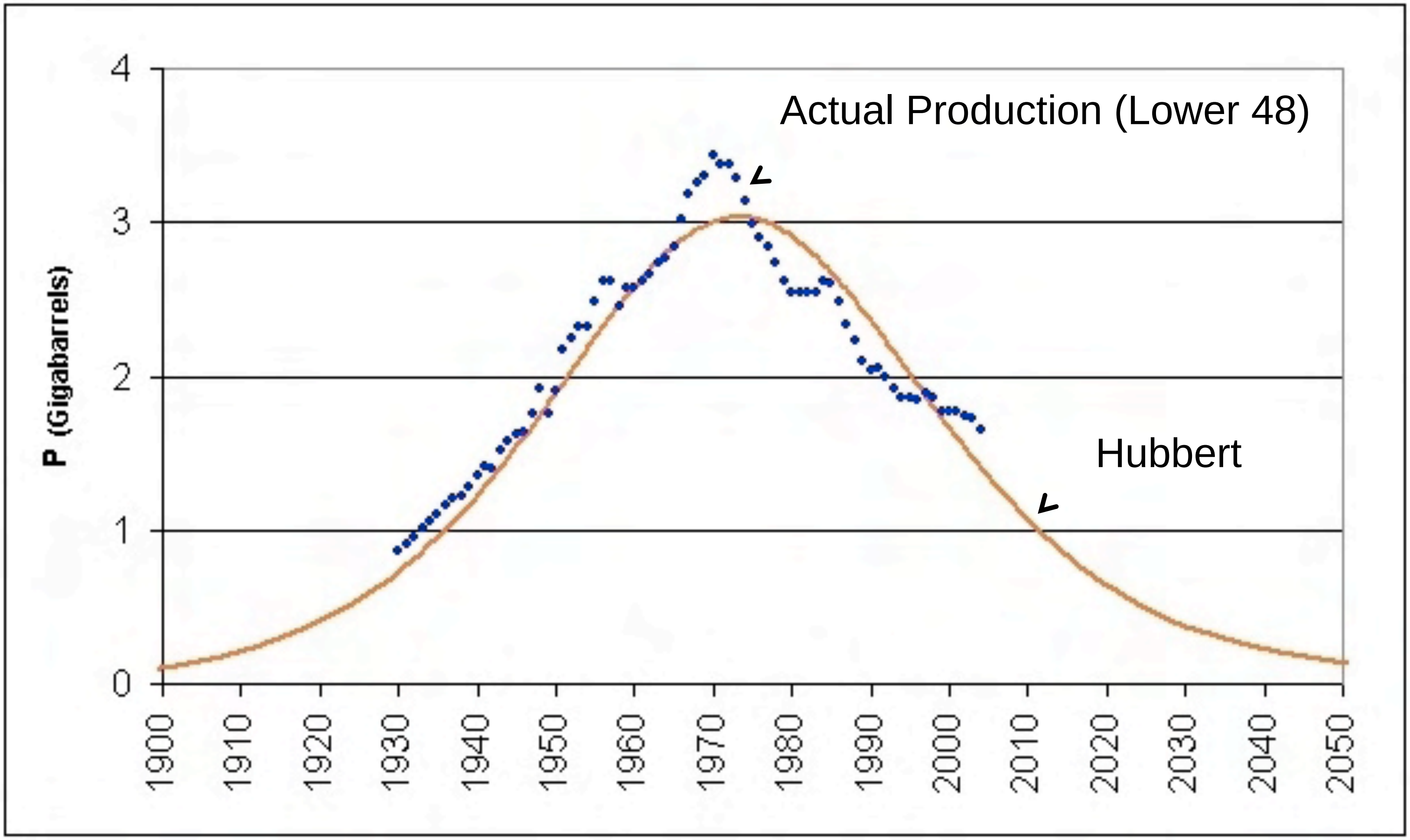
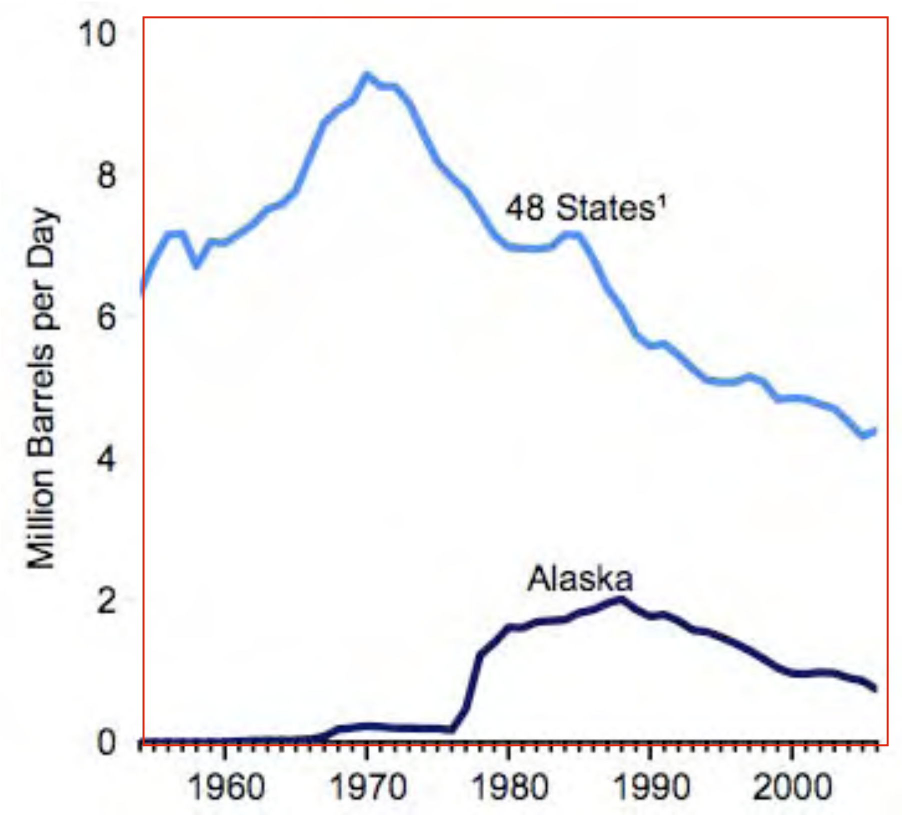


Figure 20 – Ultimate world crude-oil production based upon initial reserves of 1250 billion barrels.

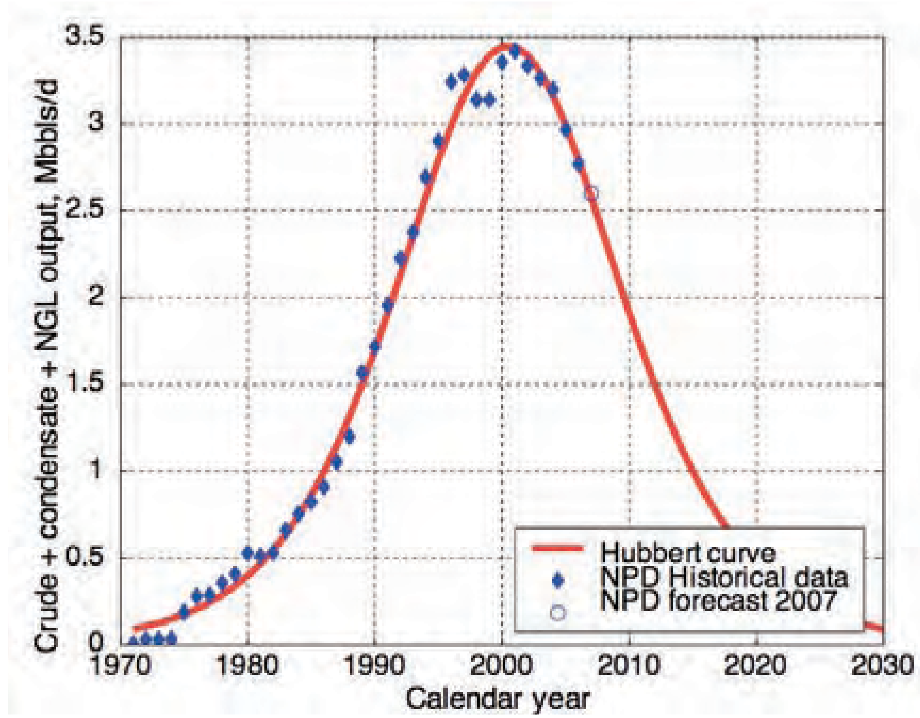
Hubbert Nailed It



EXAMPLES OF OIL PRODUCTION PEAKING

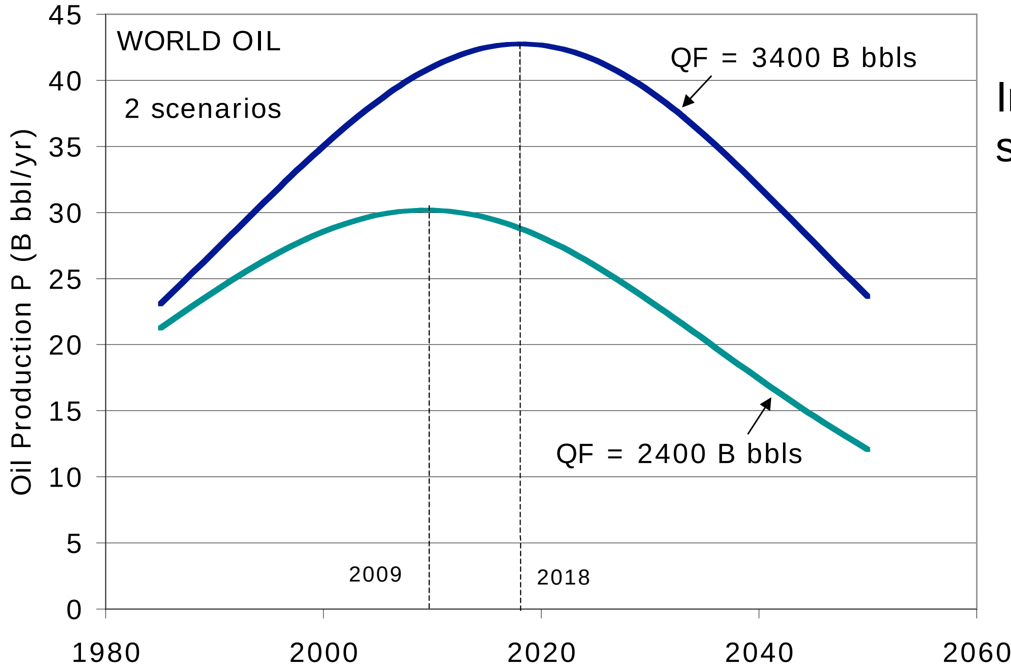


USA



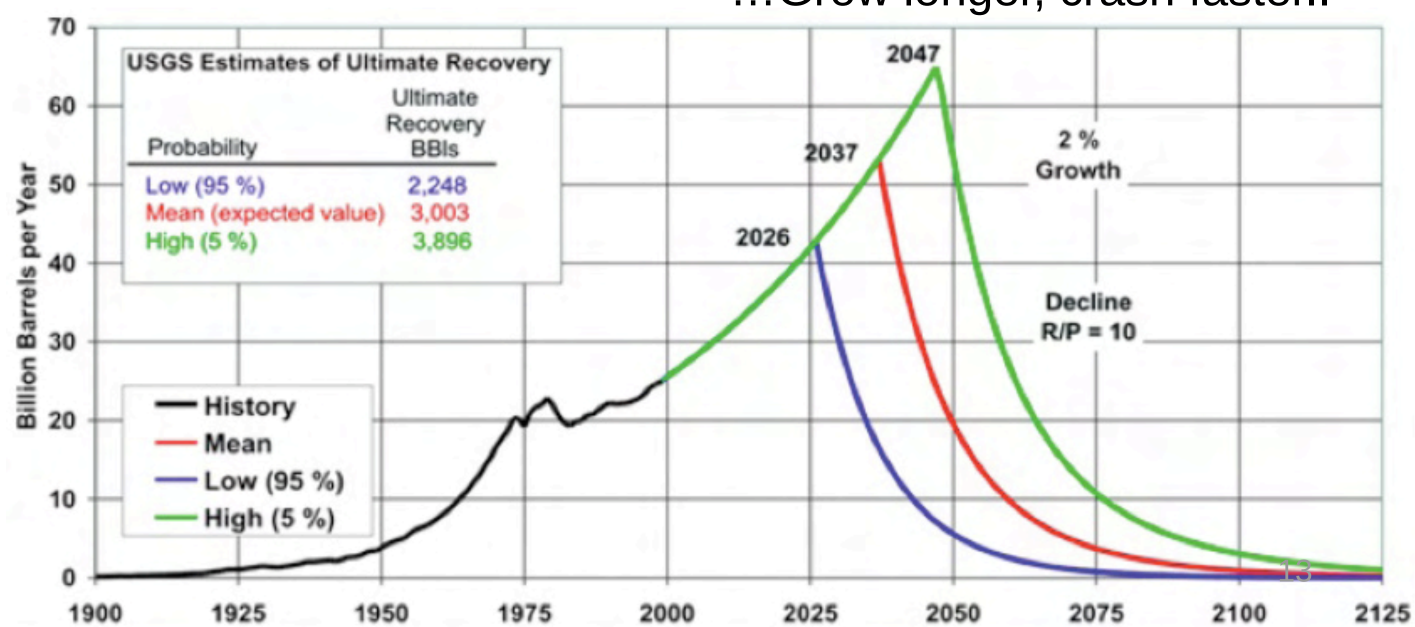
Norway

AREA UNDER THE CURVE IS TOTAL RESOURCE

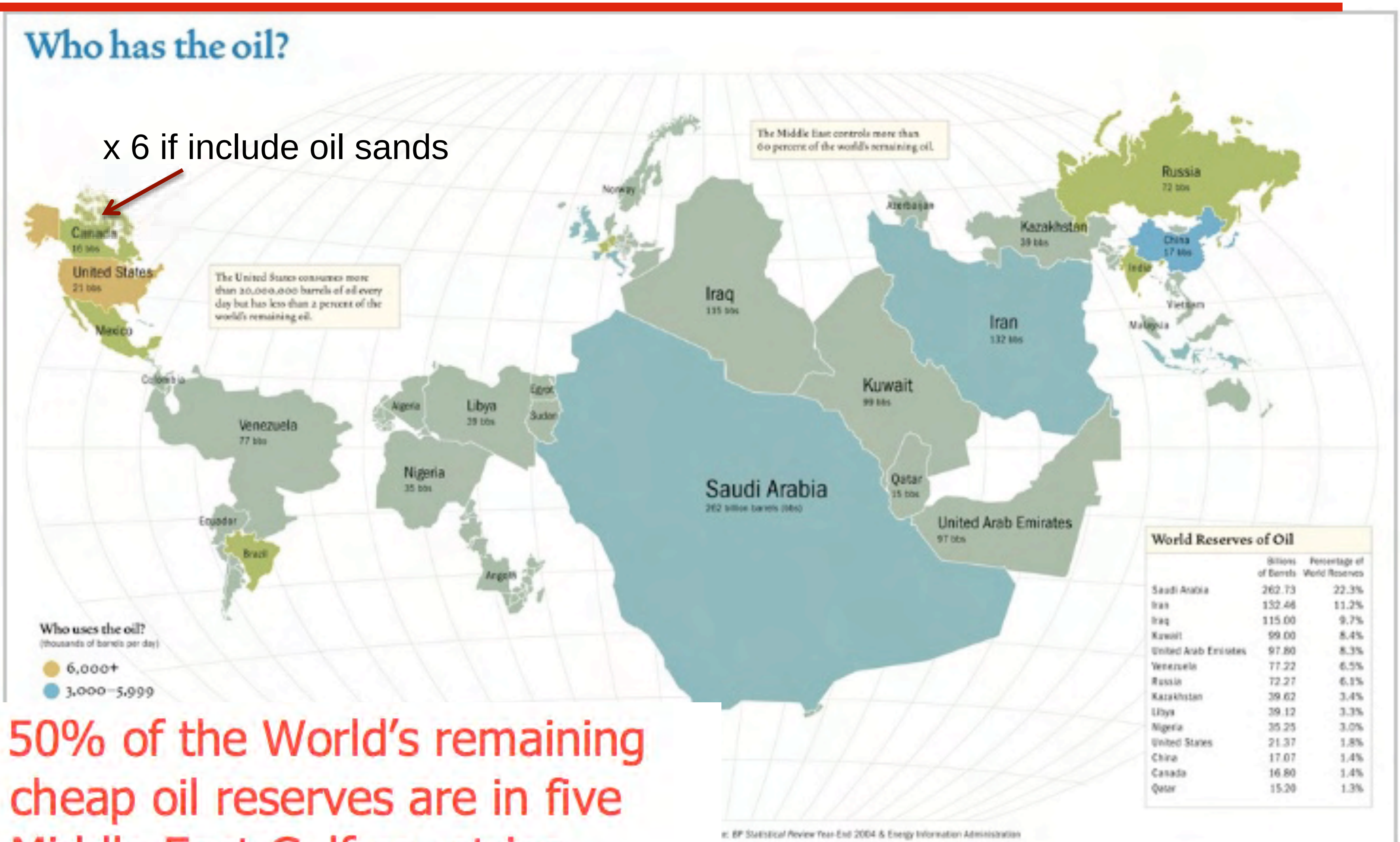


Increasing the resource by 50% only shifts the peak by about a decade..

…Grow longer, crash faster..



Who has the “cheap” (to produce) easy (to extract) readily accessible oil…



World Reserves of Oil

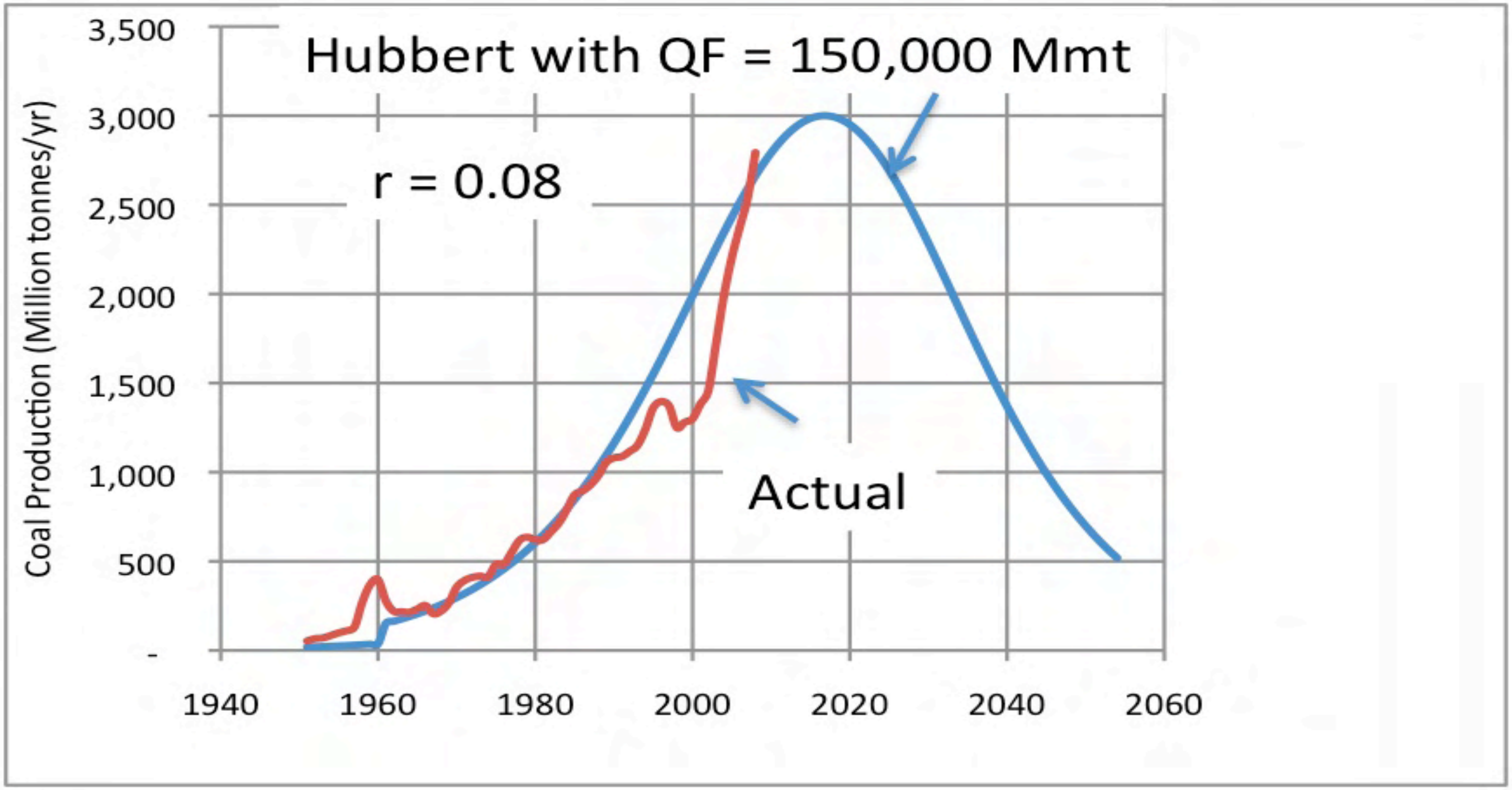
	Billions of Barrels	Percentage of World Reserves
Saudi Arabia	262.73	22.3%
Iran	132.46	11.2%
Iraq	115.00	9.7%
Kuwait	99.00	8.4%
United Arab Emirates	97.80	8.3%
Venezuela	77.22	6.5%
Russia	72.27	6.1%
Kazakhstan	39.62	3.4%
Libya	39.12	3.3%
Nigeria	35.25	3.0%
United States	21.37	1.8%
China	17.07	1.4%
Canada	16.80	1.4%
Qatar	15.20	1.3%

50% of the World’s remaining cheap oil reserves are in five Middle East Gulf countries

(Saudi Arabia, Kuwait, Iran, Iraq and the United Arab Emirates)

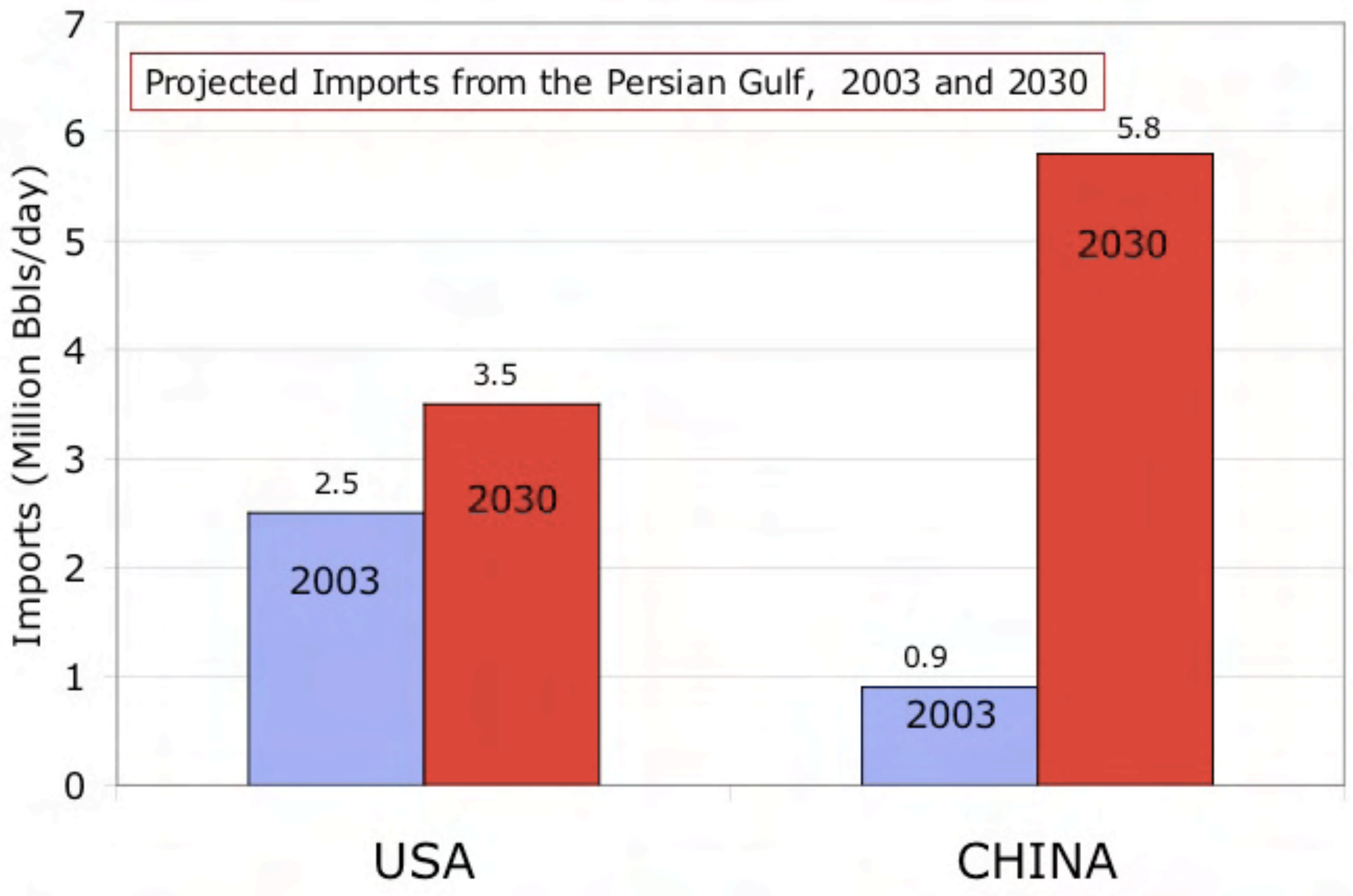
THE GOOD NEWS AND BAD NEWS ABOUT CHINA'S COAL RESOURCES

The good news is China may not have enough coal to continue its current path toward being the colossus of greenhouse gas emissions



The bad news China will have to scour the earth for energy resources

China's Dependence on Persian Gulf Oil is Expected to Grow Rapidly



Based on EIA Intl Outlook, 2006

China went from an exporter to an importer in 1993

“HUGE” NEW OIL DISCOVERIES…. ?

Oil companies see big Gulf of Mexico discovery

Tests suggest huge oil field found in deep waters

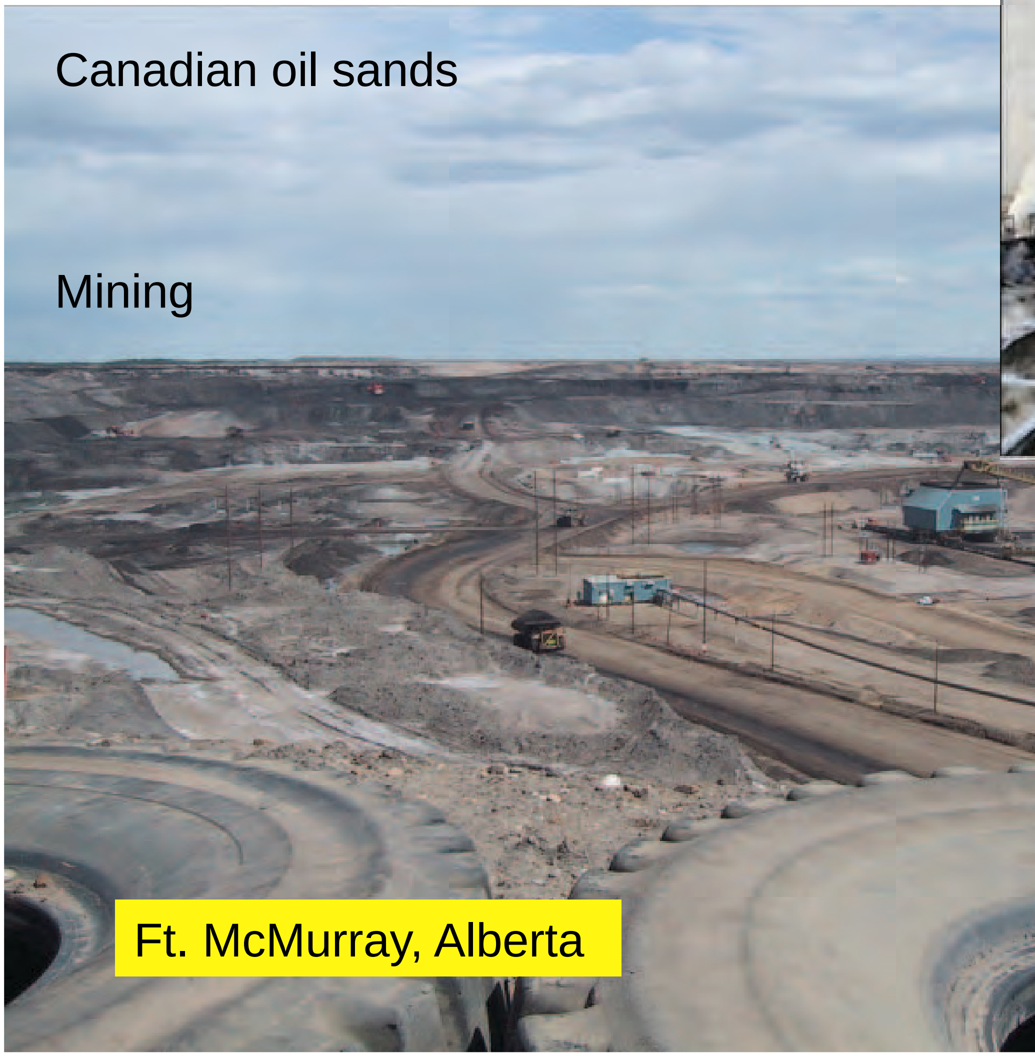
Sept. 2006

Chevron estimated the 300 square-mile region where its test well sits could hold between 3 billion and 15 billion barrels of oil and natural gas liquids.

3 billion to 15 billion barrels, 28,000 ft down

U.S. DEMAND ≈ 8 BILLION BARRELS PER YEAR

Is the world going to “run out” of oil?



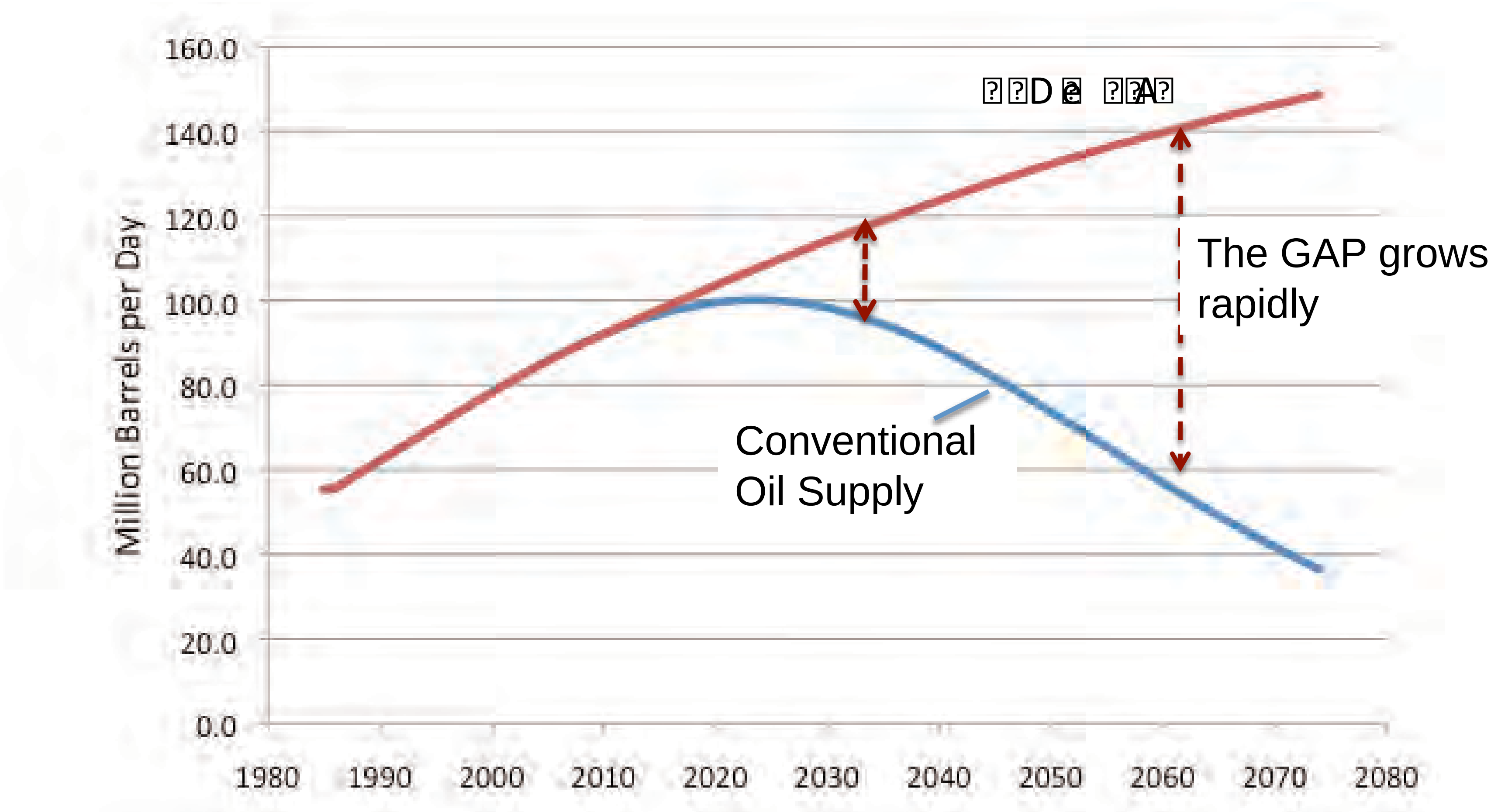
Canadian oil sands RESERVES estimated 170 billion bbls

RESOURCES ?? 1700 billion bbls

Global oil sands RESOURCES ?? 4300 billion bbls

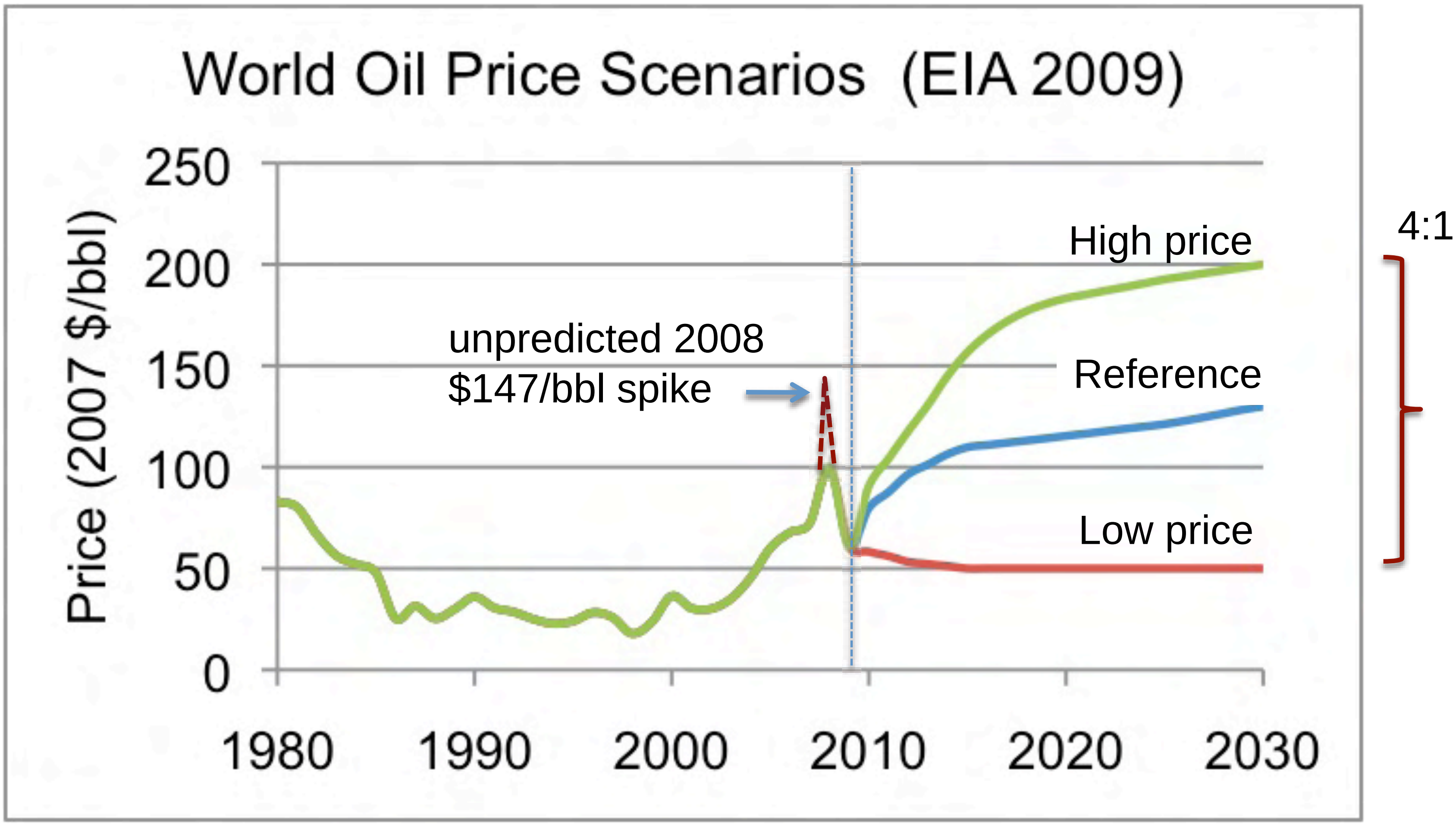
2007 World Oil
Demand = 31 Bbbls/yr

CAN UNCONVENTIONAL OIL BE DEVELOPED FAST ENOUGH?



…. Or bring down demand fast enough?

FUTURE PRICE OF OIL…. unpredictable

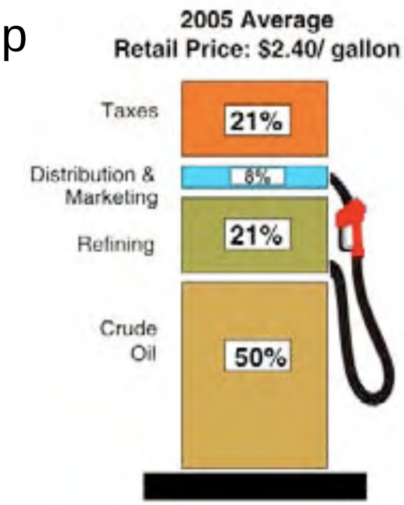


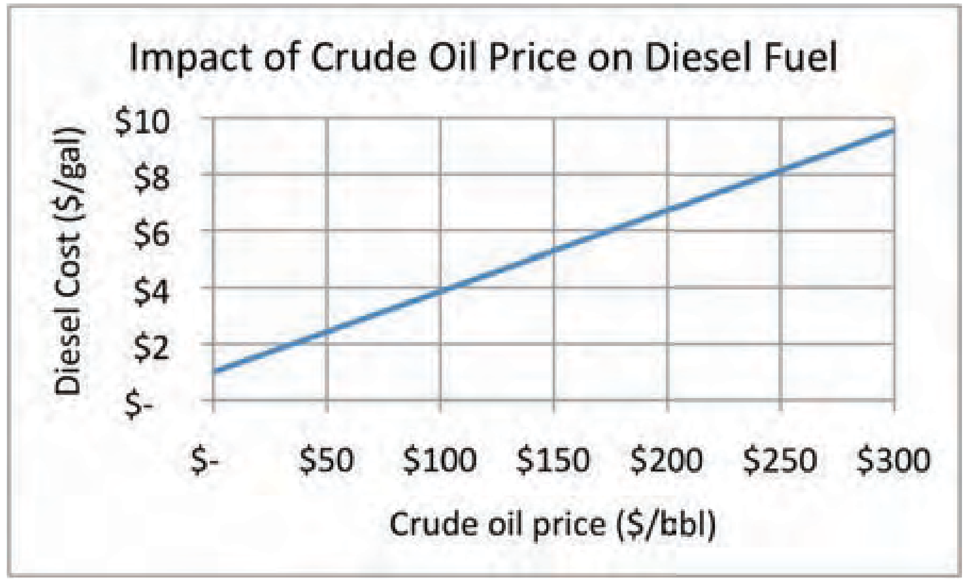
The EIA 30-yr "Reference Case"

2003: $30
2004: $40
2005: $50
2009: $130

IMPACT OF RISING CRUDE OIL PRICE ON DIESEL:

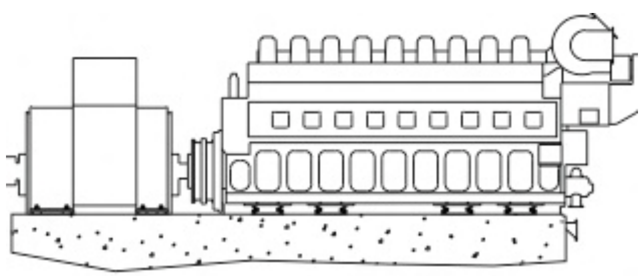
At the pump

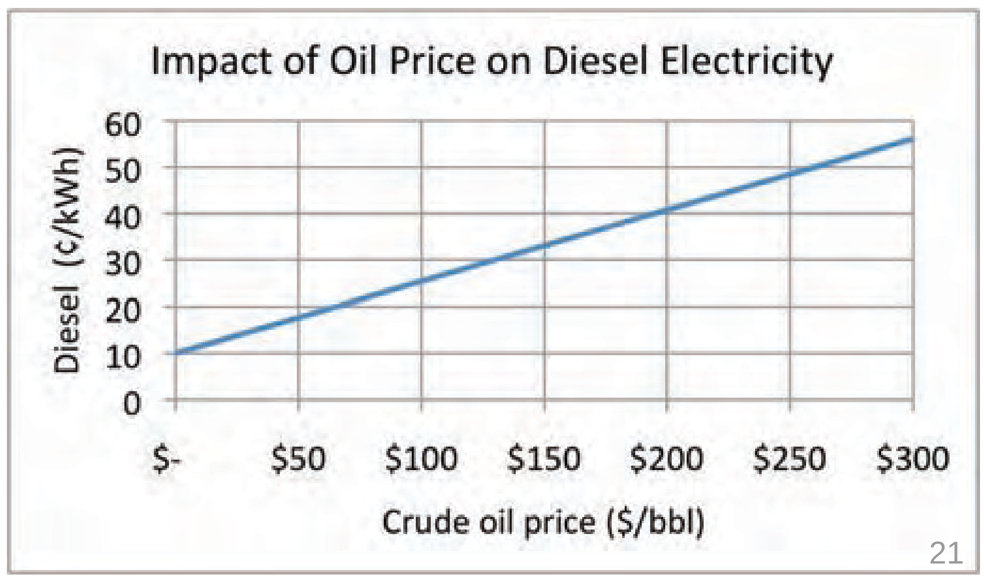




Assumptions: Wholesale $/gal price of No.2 Diesel ≈ 2.8 x $/bbl of crude, $1/gal taxes, marketing, distribution

At the electric meter



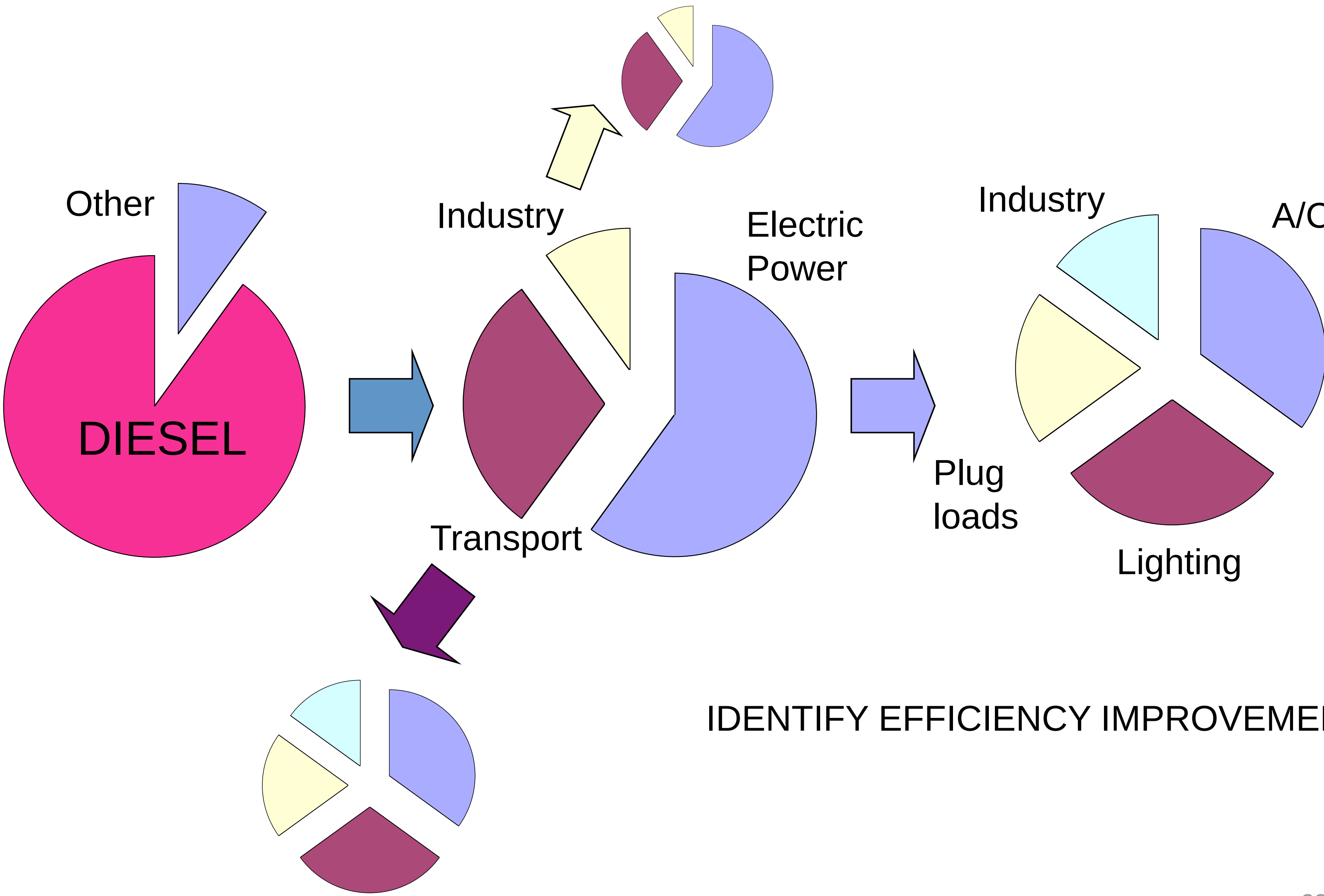


Assumptions: 7000 Btu/kWh, $0.10/kWh fixed costs

PLANNING FOR A FUTURE WITHOUT (much, cheap) OIL….

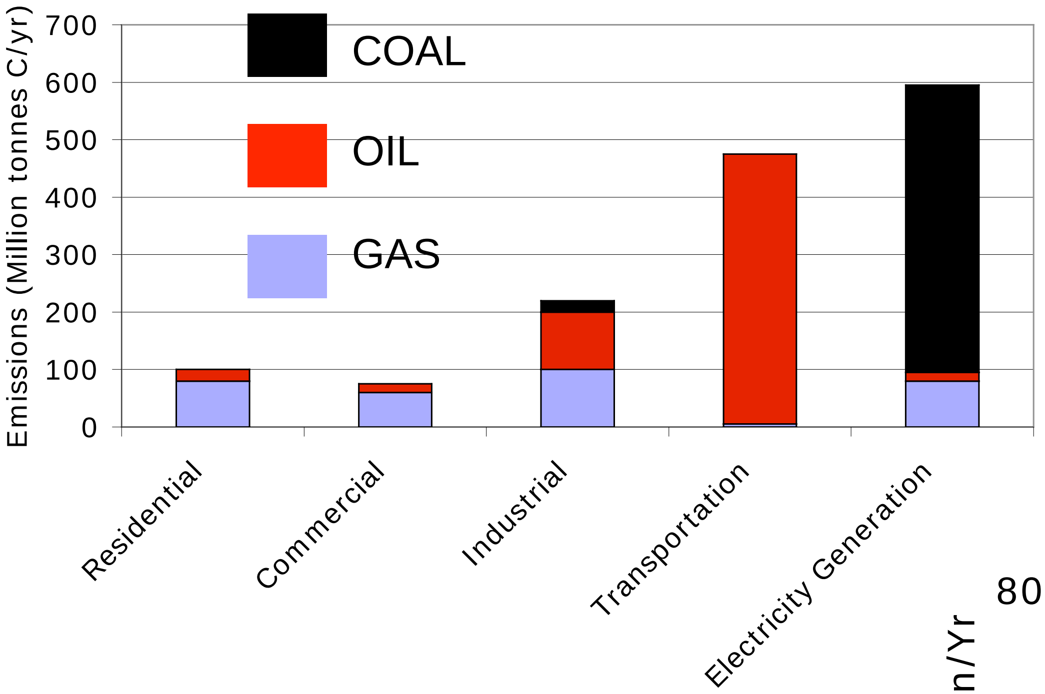
SET A GOAL:	Minimum dependence on imported fuels by 2030
BASED ON:	EFFICIENT USE OF ENERGY
	RENEWABLE ENERGY SYSTEMS
CREATE A PLAN:	Short term…. Medium term … Long term

SHORT TERM TASKS: 1) Understand energy demand

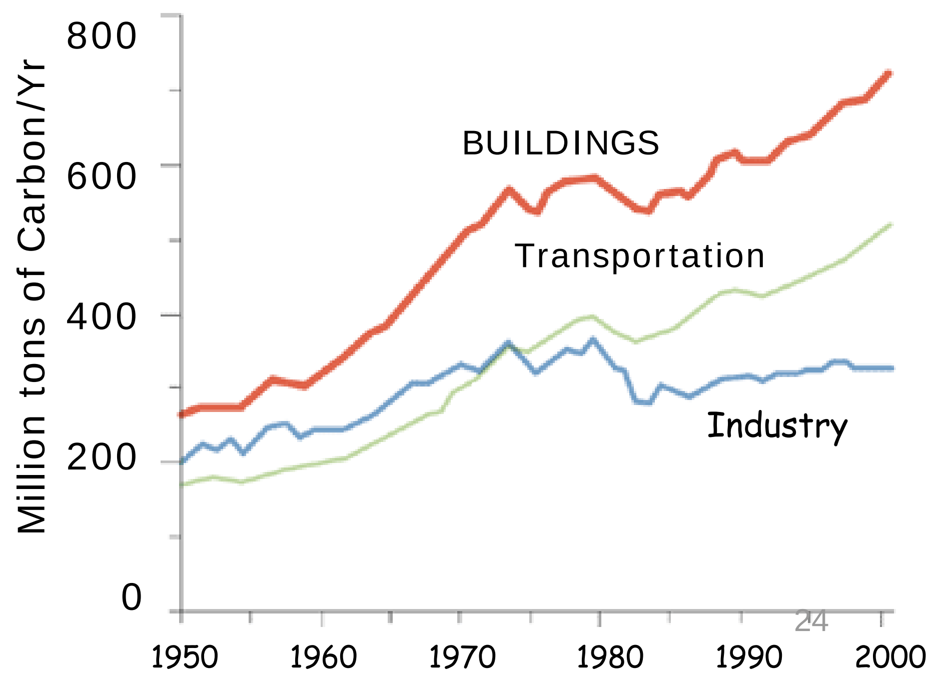


IDENTIFY EFFICIENCY IMPROVEMENTS

TWO PERSPECTIVES ON U.S. CARBON EMISSIONS



Supply-side perspective



Demand-side perspective

OUR GREATEST RESOURCE: Energy Efficiency

EFFICIENCY:
delivering the same energy service with less energy

Fastest, cheapest, cleanest energy resource

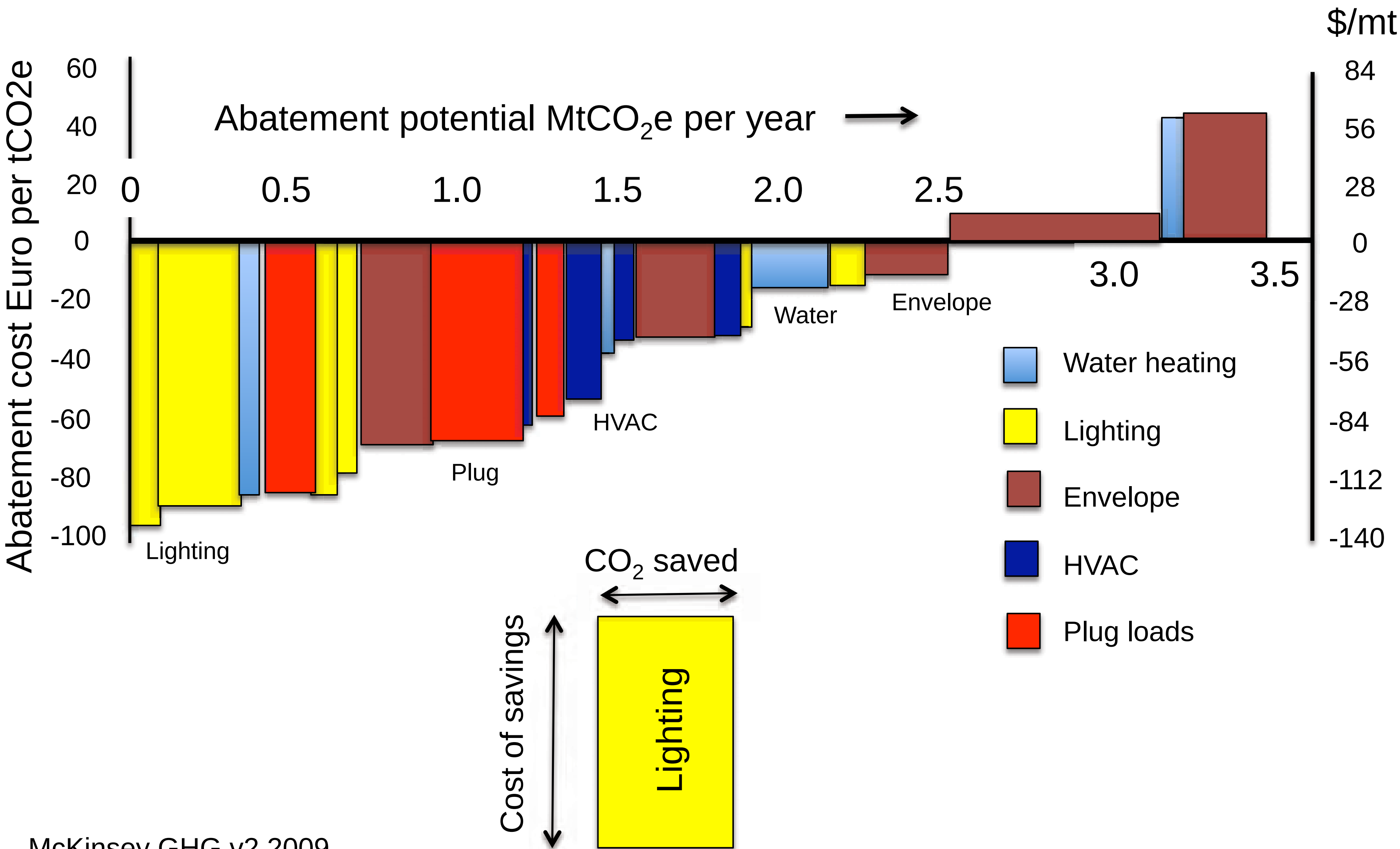
Often referred to as the

"Low hanging fruit"

But… the economist and the $20 bill

… the environmentalist and 2,000 pennies

NUMEROUS EFFICIENCY/CO_2 ABATEMENT TECHNOLOGIES SAVE MONEY !

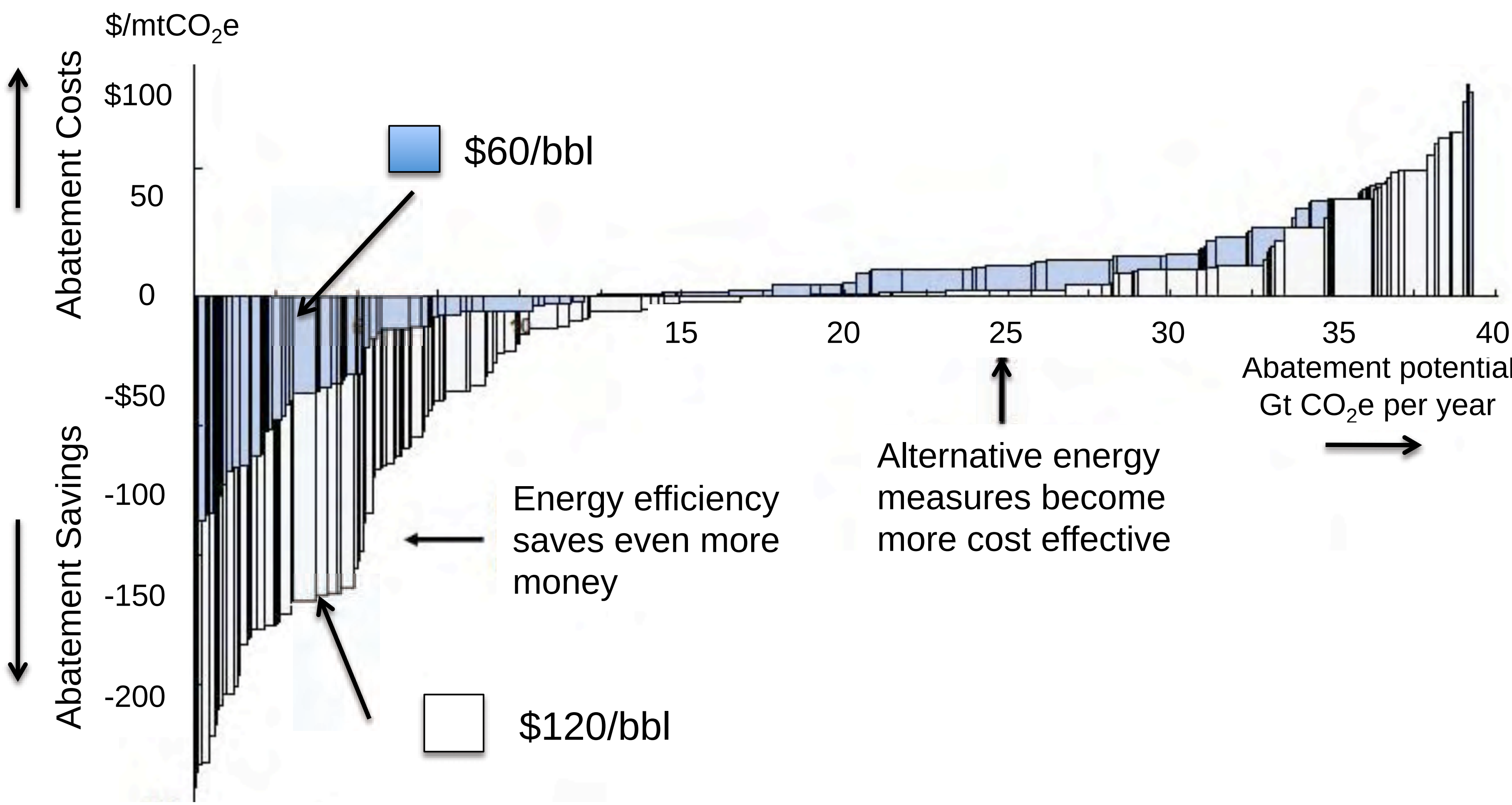


McKinsey GHG v2 2009

McKinsey Global GHG Abatement Curve for the Buildings Sector

WHEN OIL GETS MORE EXPENSIVE…

Efficiency and Renewables become even more cost effective

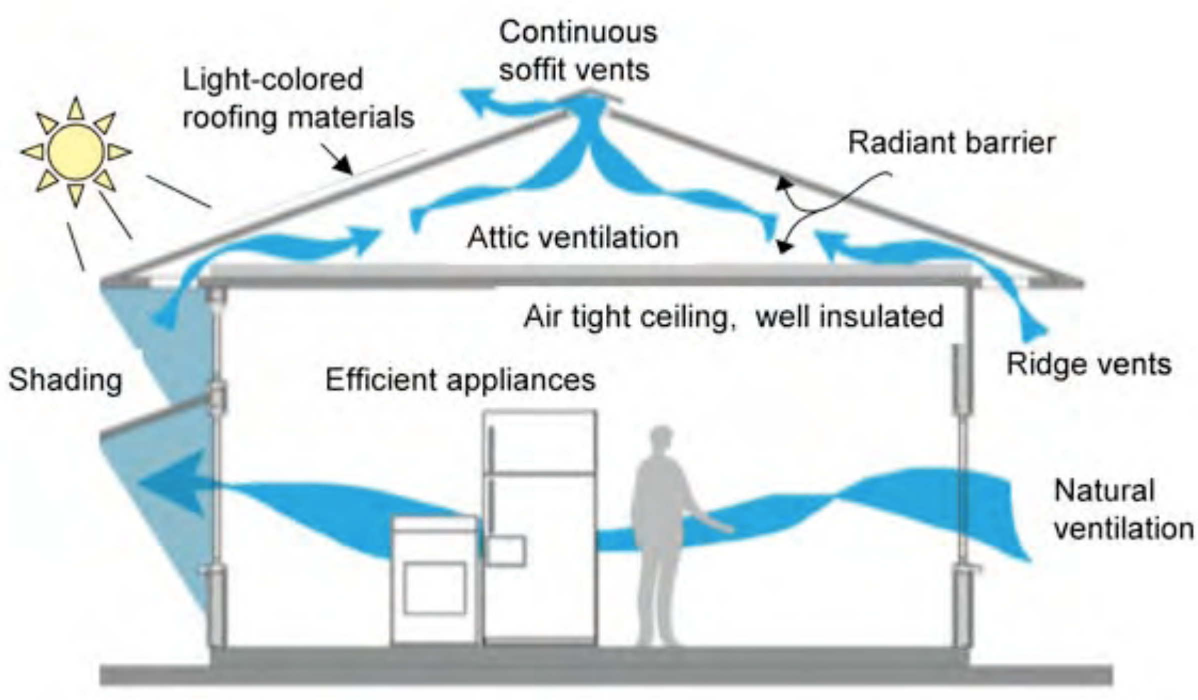


Source: McKinsey Global GHG Abatement Curve v 2.0 (2009)

ENERGY EFFICIENCY OPTIONS… Buildings

BUILDINGS: In the U.S. almost half of all energy; almost three-fourths of electricity

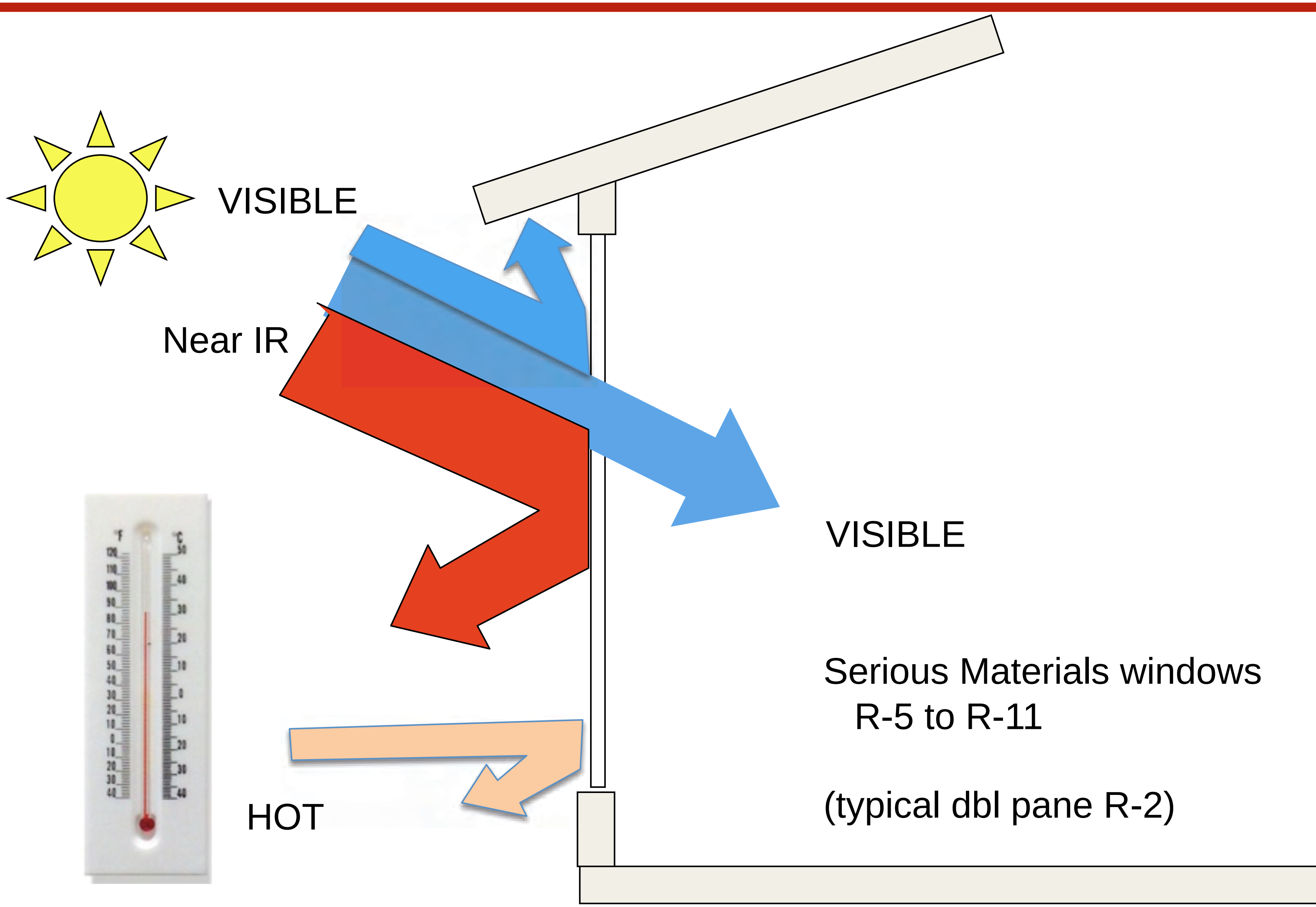
- Ventilation
- Roofing
- Windows
- Lighting
- Plug loads
- Coolng



Field Guide for Energy Performance, Comfort and Value in Hawaiian Homes
Dept of Business, Econ Development, Tourism

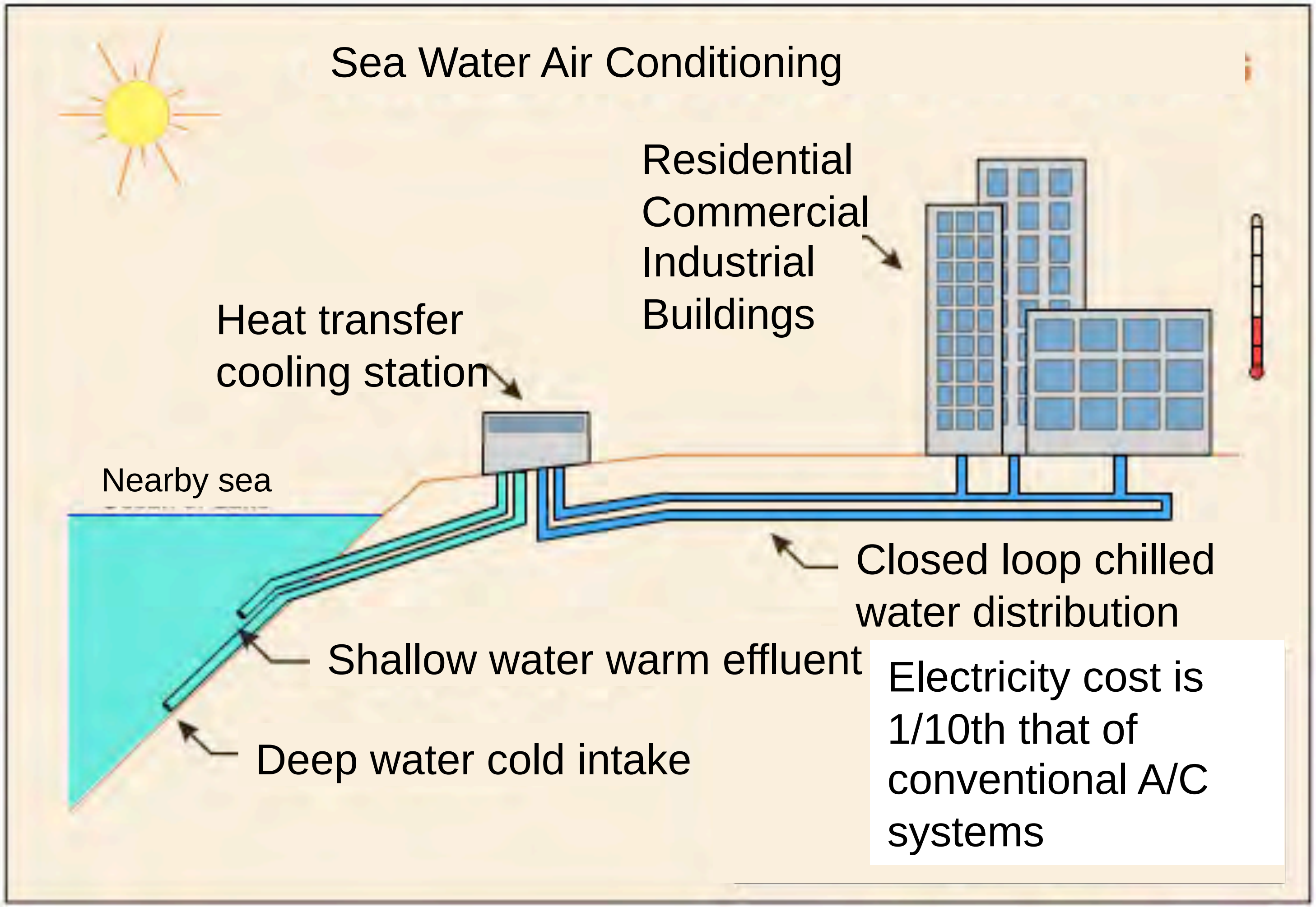
Energy-Efficient Florida Home Building Manual
Florida Solar Energy Center
http://www.fsec.ucf.edu/en/publications/html

ENERGY EFFICIENT WINDOWS TO CONTROL COOLING LOADS



want HIGH thermal resistance (R-value) LOW Solar Heat Gain Factor (SHGF)

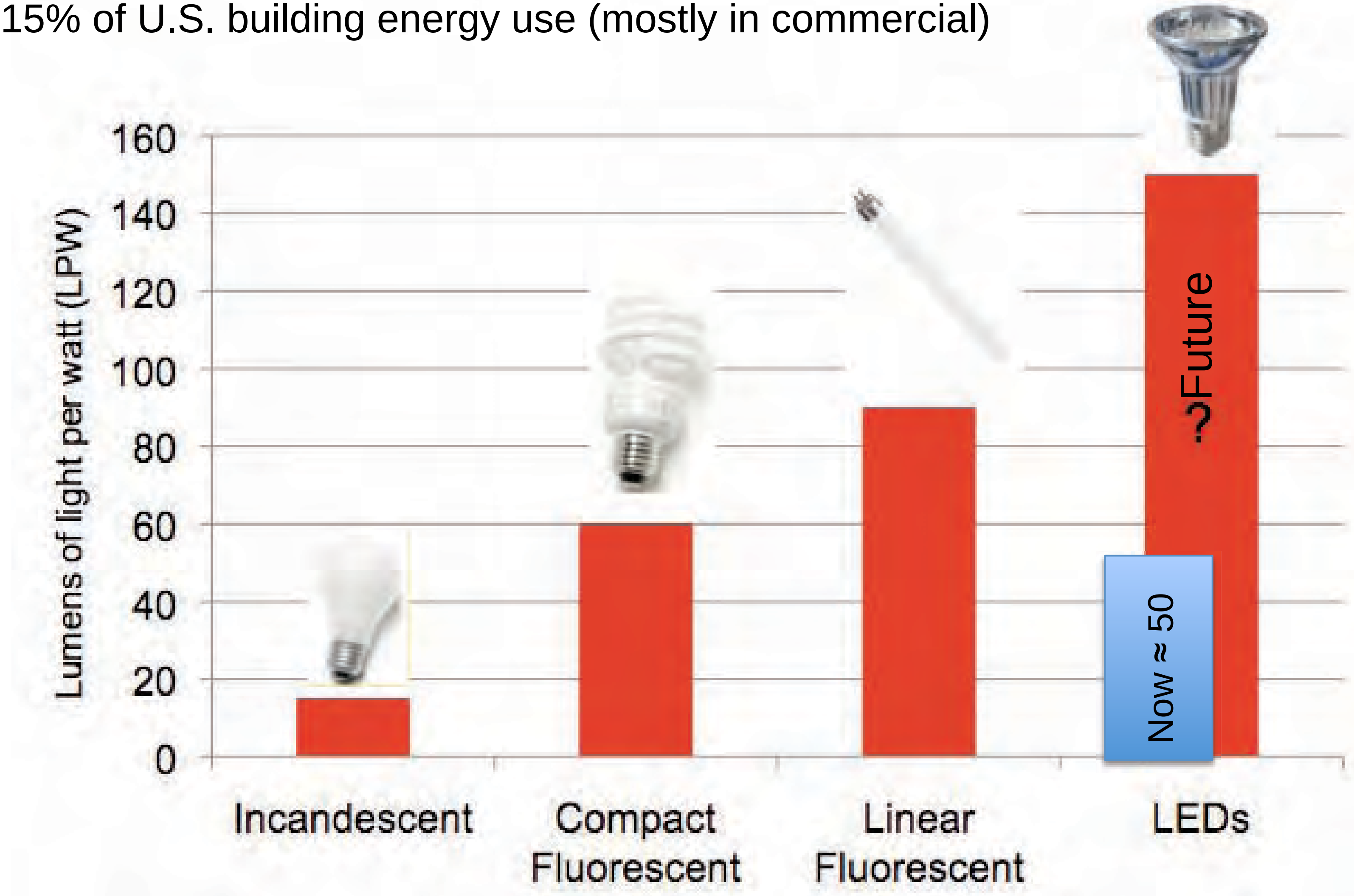
ENERGY EFFICIENCY OPTIONS…Sea water Air Conditioning



Electricity cost is 1/10th that of conventional A/C systems

Very Promising Technology for Lighting: Light Emitting Diodes (LEDs)

15% of U.S. building energy use (mostly in commercial)

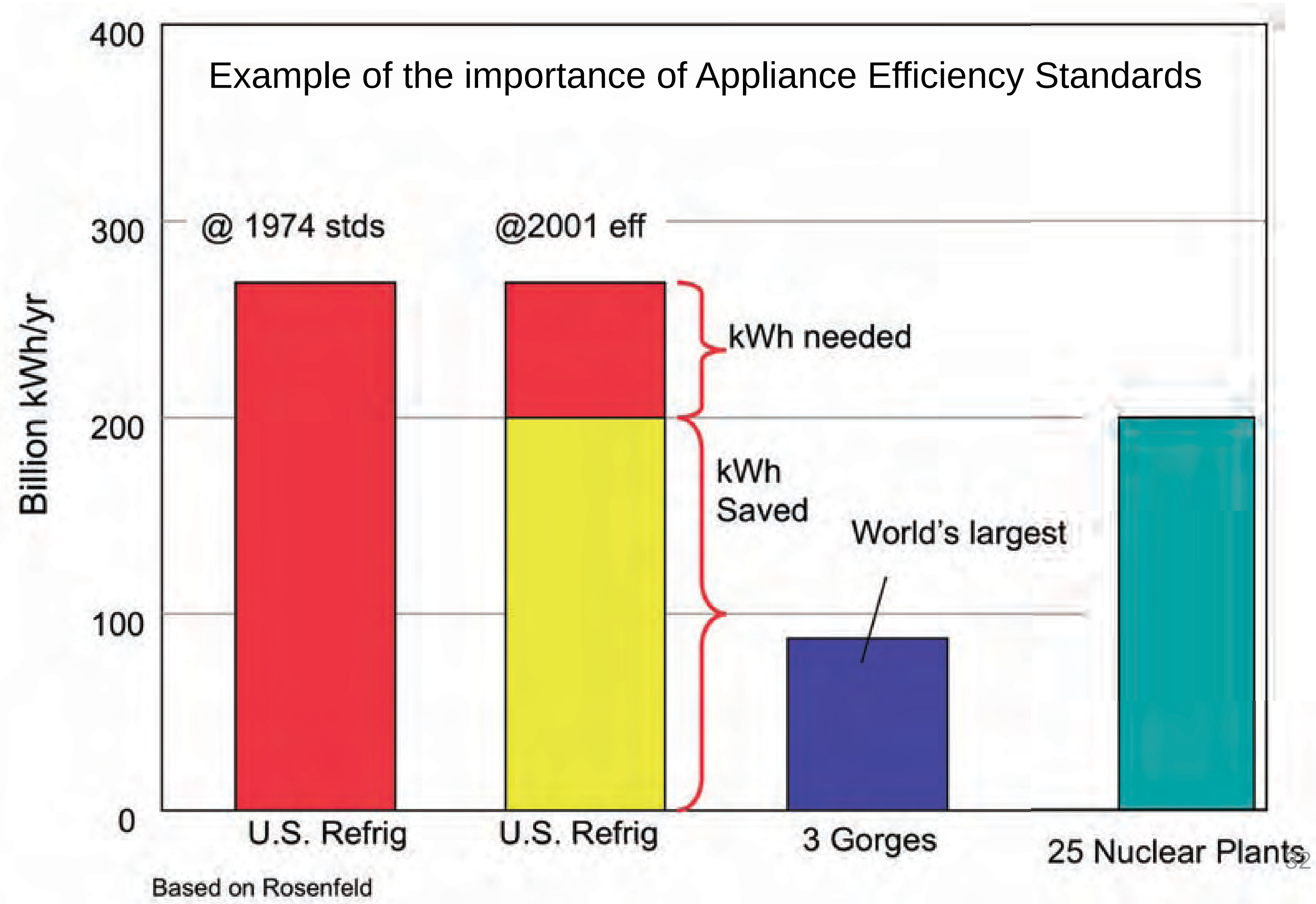


100,000 hr
No mercury
Dimmable

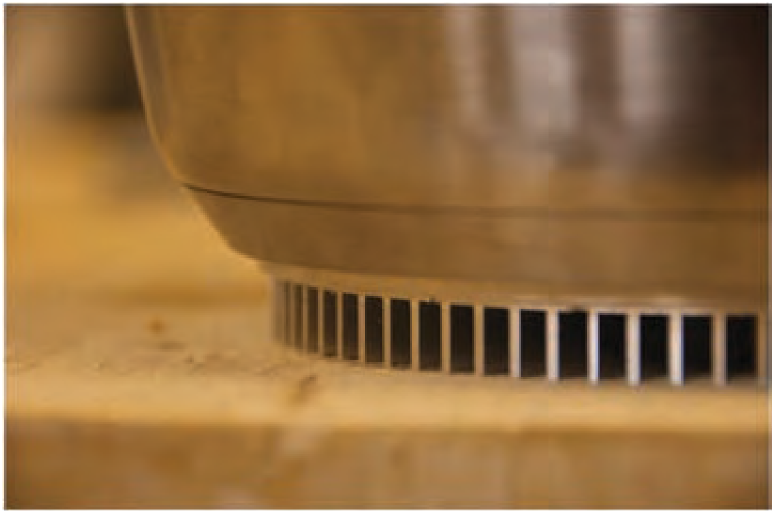
..more efficient lighting gives off less heat, needs less A/C

ENERGY SAVINGS IN U.S. REFRIGERATORS

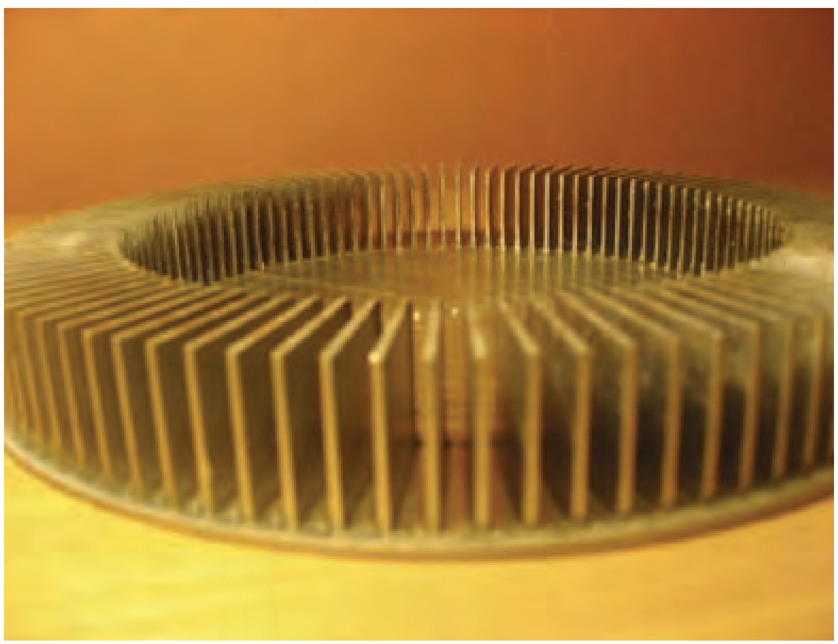
..equivalent to the full output of 25 nuclear reactors (which would cost ≈ $150B)

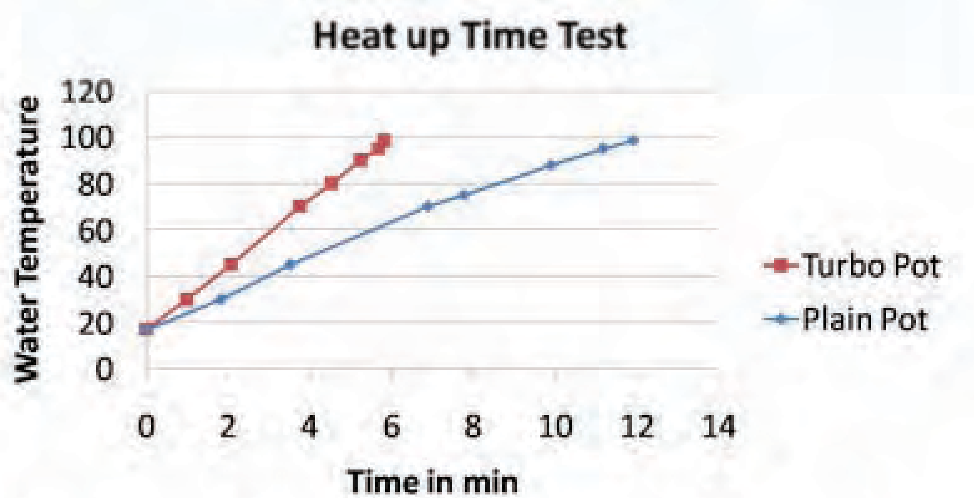


Eneron Heat-Exchanger Cooking pots…
cut fuel use in half !



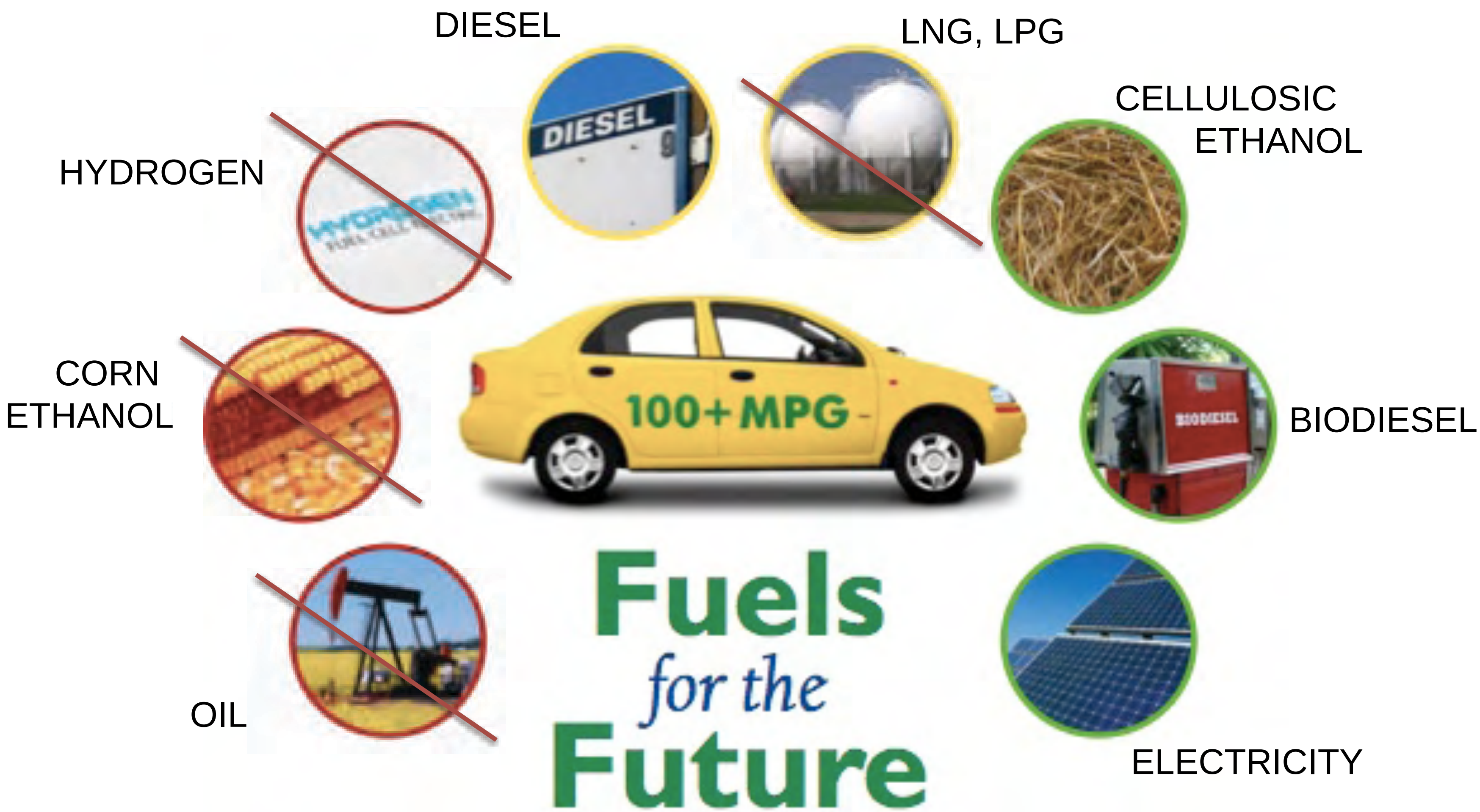
Jonas Ketterle's pots





8" pots tested on a GE Monogram range top burner rated 15000BTU heating up 1.5litre water

FIRST MAKE CARS MORE FUEL EFFICIENT …
lighter, smaller, stronger.. then



RENEWABLES FOR THE PACIFIC…. Biofuels

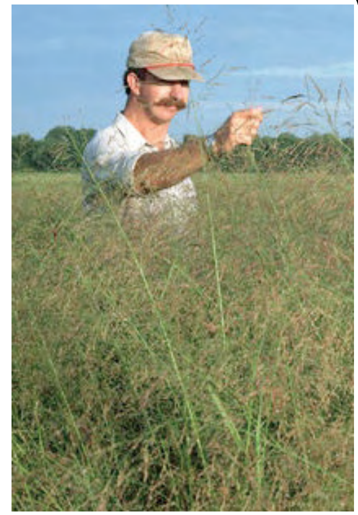
BIODIESEL

ETHANOL

BIOGAS

Corn

Sugar cane



Cellulosic

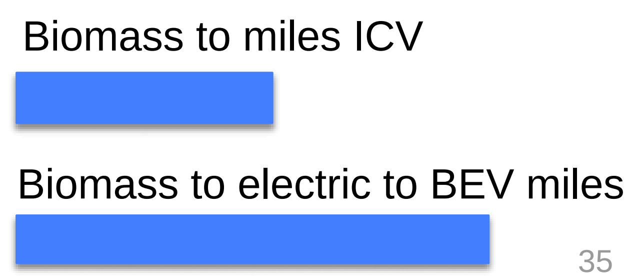
Digesters

Criteria:

- Energy ratio (input/output)
- Competition with food crops
- Carbon reduction
- Ecological impacts
- Area requirements

Cars … better X2 to convert to electricity for EVs

Trucks
Boats
Planes

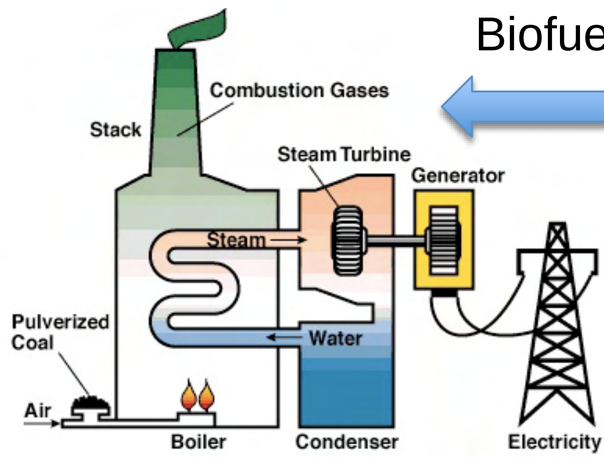


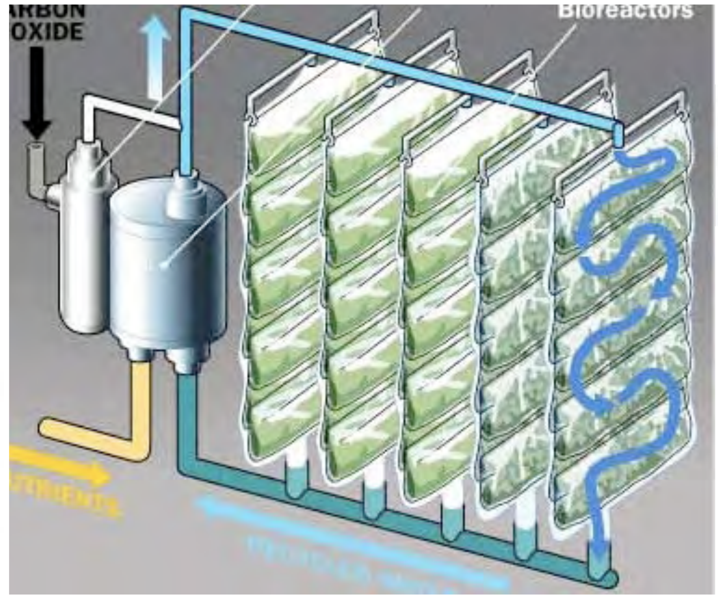
Field, Campbell, Science 2009

"NEXT GENERATION" BIOFUELS FROM ALGAE…

CO_2

Biofuel



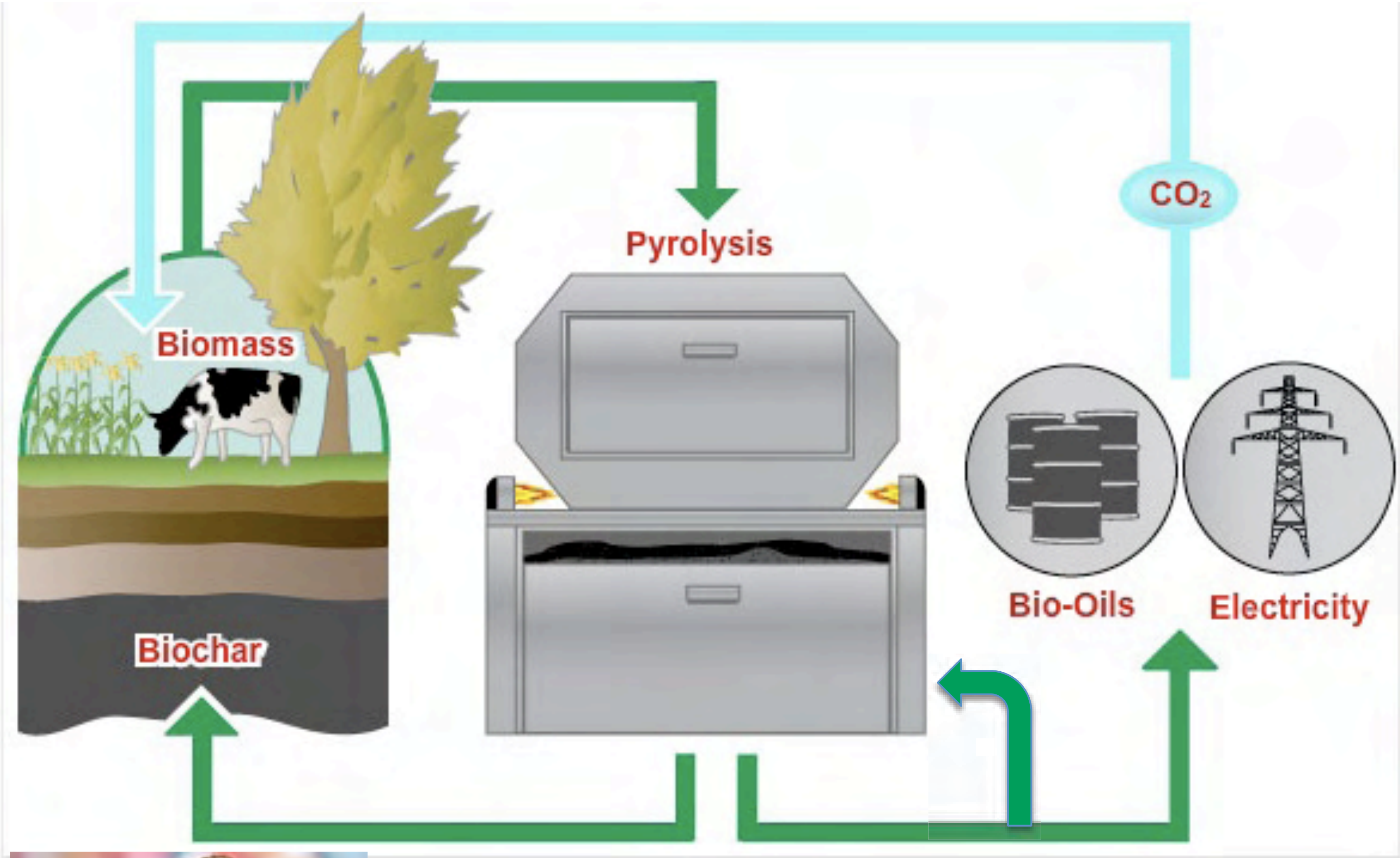


kWh

EV

Biofuels

BIOCHAR… a promising way to sequester carbon and create biofuels



Biochar's high carbon content and porous nature can help soil retain water, nutrients, protect soil microbes.

Pyrolysis converts biomass into syngas for fuel

and a porous, carbon-rich BIOCHAR, which can help soil retain water, nutrients and protect microbes

A VERY INTRIGUING APPROACH? Replace oil with electricity

REDUCED OIL DEMAND
- Stop sending money to our enemies
- Reducing demand reduces price

MULTIPLE FUEL SOURCES:
- Fossil fuels
- Nuclear
- Renewables

CLEANER:
- No tailpipe emissions
- Less smog, better health
- Lower CO_2

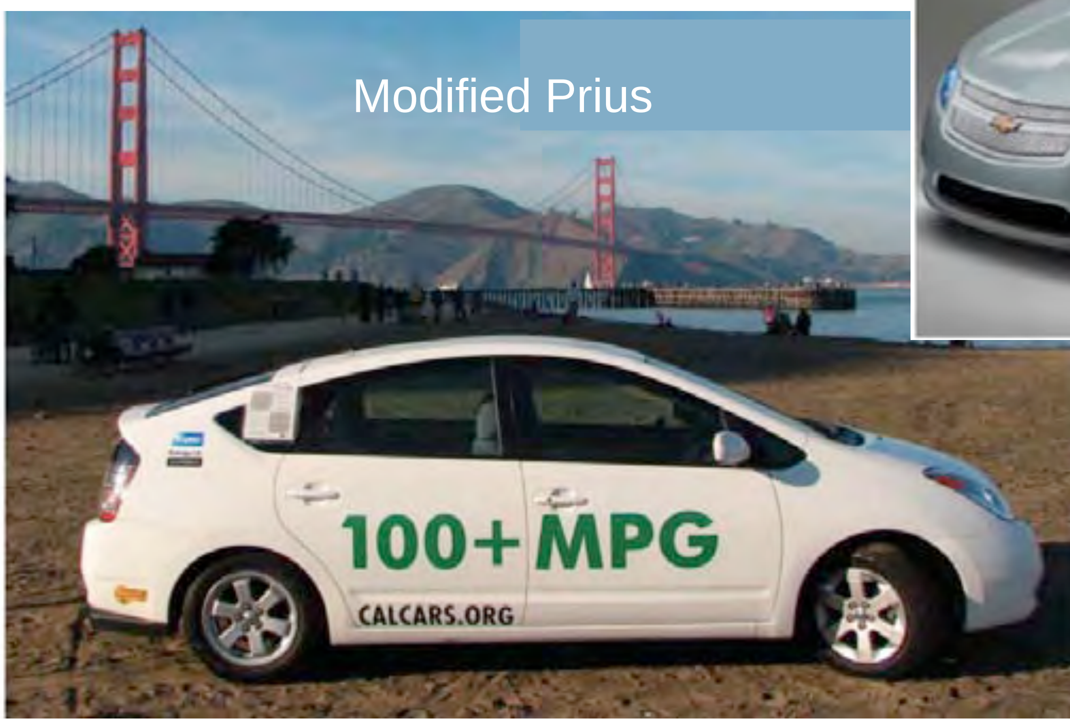
CHEAPER:
- 10¢/kWh ≈ $1/gallon

PLUG-IN HYBRID ELECTRIC VEHICLES (PHEVs)

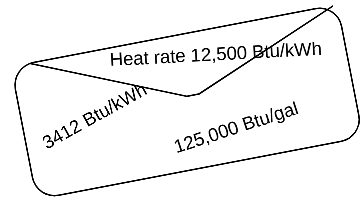
•Batteries provide 20-60 electric miles

•70% of U.S. vehicle-miles could be provided with idle generation capacity

•Gasoline provides fuel for longer trips



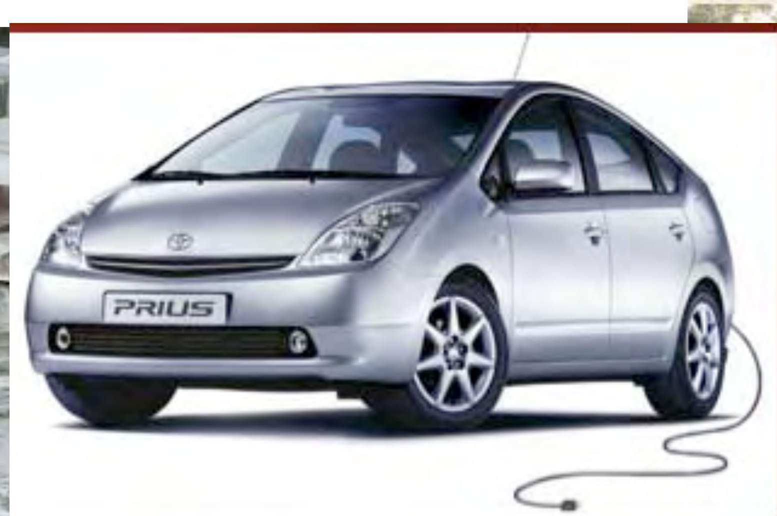
PLUG IN HYBRIDS   for Emergency Power?



PHEV generate ≈ 10 kWh/gal

10 gal in the tank ≈ 100 kWh

Typical household ≈ 20 kWh/day   1 PHEV ≈ 5 days of energy

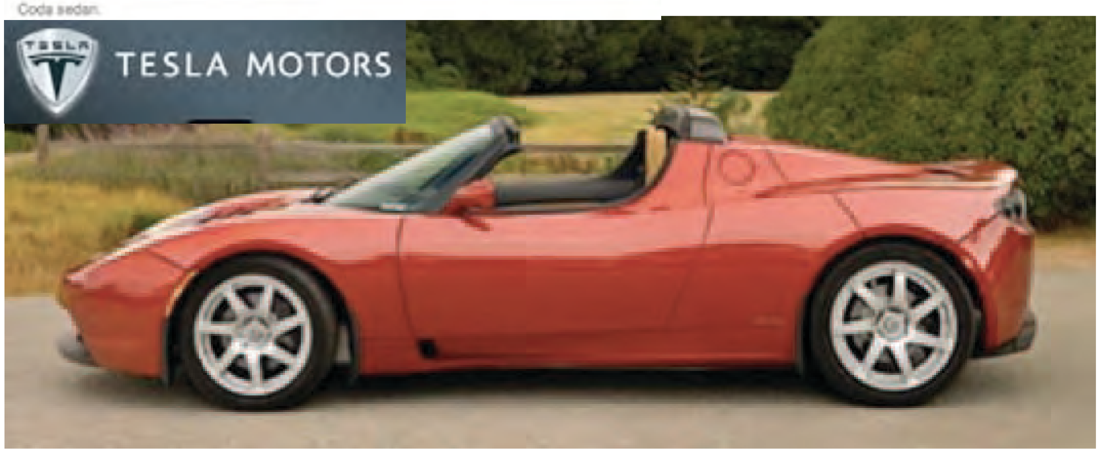


ALL-ELECTRIC Vehicles (EVs) Entering the Marketplace

Mitsubishi iMiev

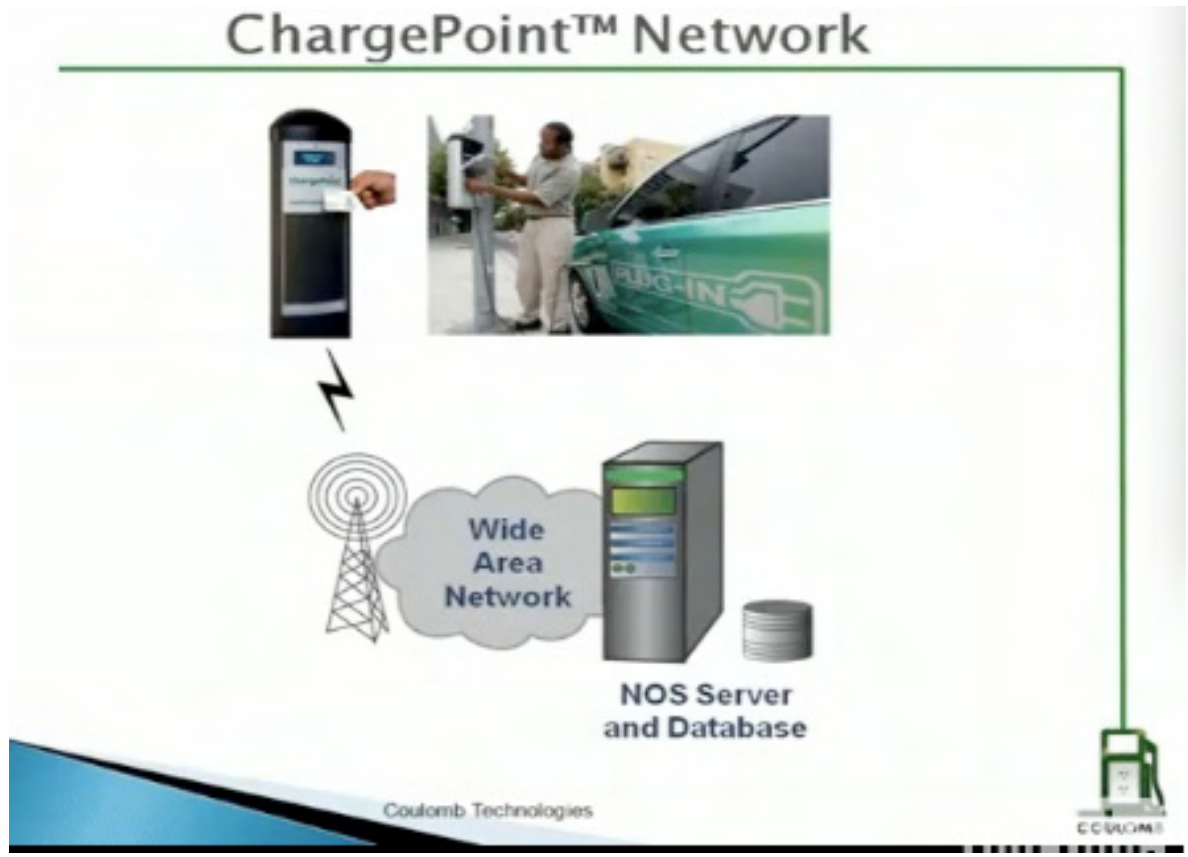
Nissan/Renault

Coda from China



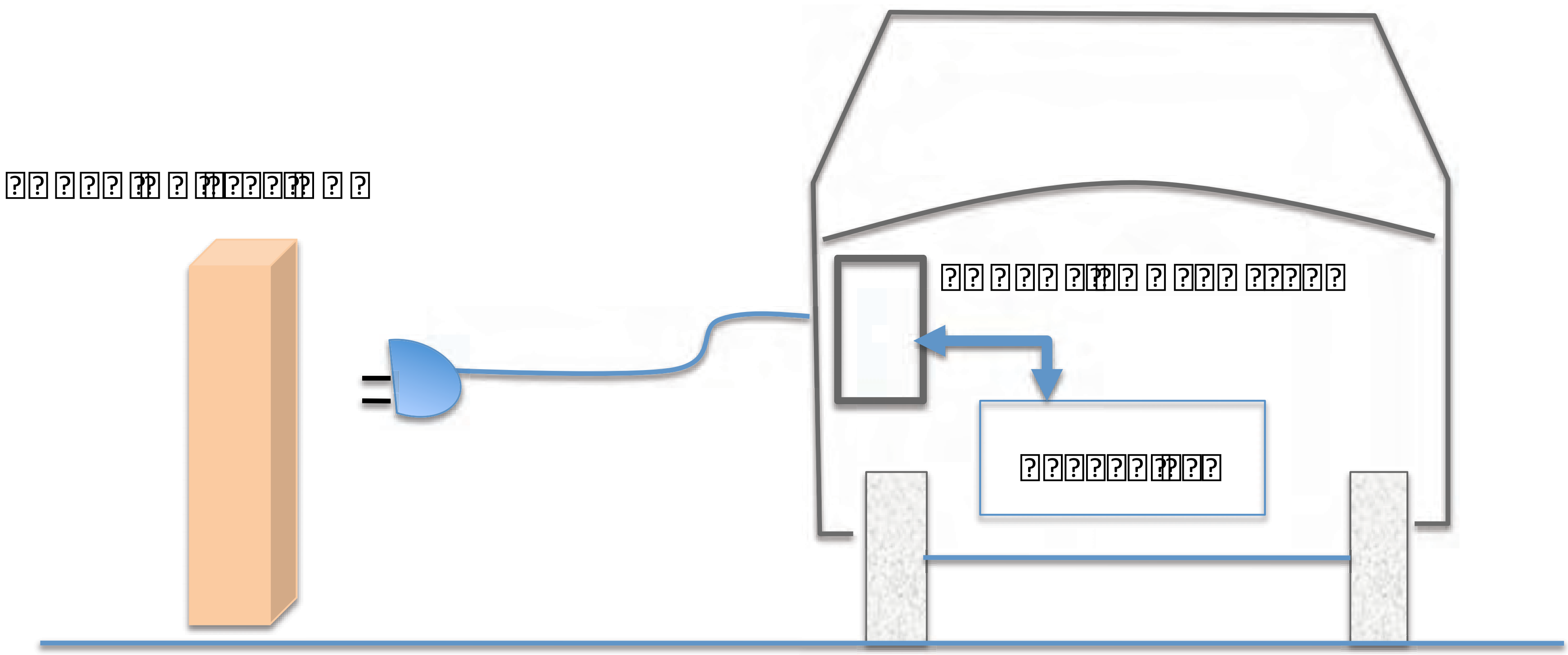
BMW Mini E

CHARGING STATIONS and Networks for PHEV and EV are coming ..

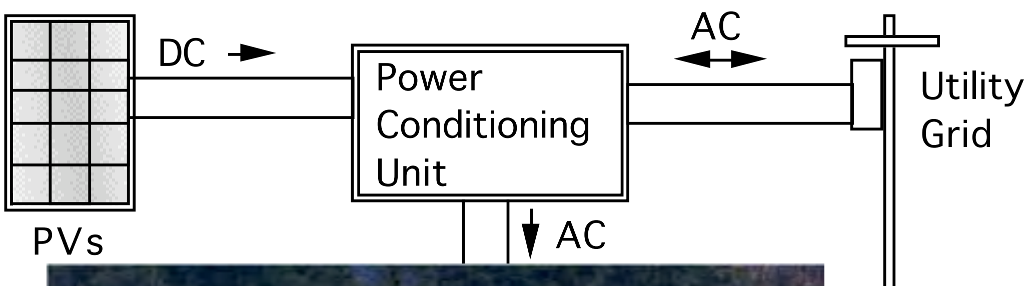


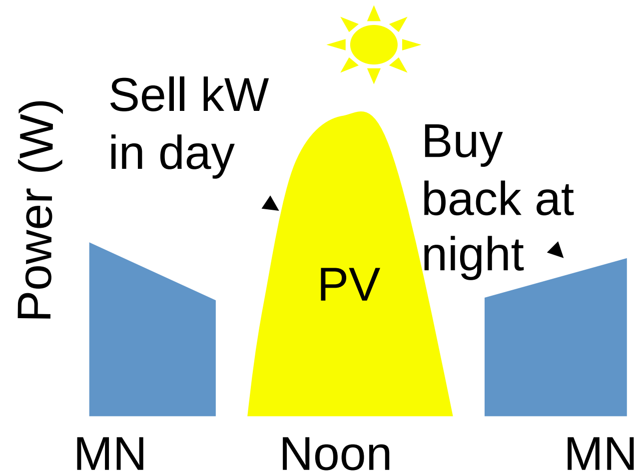
Coulomb Technologies

USER-CONTROLLED CHARGING CRITERIA

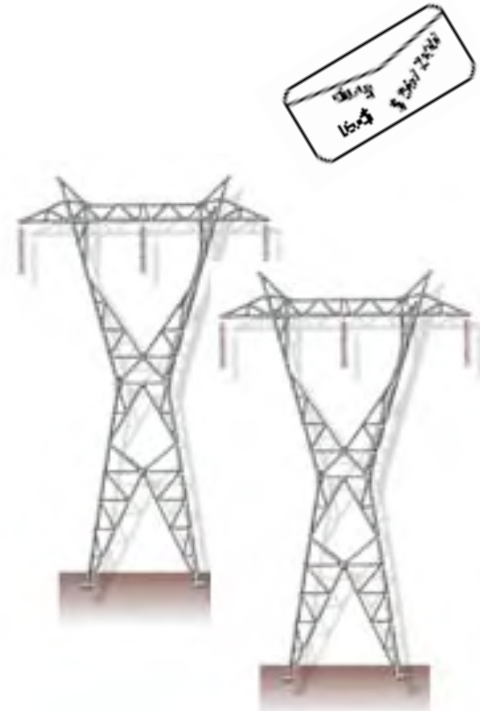


CAN A BATTERY-ELECTRIC OR PHEV USE PHOTOVOLTAIC (PV) POWER?





WHAT IF YOU GOT YOUR ELECTRICITY FROM THE SUN?



2 kWdc,stc x 0.75 x 5.5 hr/day x 365 day/yr x 3.5 mile/kWh = 10,500 mile/yr ≈ 30 mi/d

$$A = \frac{2\ \text{kW}}{1\ \text{kW/m}^2 \times 0.15\ \text{efficiency}} = 13.3\ \text{m}^2 = 140\ \text{ft}^2$$

FUEL COST FOR A VEHICLE IN THE PACIFIC….

25 mpg

$$\frac{\$4.00/\text{gallon}}{25\ \text{mi/gal}} = 16\ \text{¢/mile}$$

50 mpg hybrid:

$$\frac{\$4.00/\text{gallon}}{50\ \text{mi/gal}} = 8\ \text{¢/mile}$$

Grid electricity = 30¢/kWh x 0.25 kWh/mi = 7.5¢/mi

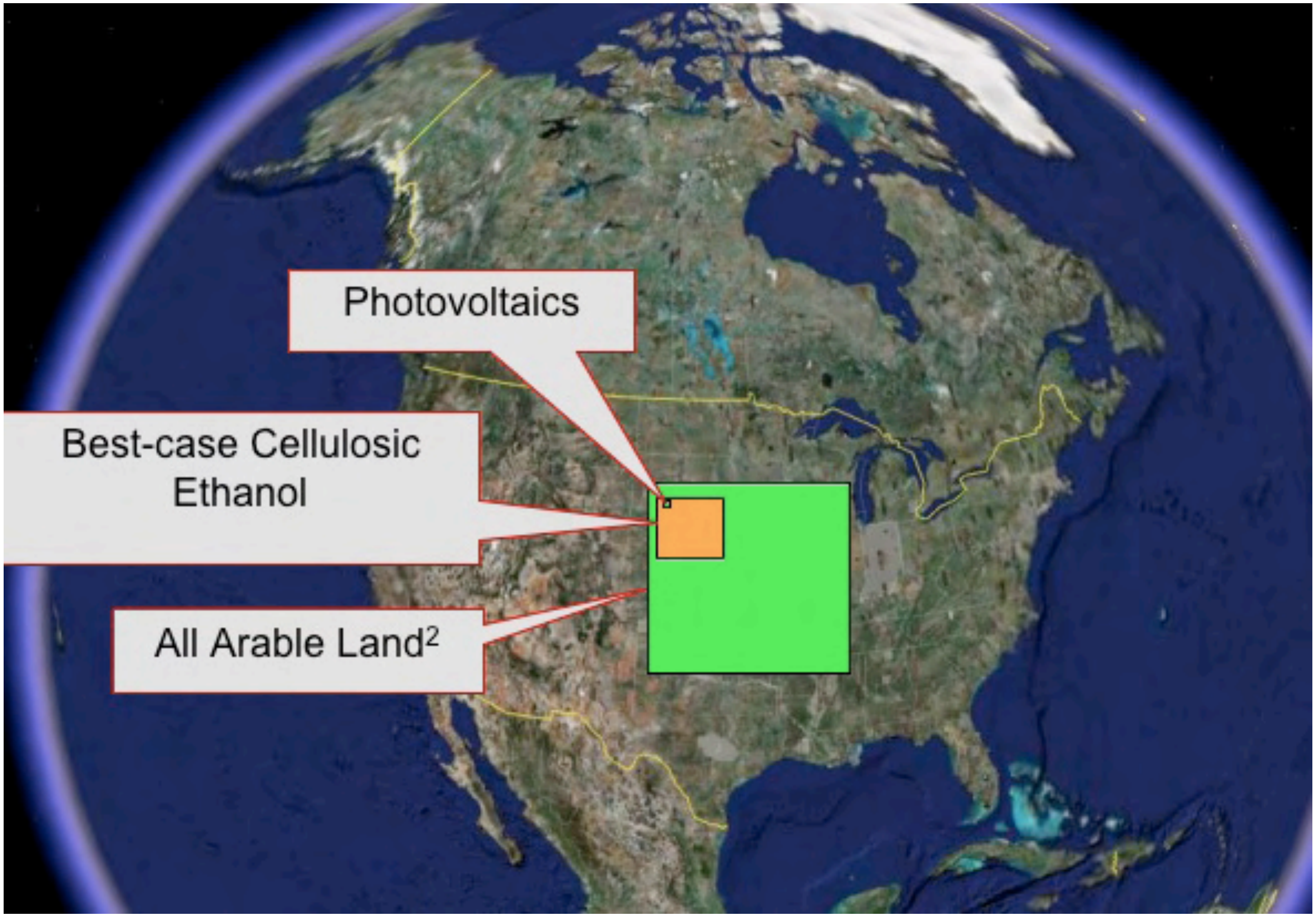
0.25 kWh/mi

WOW !

U.S. costs
w/o subsidies
6%, 30 yr loan

$$\text{PV electricity} = \frac{\$7/\text{Wdc} \times 0.0726/\text{yr} \times 250\ \text{Wh/mi}}{0.75\ \text{Wac/Wdc} \times 6\ \text{h/day} \times 365\ \text{day/yr}} = 7.7\text{¢/mi}$$

AREA REQUIRED
..to supply 50% of U.S. Passenger vehicle miles



JBStraubel, Tesla Motors

RENEWABLE ENERGY RESOURCES IN THE PACIFIC

WIND

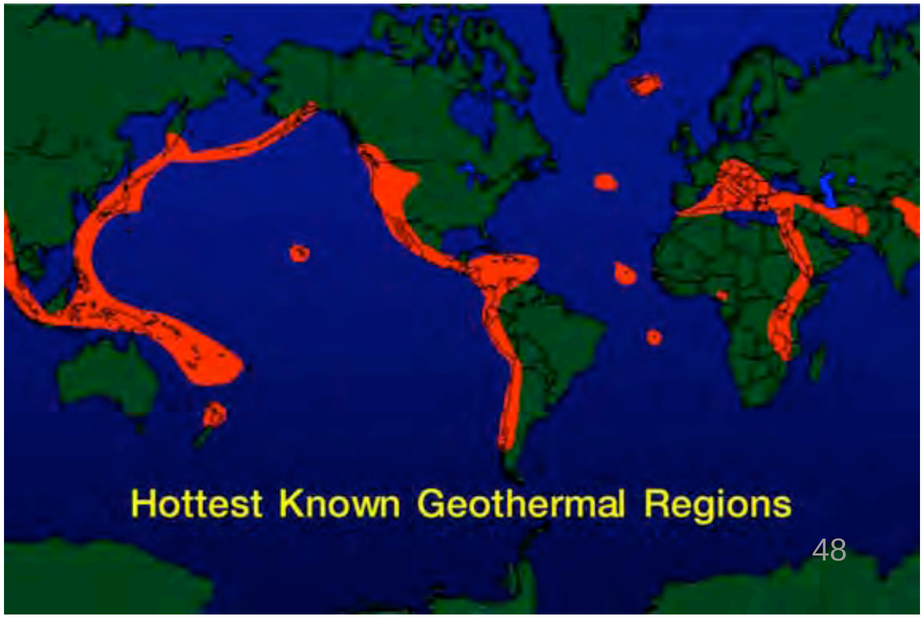
TIDES AND WAVES

SMALL HYDRO

BIOMASS

SOLAR

GEOTHERMAL



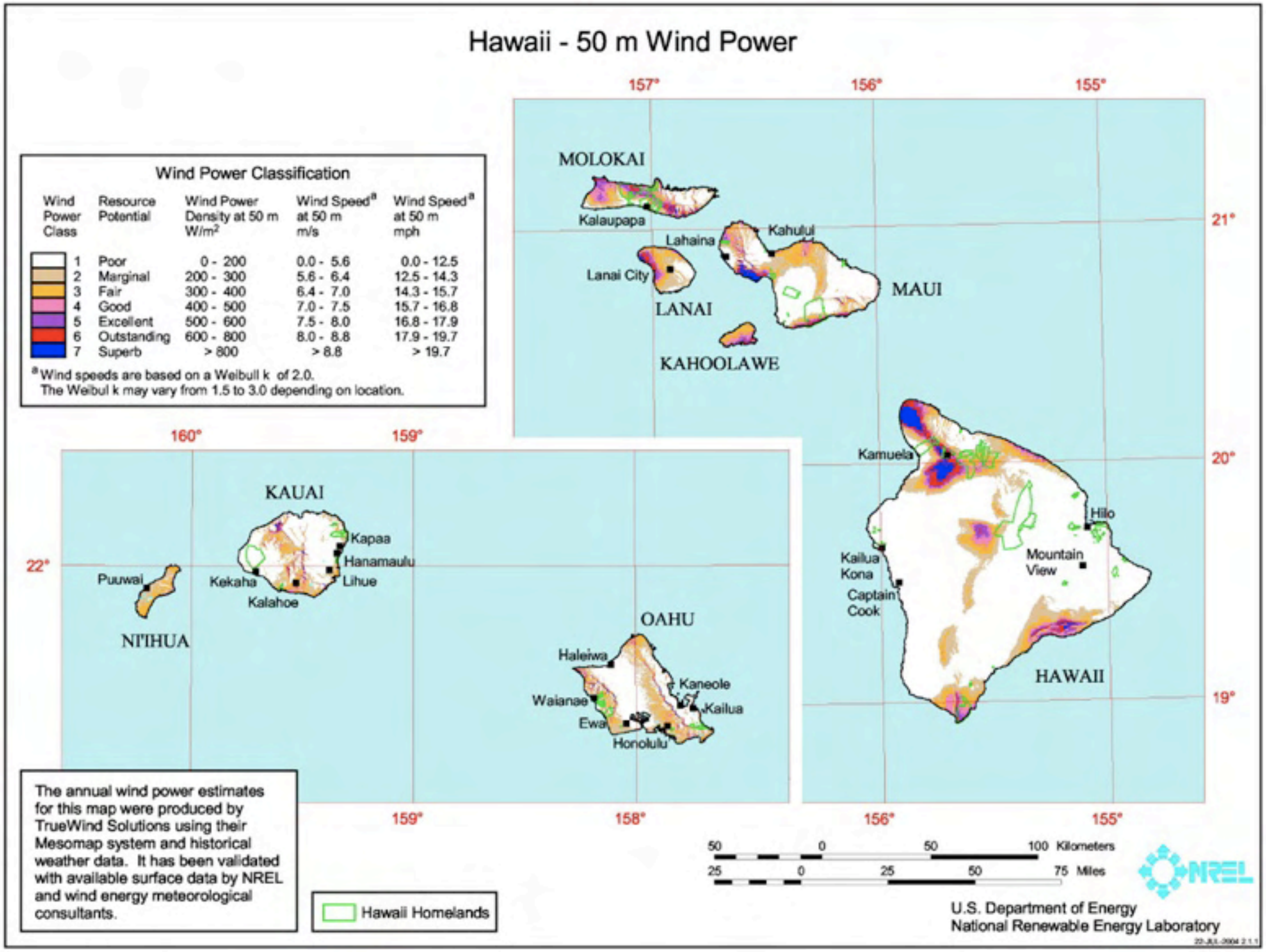
WIND POWER: The most mature renewable energy system

Global installed capacity growing 25% per year

In 2008 wind provided 40% of all new generation capacity worldwide

Competitive $ with all conventional power generation

FIRST STEP: CHARACTERIZE THE WIND RESOURCE

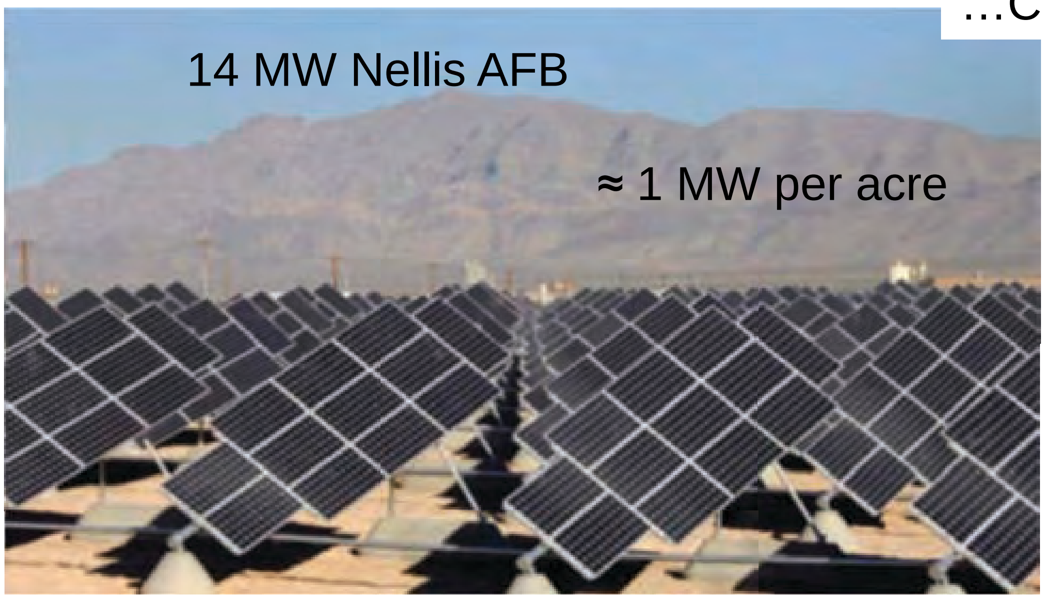


PHOTOVOLTAICS production growing 40% per year:

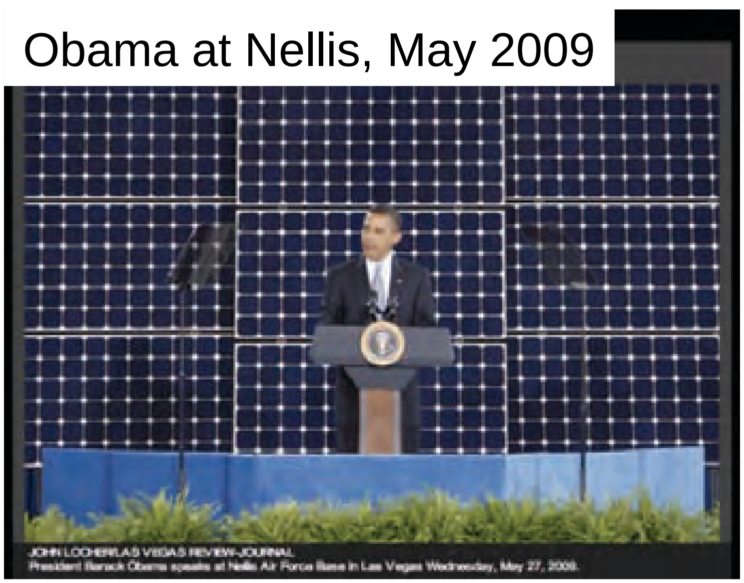
…Crystal silicon still dominant technology

14 MW Nellis AFB

≈ 1 MW per acre

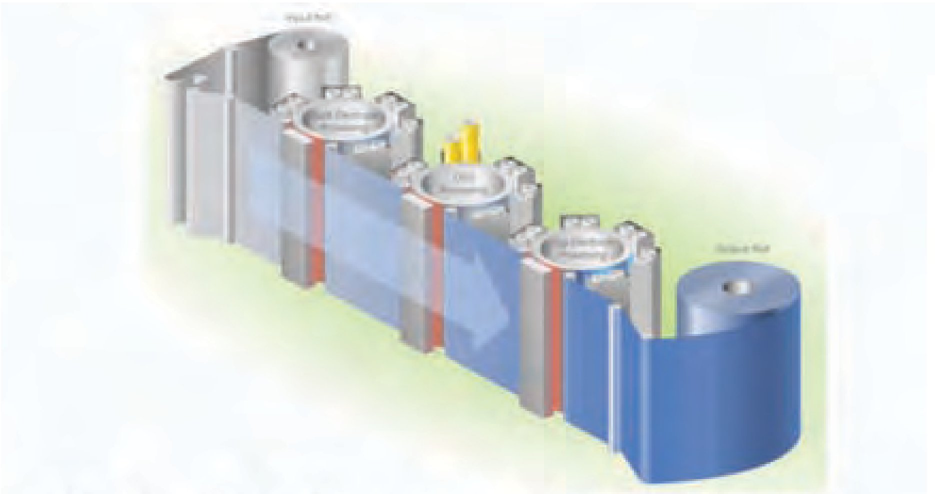


Obama at Nellis, May 2009

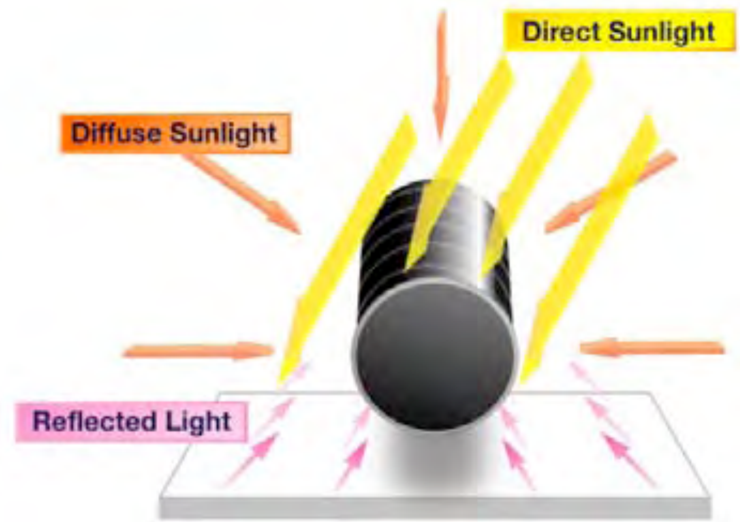


Mauna Lani Bay Resort Hotel, Hawaii 100 kW

Thin-film PV technologies promise to drop prices of solar cells dramatically



Roll-to-Roll (like newspapers or film)

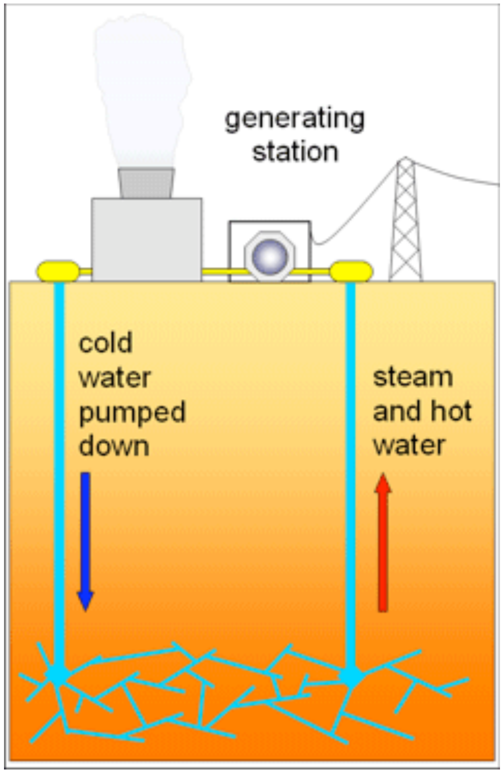


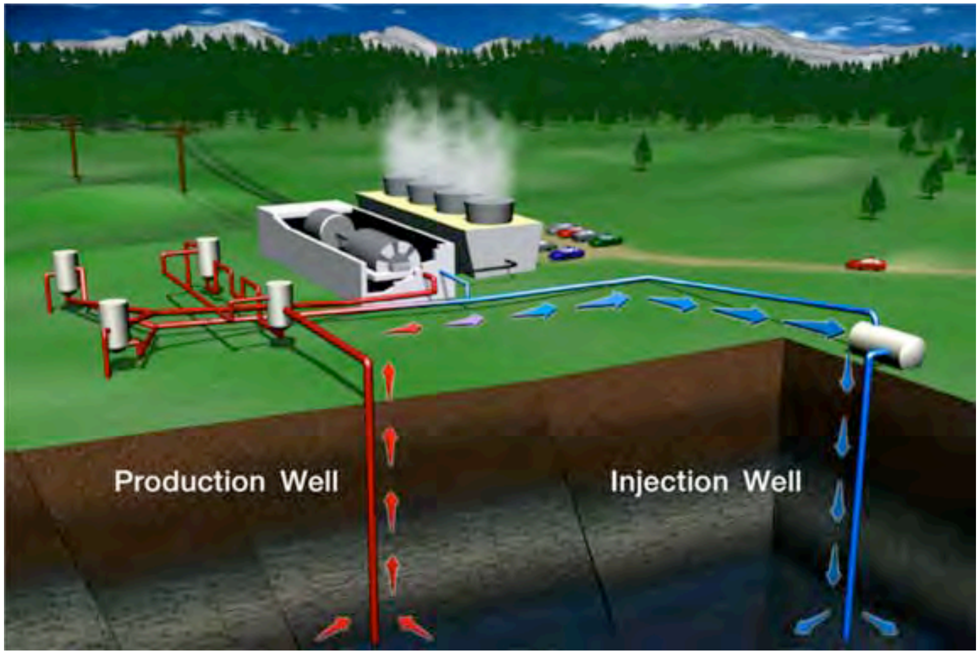
Solyndra CIGS

CONCENTRATING SOLAR POWER (CSP) SYSTEMS… competition for PVs

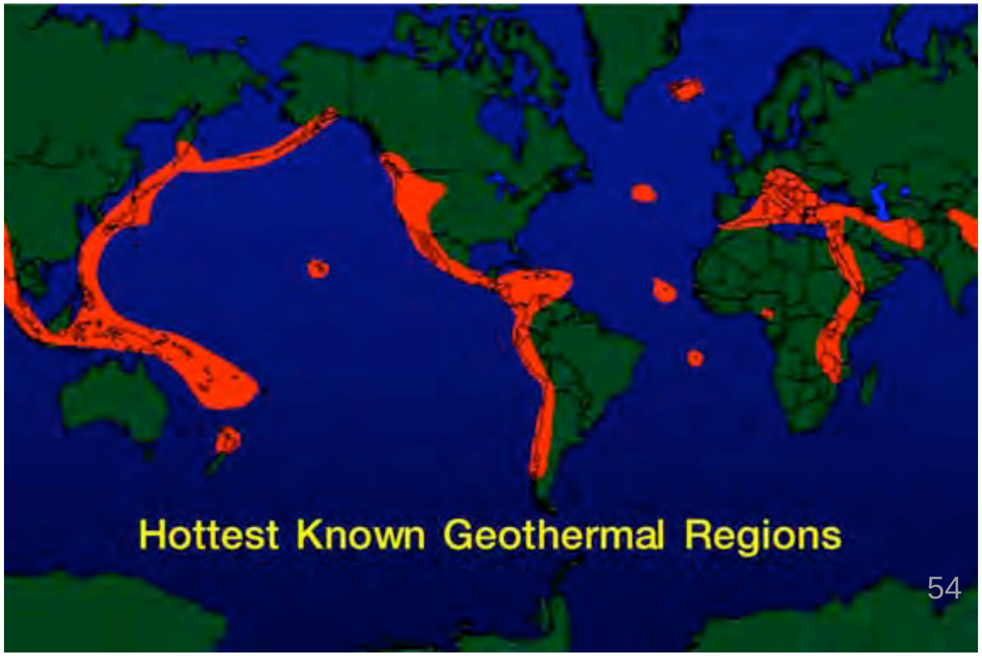
POTENTIAL FOR THERMAL STORAGE ! (but H_20 issues)

GEOTHERMAL : ESPECIALLY IMPORTANT AS RENEWABLE BASELOAD CAPACITY



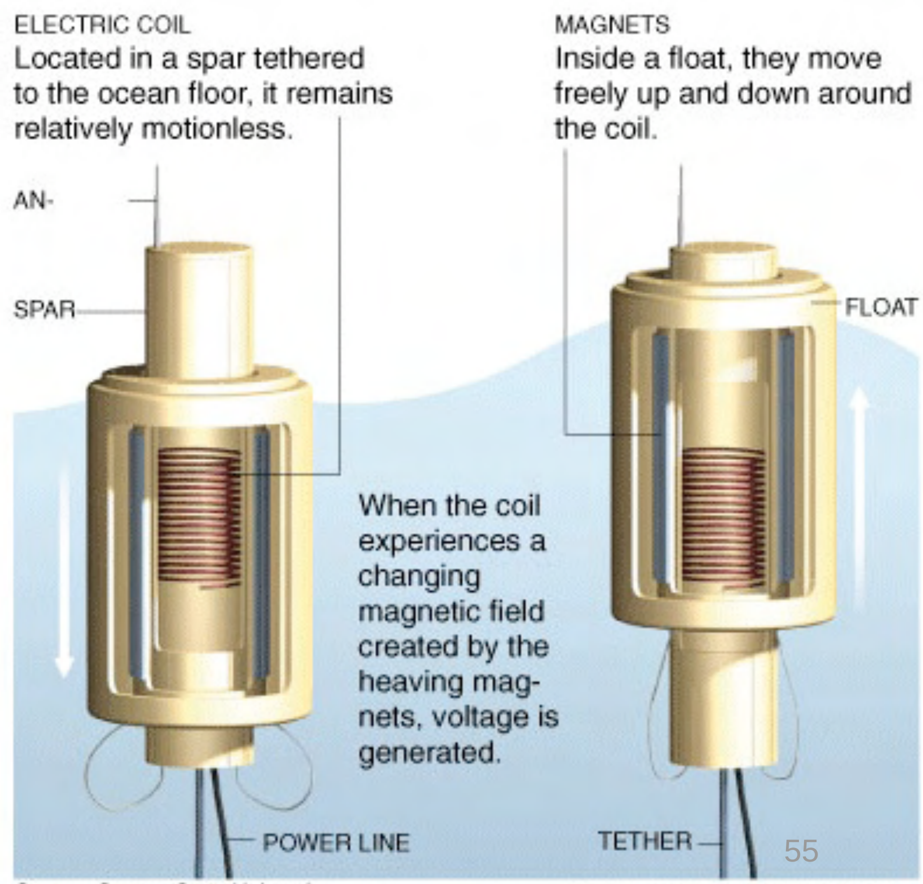


28% of Philippines power from geothermal



RENEWABLES FOR THE PACIFIC…. Wave Power ?

Pelamis

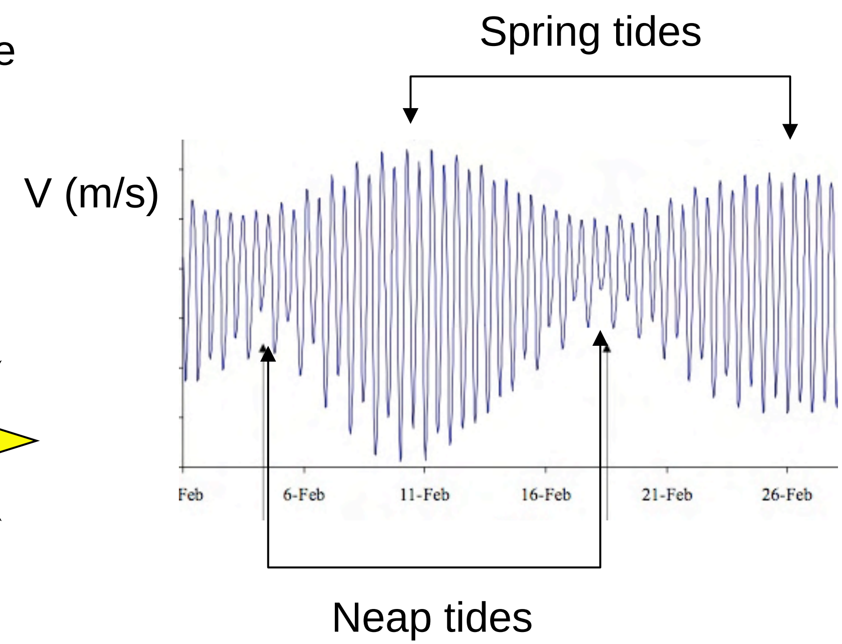


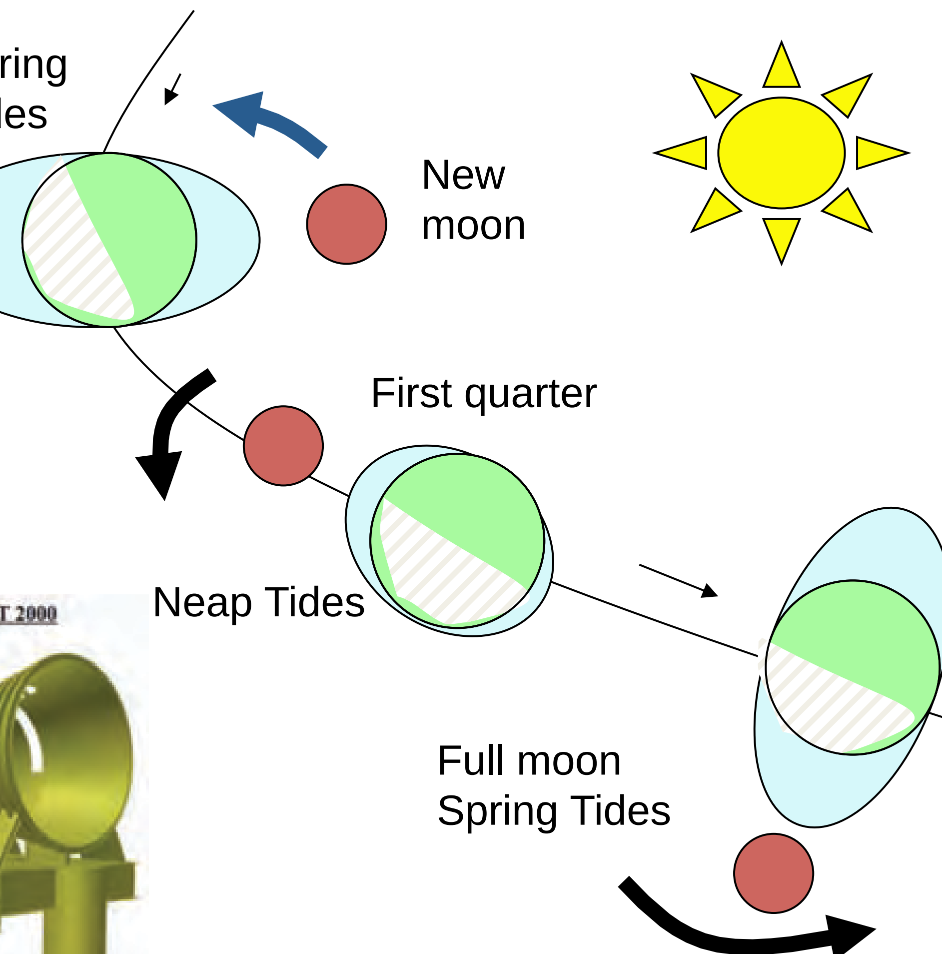
Source: Oregon State University

FRANK O'CONNELL/THE NEW YORK TIMES

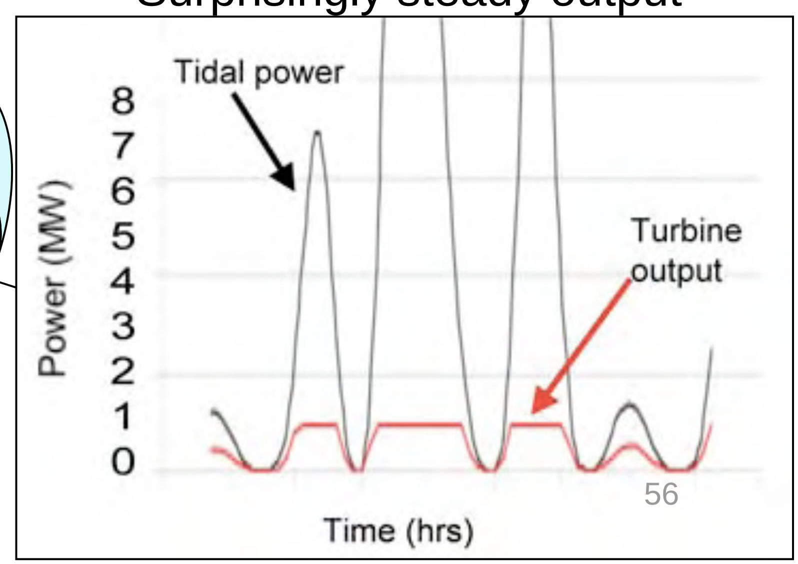
RENEWABLES FOR THE PACIFIC…. Tidal Power ?

Intermittent (like wind) but totally predictable





Surprisingly steady output



FOR RENEWABLES TO PLAY A SIGNIFICANT ROLE.. need a smart grid

Integration of generation, transmission/distribution, buildings, vehicle-to-grid

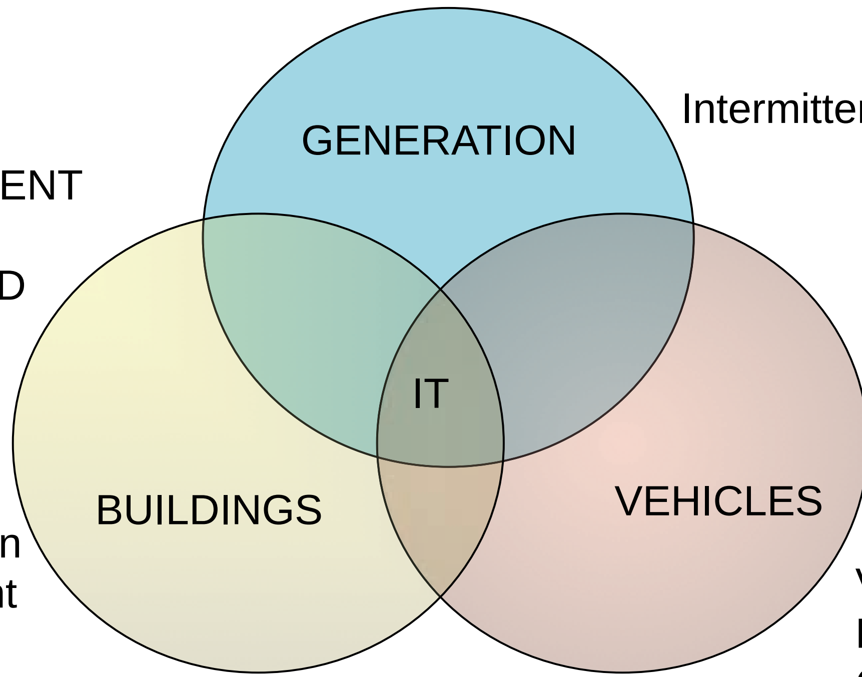
BOTH SIDES OF THE METER:

* PORTFOLIO OF RENEWABLES

* SMART METERS

• LOAD MANAGEMENT

• VEHICLE-TO-GRID



Intermittent Renewables

On-site Generation
Load Management
Energy Storage

Vehicle-to-Grid
Energy storage
Grid Support

PLANNING FOR A FUTURE WITHOUT OIL..

SHORT-TERM TASKS:

DEMONSTRATION PROJECTS

- Wind turbines (kW)
- Photovoltaics (kW)
- Energy-efficient Buildings (Residential, Small commercial, New and Retrofit)
- Electric vehicles (PHEVs, BEVs, 2-Wheel Evs)
- Biofuels (Biodiesel from waste oils)

MAP RENEWABLE ENERGY RESOURCES

CURRICULUM DEVELOPMENT…educating the green workforce of the future

- High school
  - Energy and environmental awareness, Environmental science
- Community College
  - Science, Technology, Policy
- Green Job Training Programs
  - Building energy auditors, retrofits; PV and wind installation

MEDIUM-TERM TASKS: Decision Making and Implementation

Follow Hawaii's Lead..

UTILITY-SCALE DEMONSTRATION PROJECTS

MW-scale Renewables (PVs, Wind, CSP, geothermal..)

Address transmission constraints

Diesel generators begin to act as backup power for renewables

Biodiesel (pilot projects) algae, wastewater, etc.

ZERO-ENERGY demonstration buildings

SMART METER INSTALLATION Begin demand response

VEHICLE RECHARGING STATIONS

LONGER TERM TASKS: Smart Grid Systems

INTEGRATION OF DISTRIBUTED GENERATION INTO THE GRID

- Intermittency of Renewable Energy Systems (easy for RE < 20%)
- Grid stability: Voltage, frequency, real and reactive power, reliability
- Demand response in buildings
- Energy storage: Battery, flywheels, vehicles, hydro

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PACIFIC ISLAND NATIONS CAN BECOME THE PROVING GROUND FOR RESEARCH, DEVELOPMENT AND DEMONSTRATION OF THE THE COMING SMART GRID….. !

The best time to plant a tree was 20 years ago.

The second best time is today.

--ancient Chinese proverb