Extreme Energy Efficiency

Useful Intersections of Science and Public Policy

American Academy for the Advancement of Science
- Annual Meeting -
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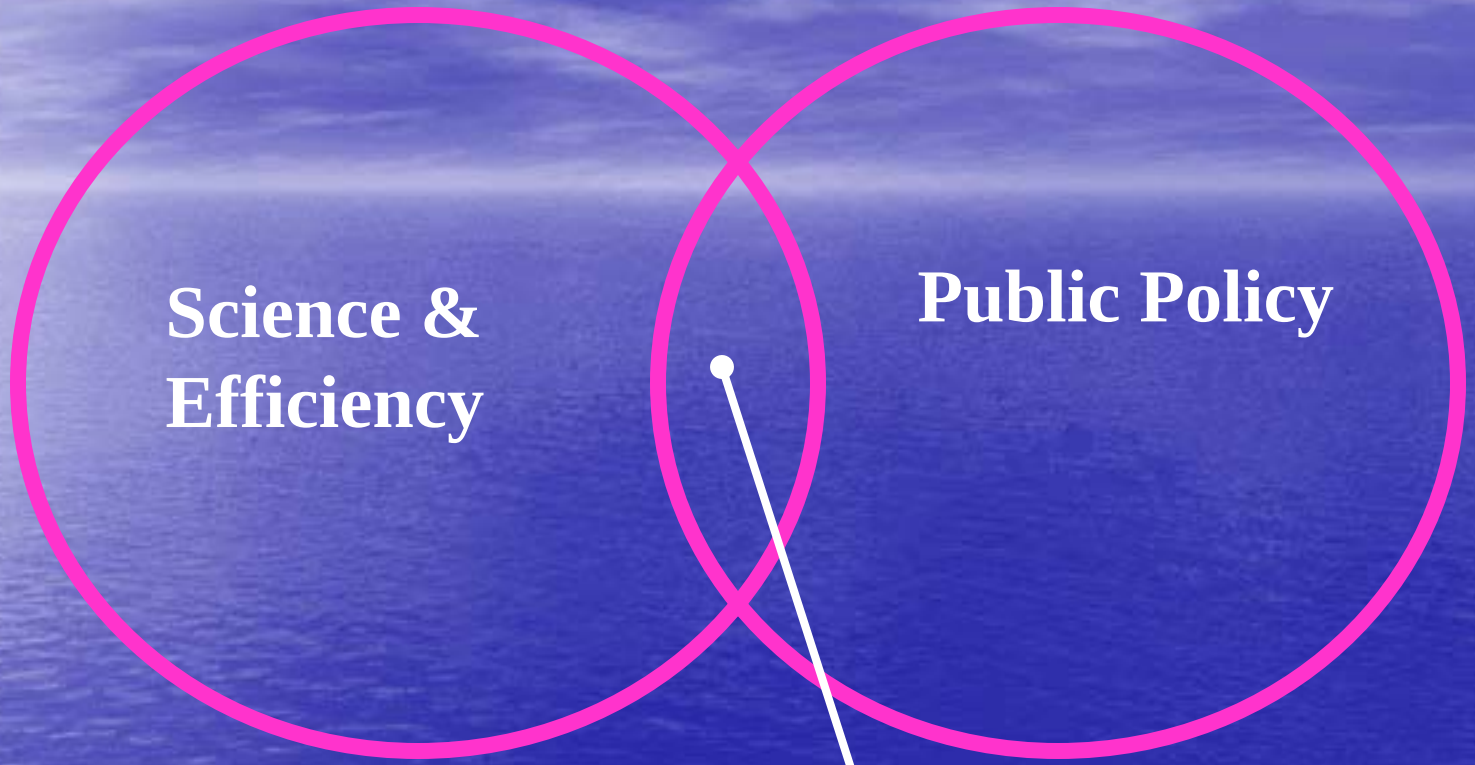
Overview



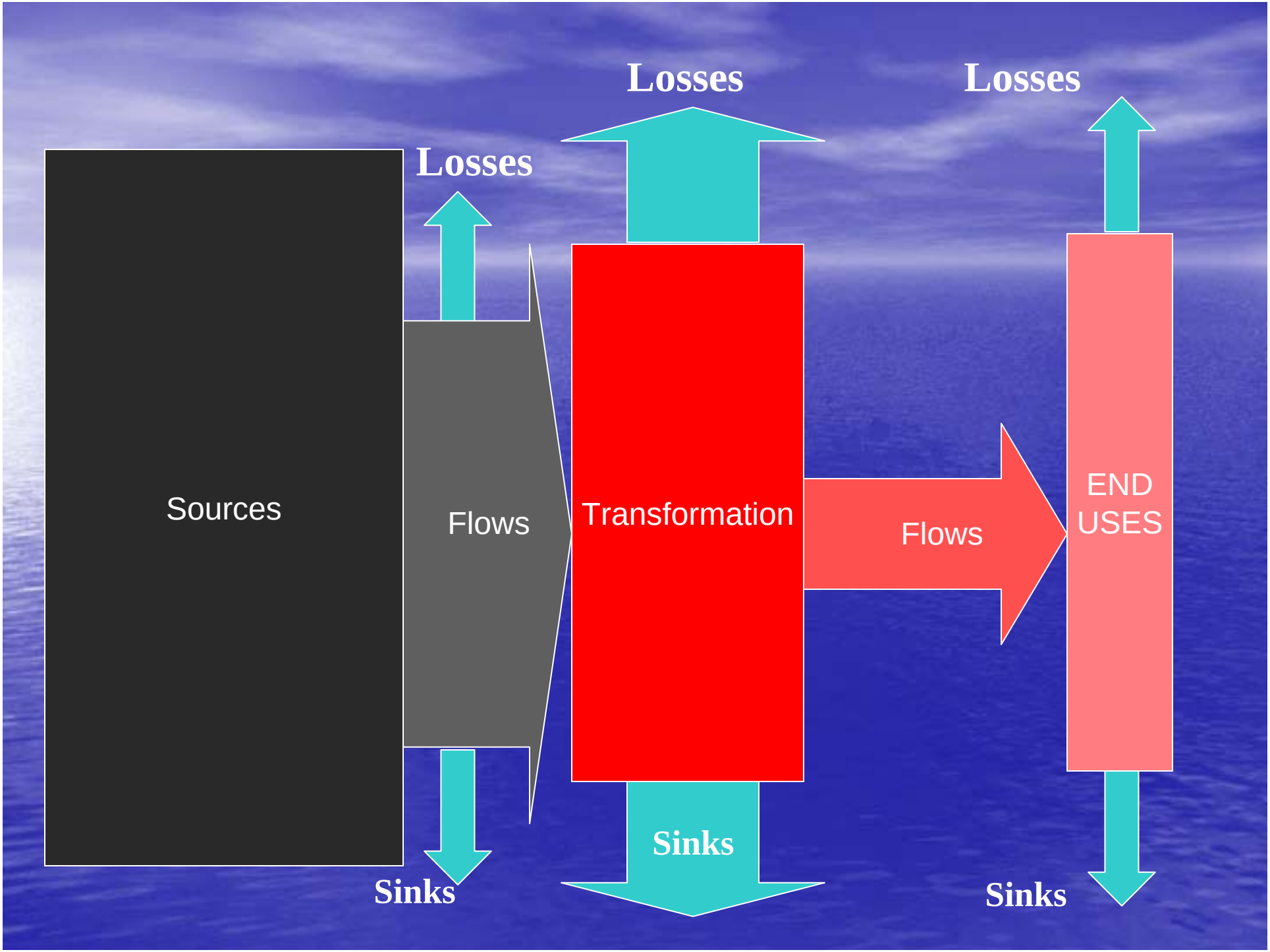
Useful Intersections & Successes

Where Might We Go from Here?

Efficiency in the Looking-Glass
- Cycles -

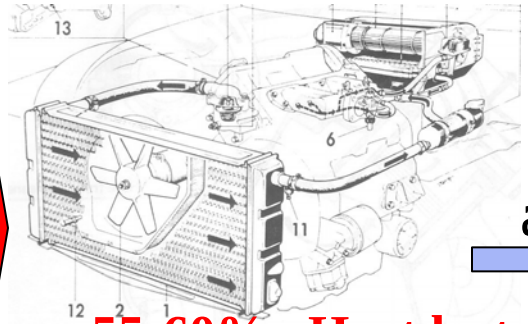
- *Carnot*
- Otto
- Diesel
- Atkinson
- Rankine
- Stirling
- Brayton/Joule
- etc.

Traditional view of efficiency as:
Useful Energy OUT / Energy IN


Losses
Losses
Losses
Sources
Flows
Transformation
Flows
END USES
Sinks
Sinks
Sinks

Typical Automotive Energy Losses

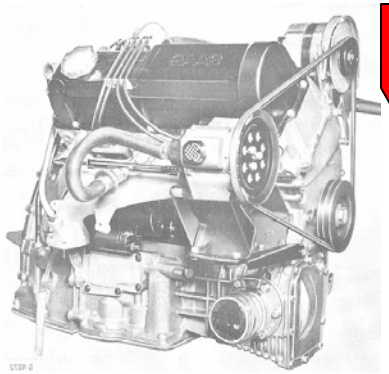
IN



55-60%- Heat lost

Converting Chemical to Mechanical energy

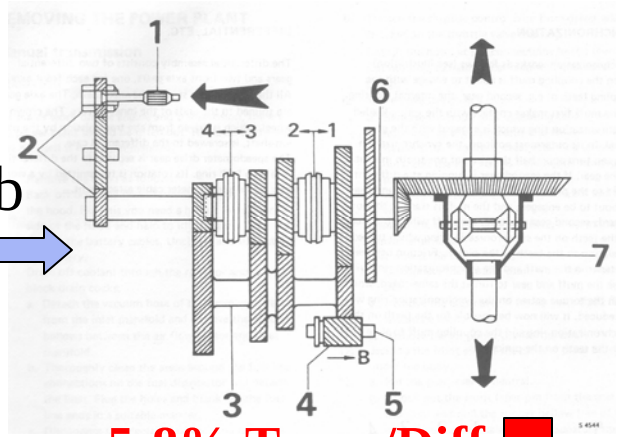
a



10% internal Engine Friction Losses

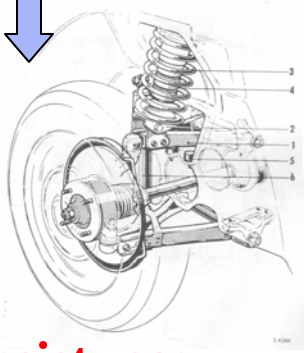
5% Lost to Accessories

b

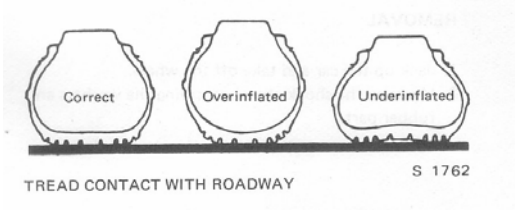


5-8% Trans/Diff.

c



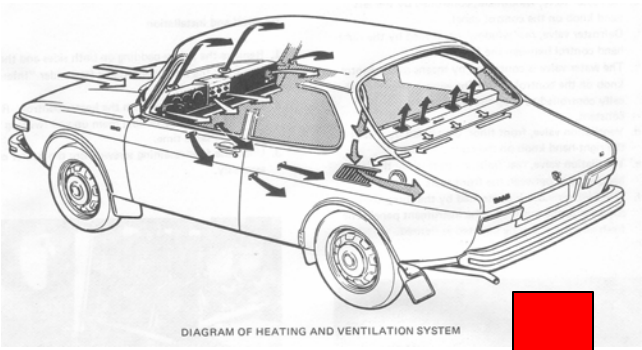
5% Rolling Resistance



d

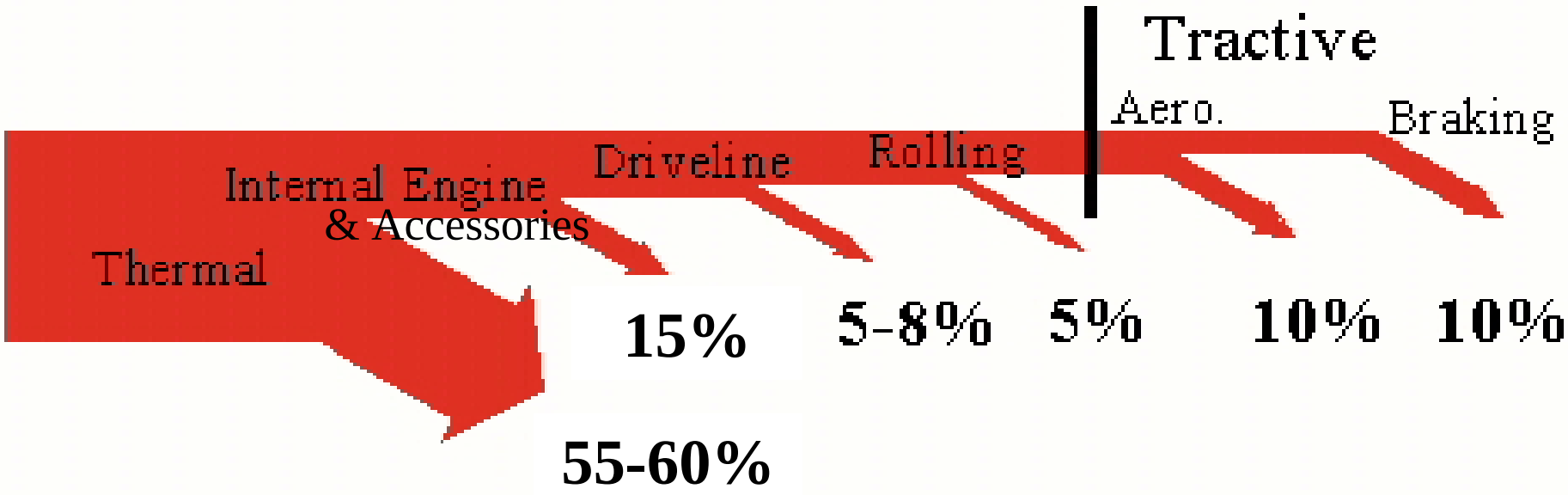
10-20%

Tractive:



Load, Aero./vents, Braking

Efficiency in the Looking-Glass



Traditional View of Efficiency

Efficiency in the Looking-Glass

EXTREME EFFICIENCY requires comprehensive system-wide thinking:

Useful Human OUTCOMES / Energy IN

TRADITIONAL:

-Engineering Efficiency of automotive Powerplant or propulsion unit

EMERGING:

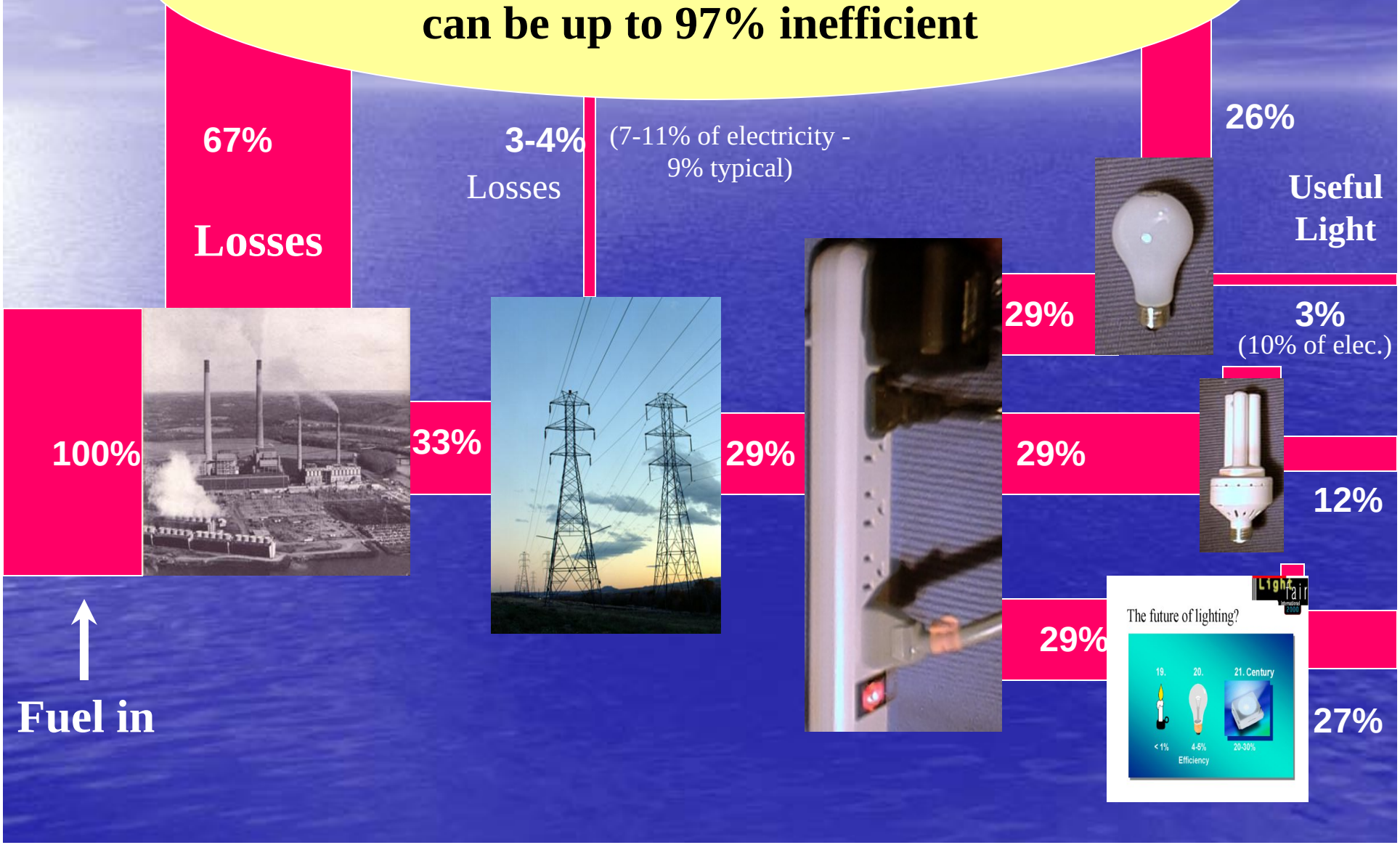
- Efficiency of transportation SYSTEM

- Propulsion unit

- Load factor

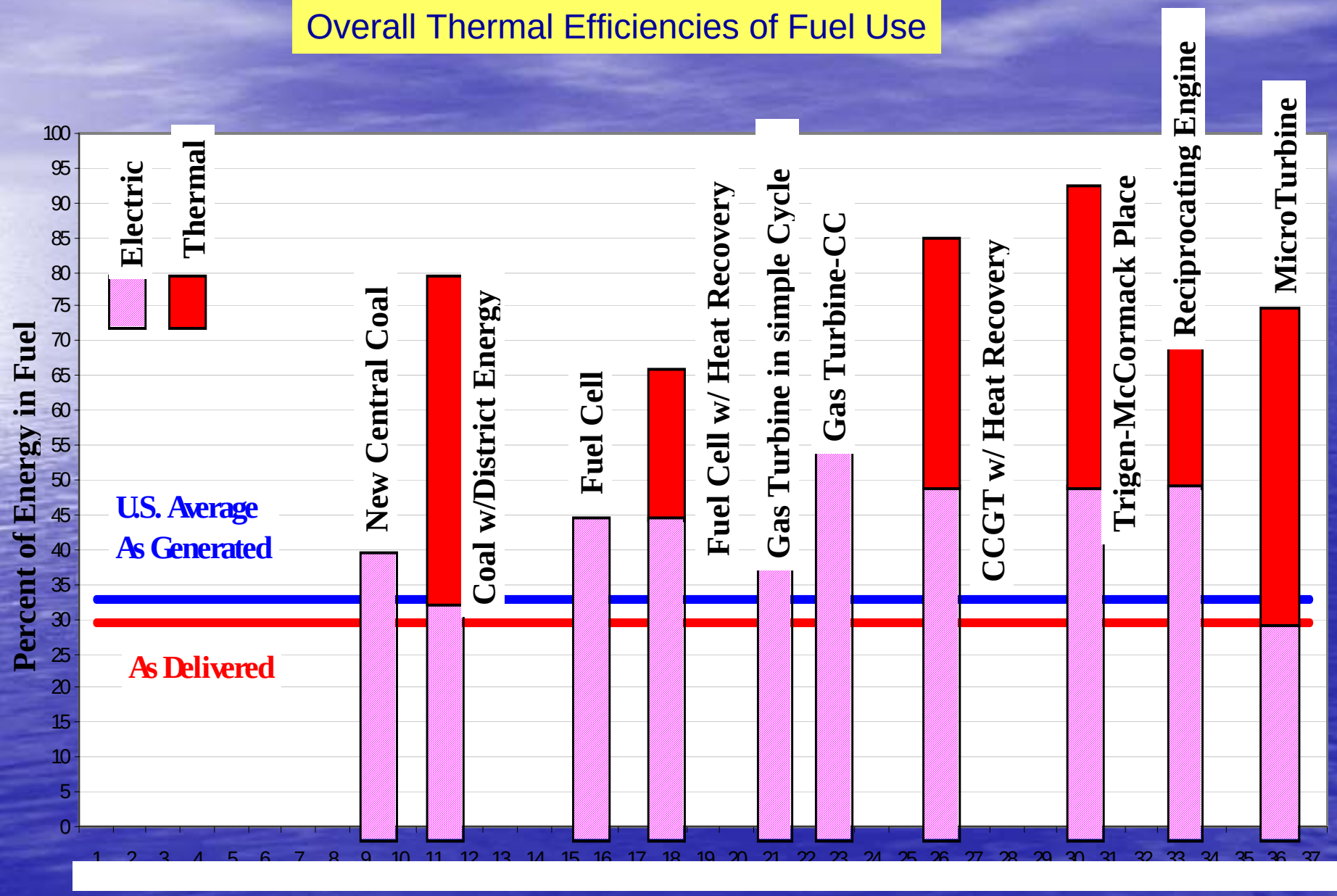
- Highway congestion/efficiency

If you want only illumination, the current electric energy delivery system can be up to 97% inefficient

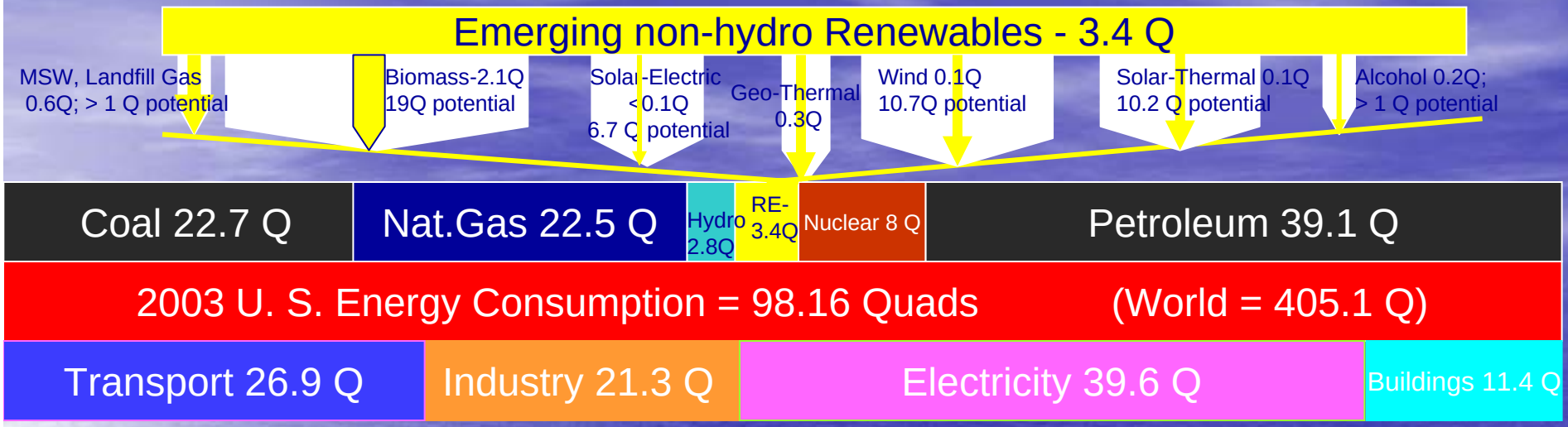


Useful Human OUTcomes/Energy IN

Overall Thermal Efficiencies of Fuel Use



Approximate U.S. Energy Flows - 2003



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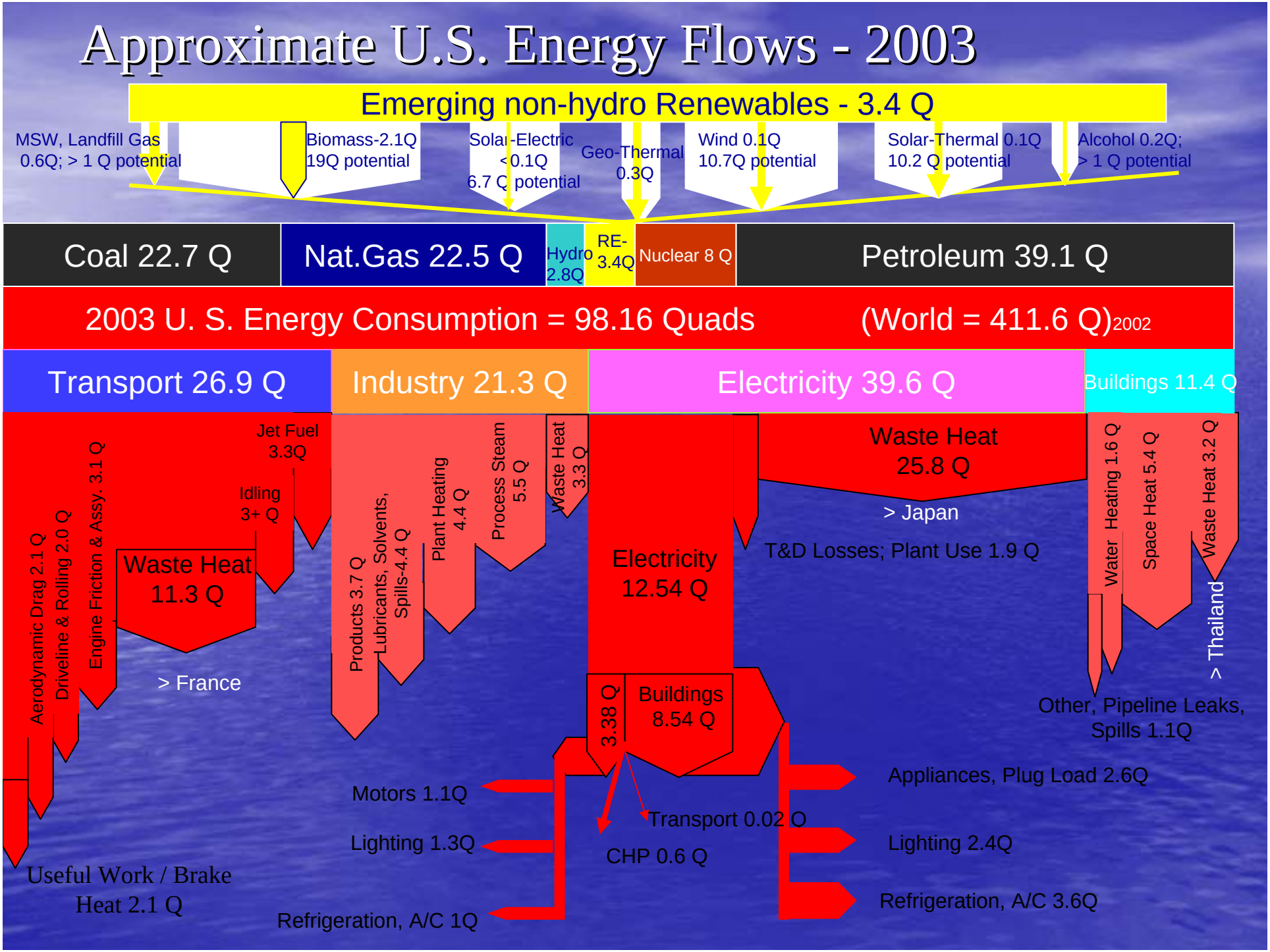
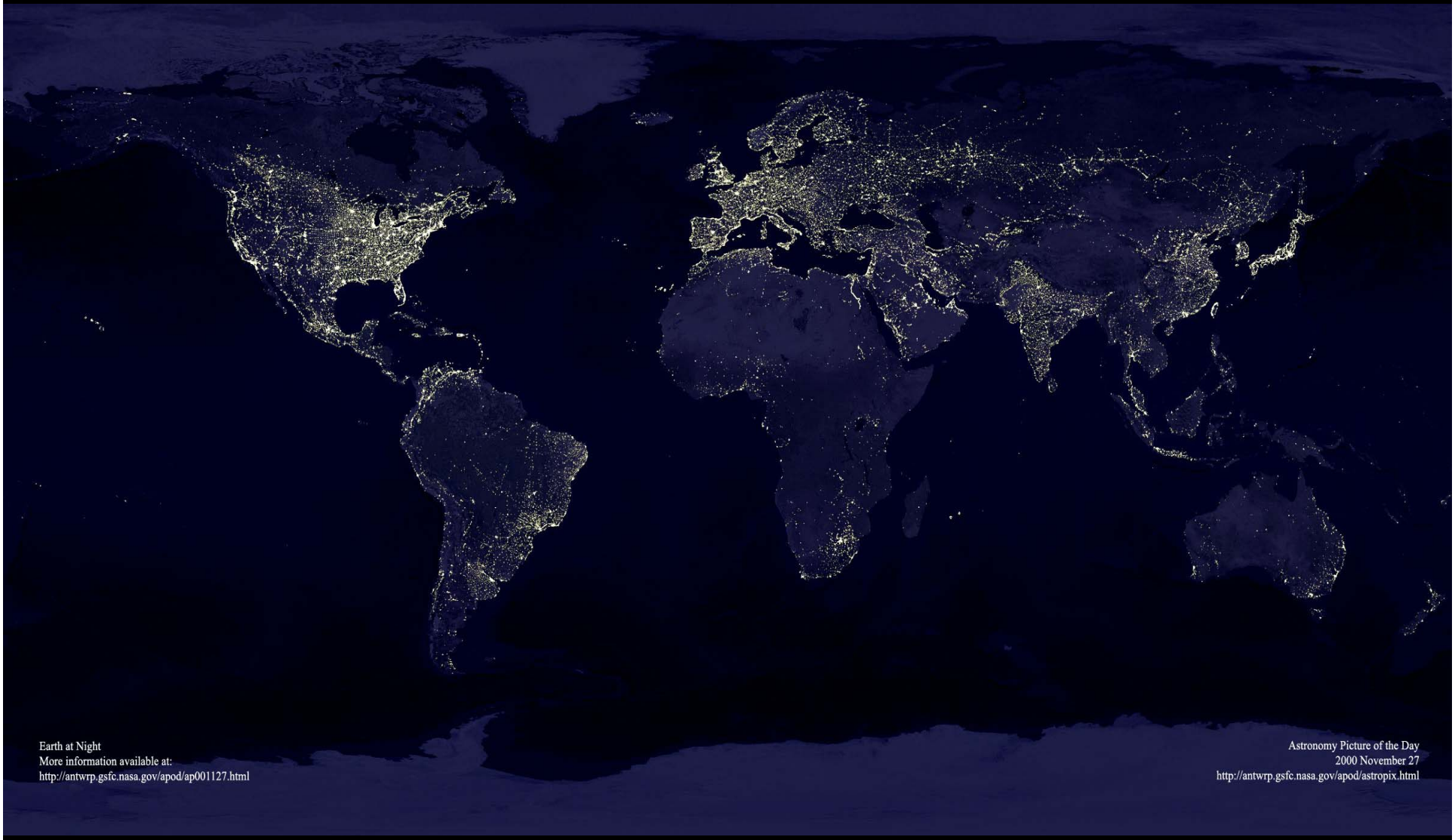
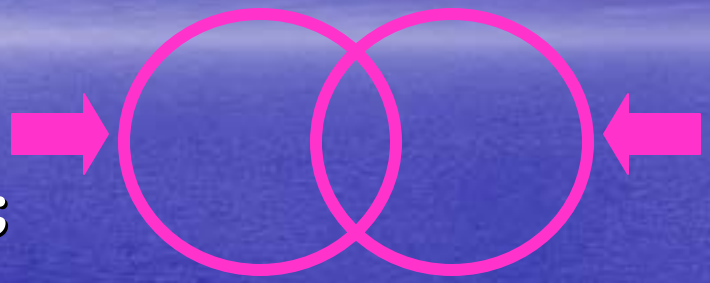


Earth at Night as viewed from Space



…yet 1/3 of Earth's human population lacks access to electricity…

Public Policy in the Looking-Glass: Public Policy GOALS



- **Provide for the Common Good;**
- **Ensure Domestic Tranquility;**
- **Provide for the Common Defense;**
- **Promote the General Welfare;**
- **Protect basic freedoms-** unreasonable search and seizure, etc.
- **Establish Justice,** Provide framework for Due Process, etc.
- **Secure the Blessings of Liberty to ourselves <u>and our Posterity</u>;**
- **Trending toward a "more perfect Union"...**

- Protect Human Health and Welfare - Clean Air Act 1970
- Restore & Maintain Chemical, Physical and Biological Integrity of the Nation's Waters - fishable, swimable, etc. - Clean Water Act, 1972

Public Policy TOOLS

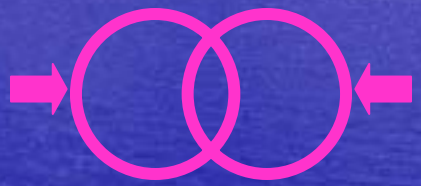
- Lead by Example, (*Greening of the White House*)
- Financial and Fiscal Policy
  - taxes
  - underwriting loans, loan guarantees
  - revolving funds
  - bond underwriting & rating policies
  - grant conditioning
- Laws, Regulations & Standards *(mil. Spec., CAAA90);*
- R&D; Incentive Programs - (*Golden Carrot*);
- Voluntary Programs- *(1993 Climate Change Action Plan)*
- Federal Purchasing, procurement;
- Bully pulpit; Seal of Approval *(Energy STAR)*

Public Policy QUESTIONS

How effective /efficient /efficacious is current policy?

Where and How does current policy miss the mark?

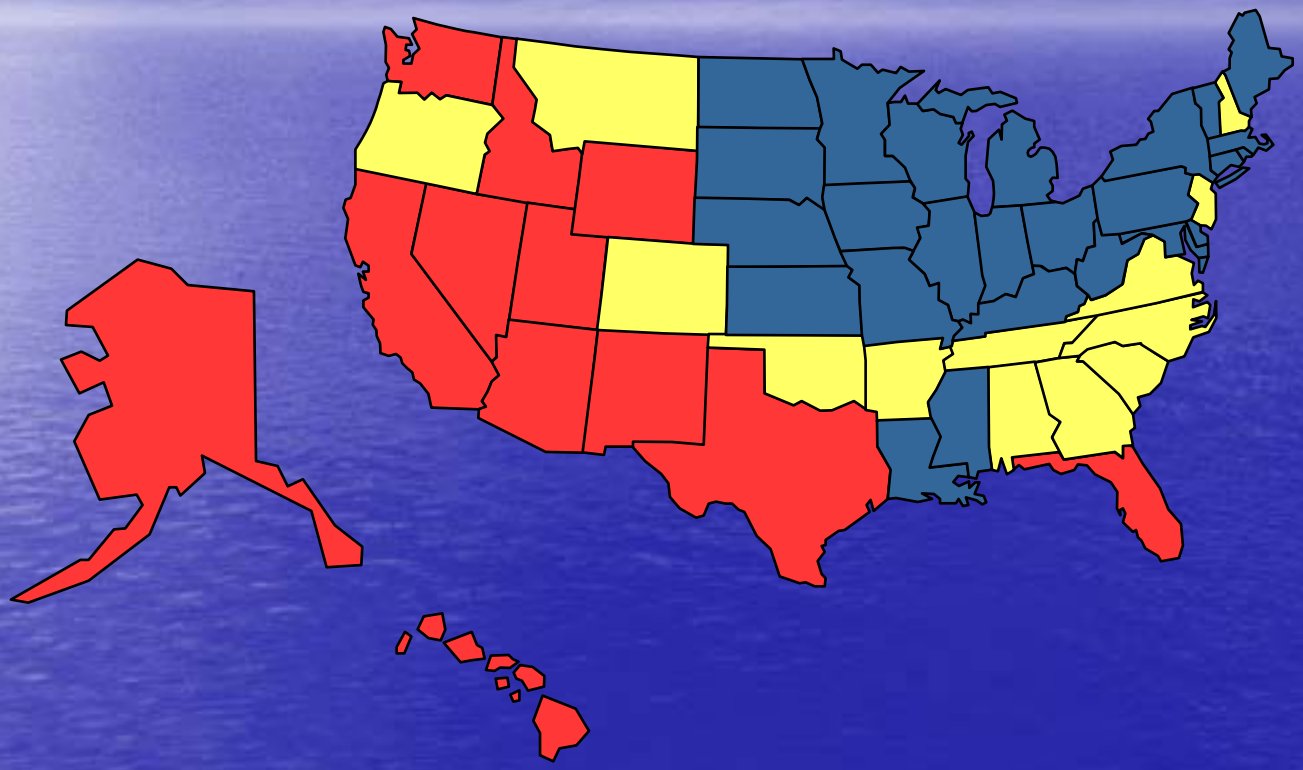
How might our aim be improved?



How might policies be aligned more surgically and systematically? Today? Tomorrow?

What is standing in the way of comprehensive integration? …of Extreme Policy Efficiency?

U.S. Population Growth Projections 1995-2025



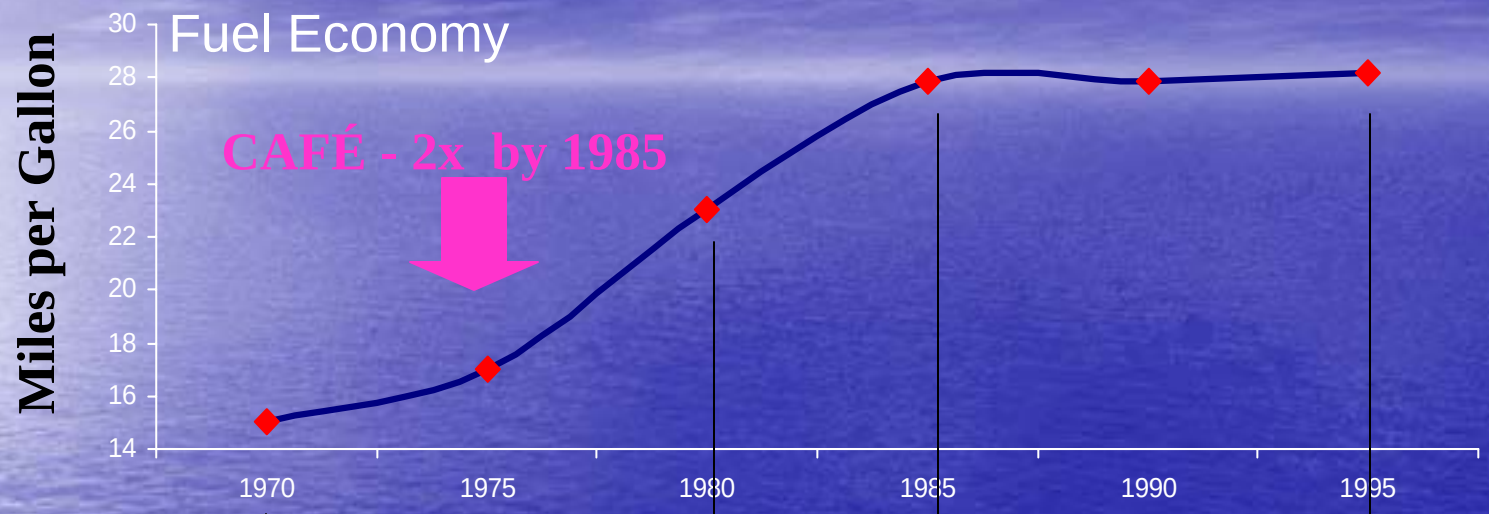
<20% 20-40% >40%

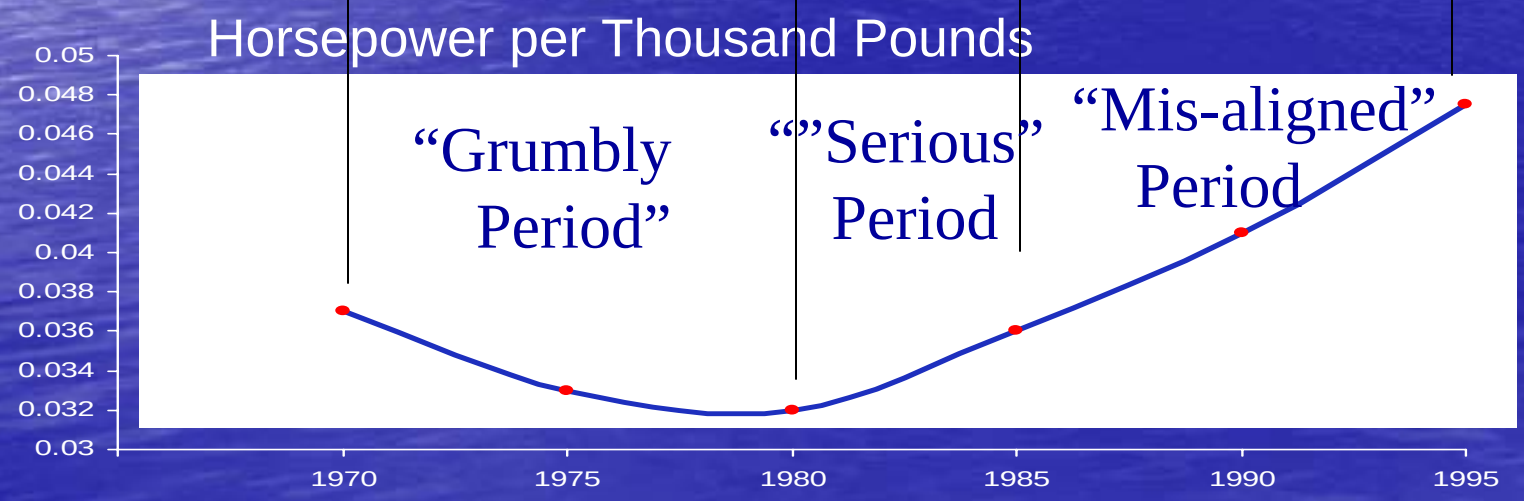
Presumably, Public Policies should be “Forward-Looking”...

Public Policy in the Looking-Glass: Air Emissions & Public Health

- 54 million Americans live in counties that regularly violate air quality standards.
- The American Lung Association estimates that Americans spend $50 billion a year on health care as a result.

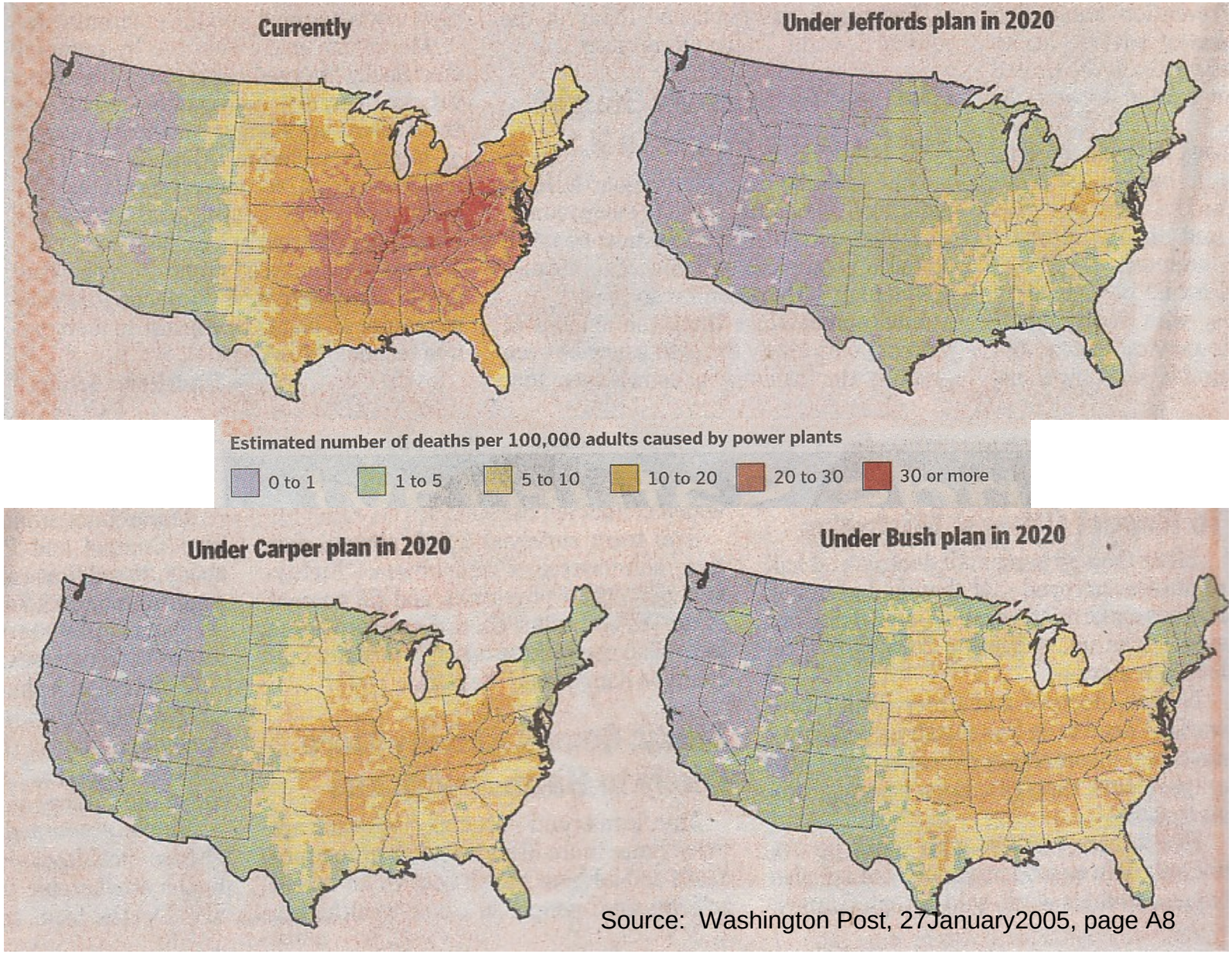
Passenger Car Performance





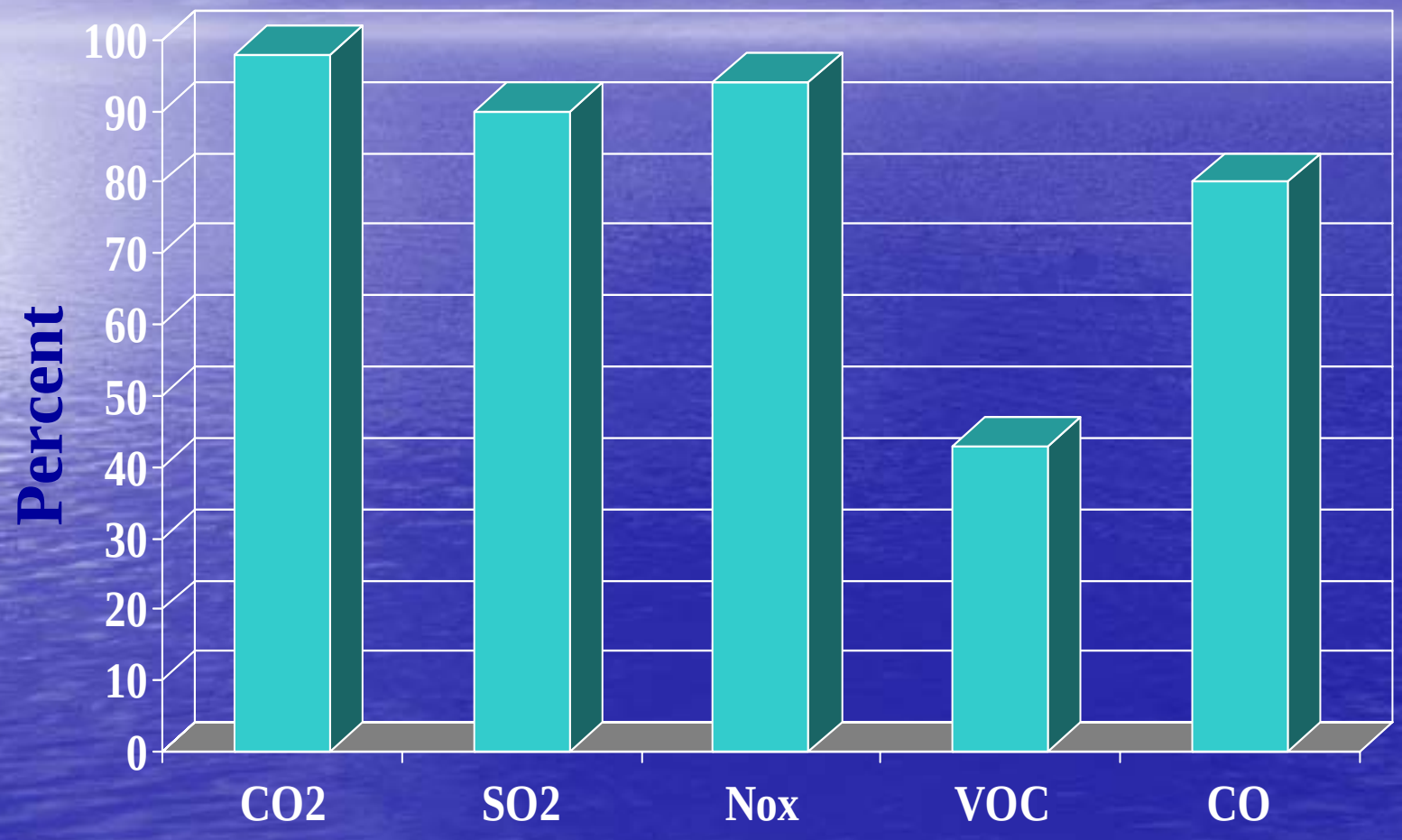
Intersections of Science and Policy

- Air Quality and Estimated Deaths -



Source: Washington Post, 27January2005, page A8

Emissions from Combustion-based Energy Use

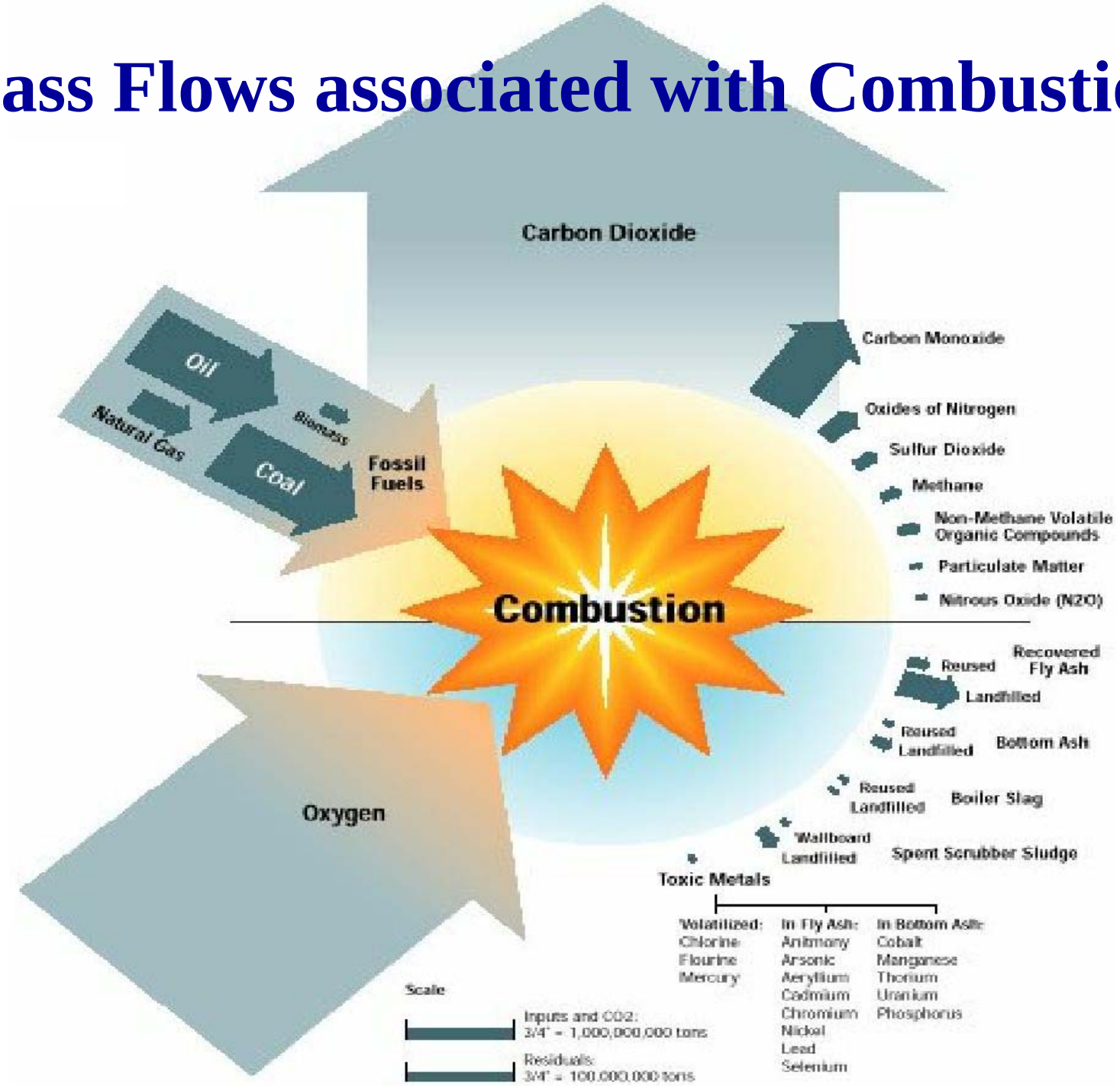


Source: 1999 Emissions Trends Report, EPA

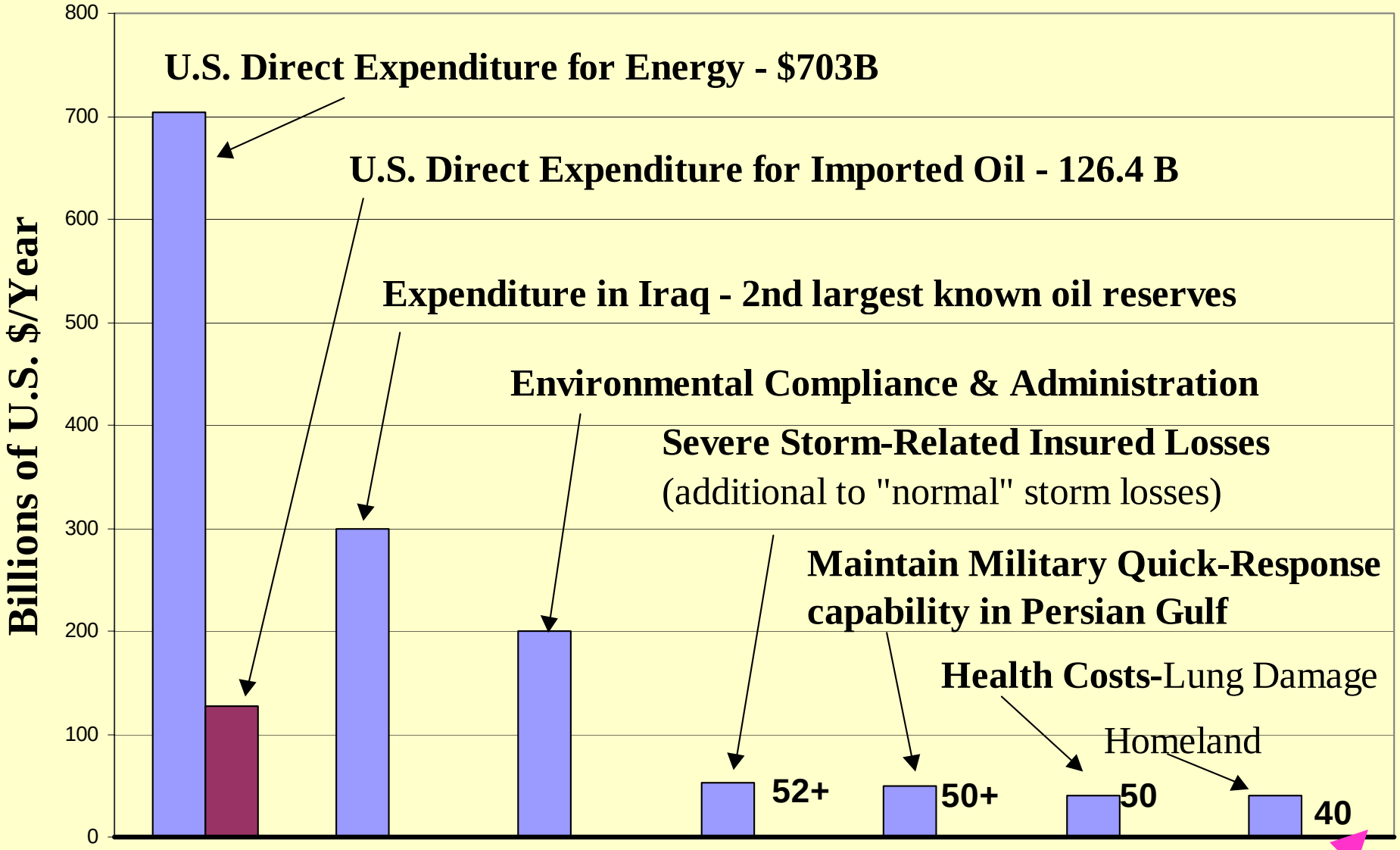
Mass Flows associated with Combustion:

- Inputs and output flows scaled – (tons/year)
- Inputs, Oxygen and CO2 scaled at ¾ inch = 1 Billion tons/year
- Residuals scaled at ¾ inch = 100 million t/y
- Criteria Pollutants <u>plus</u> 22 additional elements and compounds

Mass Flows associated with Combustion:

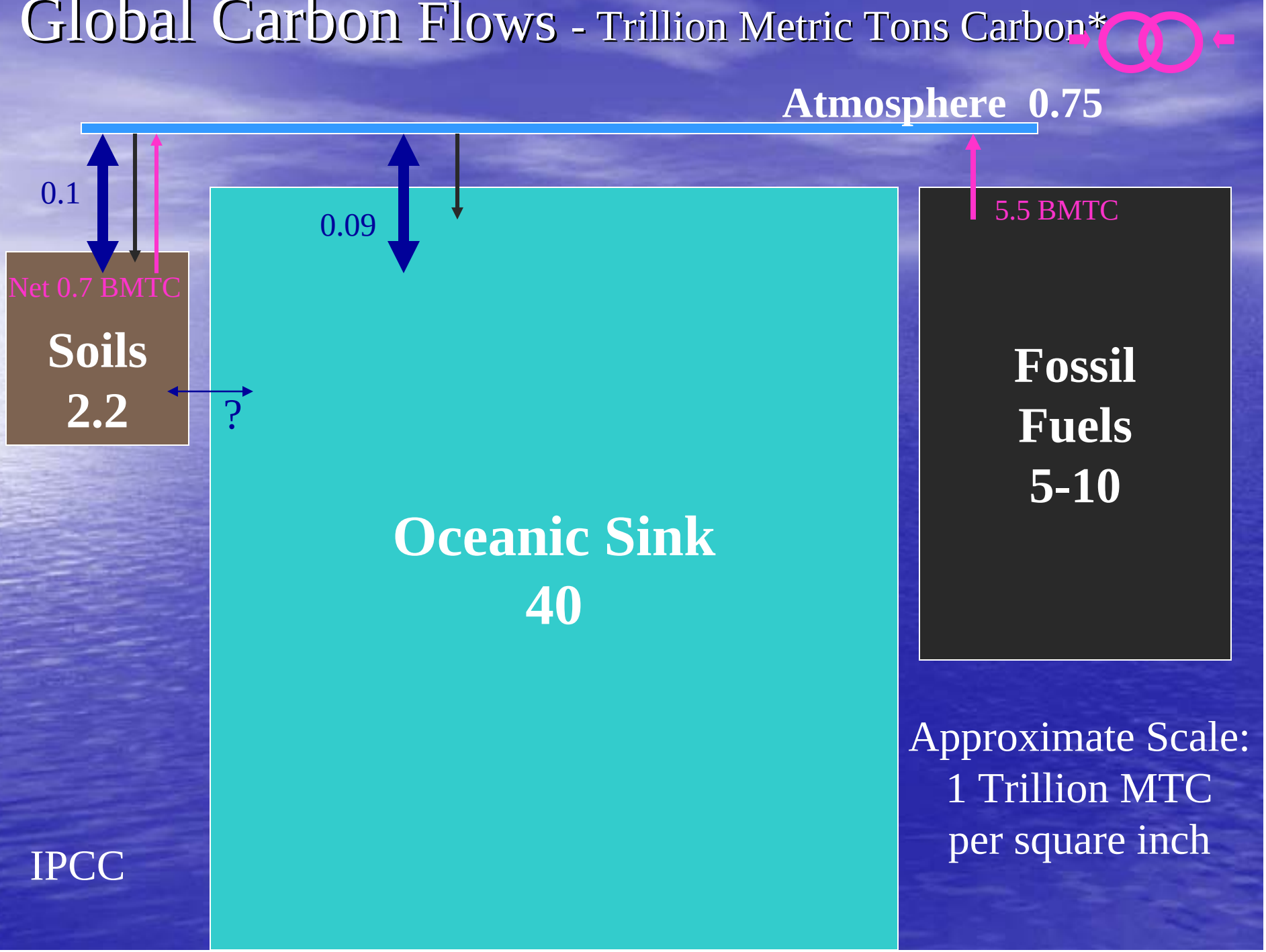


Energy and Related Costs



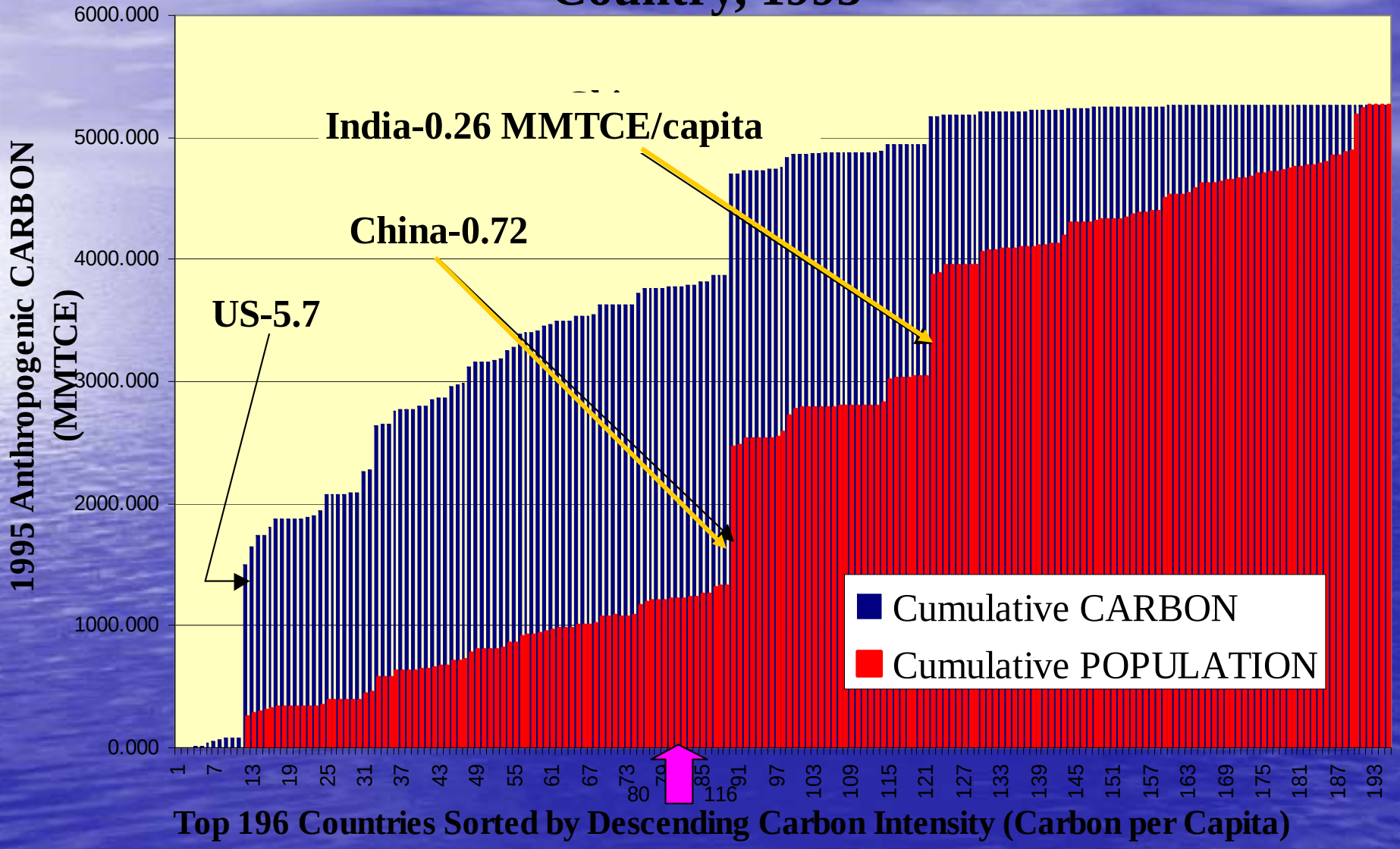
Federal Expenditure on Energy Efficiency R&D, < $1B

Global Carbon Flows - Trillion Metric Tons Carbon*



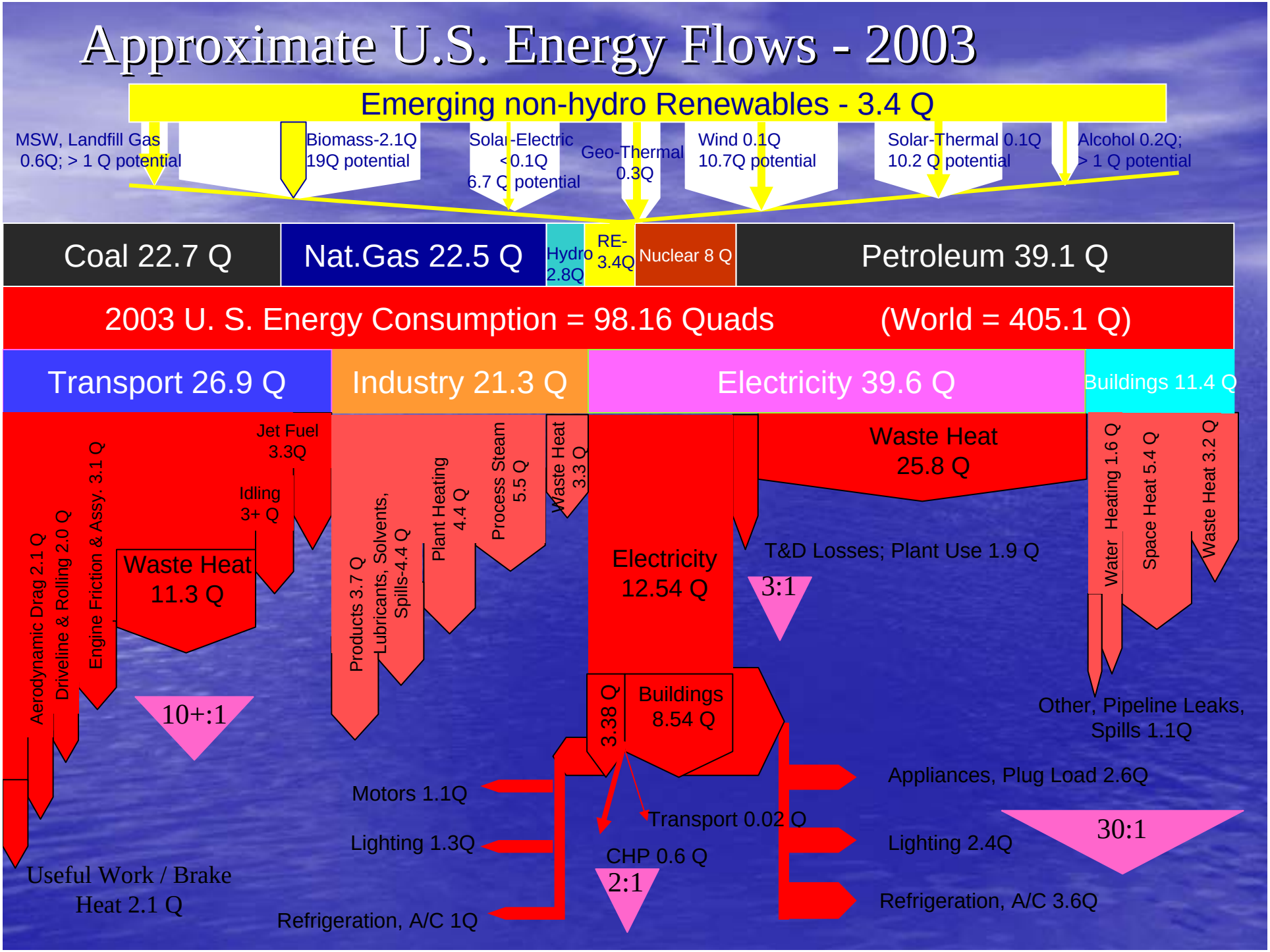
IPCC

World Cumulative CARBON and POPULATION - by Country, 1995



Average Planetary Citizen emits 1 metric ton of Carbon per Year

Approximate U.S. Energy Flows - 2003



Some Successes

- E-Glass $3M-> $750M/yr; 30% new glass
- Electronic Ballasts: $3M -> /$275M/yr.
- Flame Retention Head Oil Burner
- Green Lights
- Energy Star
- Golden Carrot programs
- Cool Communities

Current Performance Examples: based on GAO comments and analysis

	$ Billions	MMTCE
Building Design Software energy savings directly linked to DOE	11.0	
Refrigerator Compressor energy savings directly linked to DOE	6.0	
Electronic Ballast energy saving of ballasts in use	3.7	
Flame Retention Head Oil Burner consumer savings from market acceleration	5.0	
Advanced Windows savings of windows in use	3.0	
Cumulative Savings	**$ 28+**	
Total Energy Efficiency R & D Budget FY 78-97	**$ 8+**	
Annual Carbon Savings in MMTCE		**16**

***Note: All savings are net present value in 1996 dollars; the estimates take into account the recommendations provided by the General Accounting Office in their 1995/1996 review. Savings for burner and compressor are through 1996 only; the remainder are savings over the lives of investments made through 1996.**

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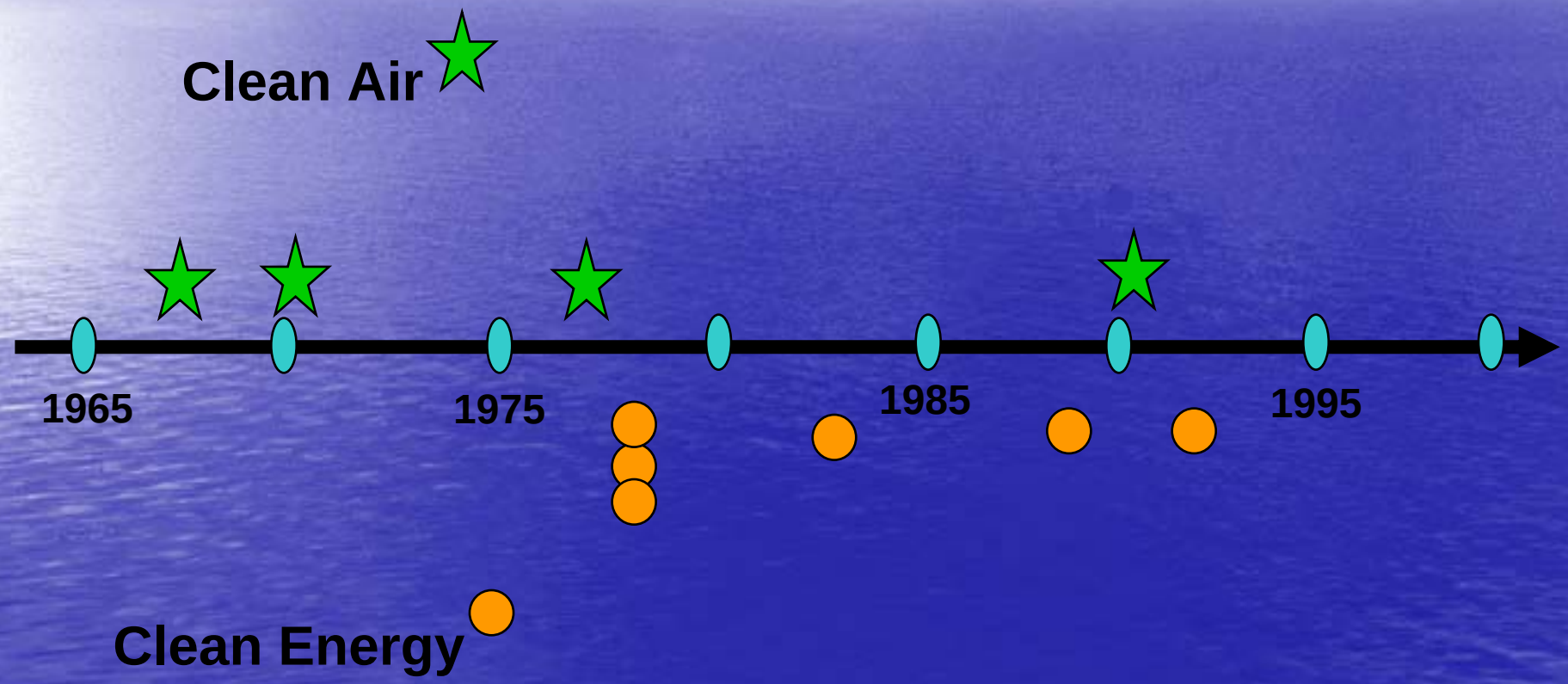
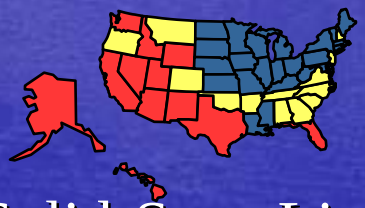
Where Might We Go from Here?

Legislative Timeline



Some Likely Features of the *ENERGY SELF-RELIANCE, HOMELAND SECURITY and OIL SUBSTITUTION ACT of 2009*

- Electric Infrastructure Security through Distributed Generation and Rooftop Photovoltaics
- Light-colored Surfaces for Roofs and Cities;



- Enhanced Market Penetration & Diffusion of Solid-State Lighting & Electro-Chromic Glass;
- Combined Heat and Power as the Design of First Choice - burden on applicant to show non-feasibility (after UK model)
- Revolving Efficiency Investment Fund for States and Cities
- National implementation of California system of FeeBates to encourage Efficiency, discourage inefficiency;

ENERGY SELF-RELIANCE, HOMELAND SECURITY and *OIL SUBSTITUTION ACT of 2009* Continued...

- Federal highway funding linked to State adoption of FeeBates; demonstrated efficiency of transport system;
- Quadrupling of the Energy-Related Inventions Program and "pathfinder" technology development programs;
- Simplification and Harmonization of the Tax Codes to promote System Efficiency;
- Comprehensive Integration of Energy & Environmental policies.

Extreme Energy Efficiency

Useful Intersections of Science and Public Policy

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