The Limits of Technology or The Need for Behavioural Change in Transportation

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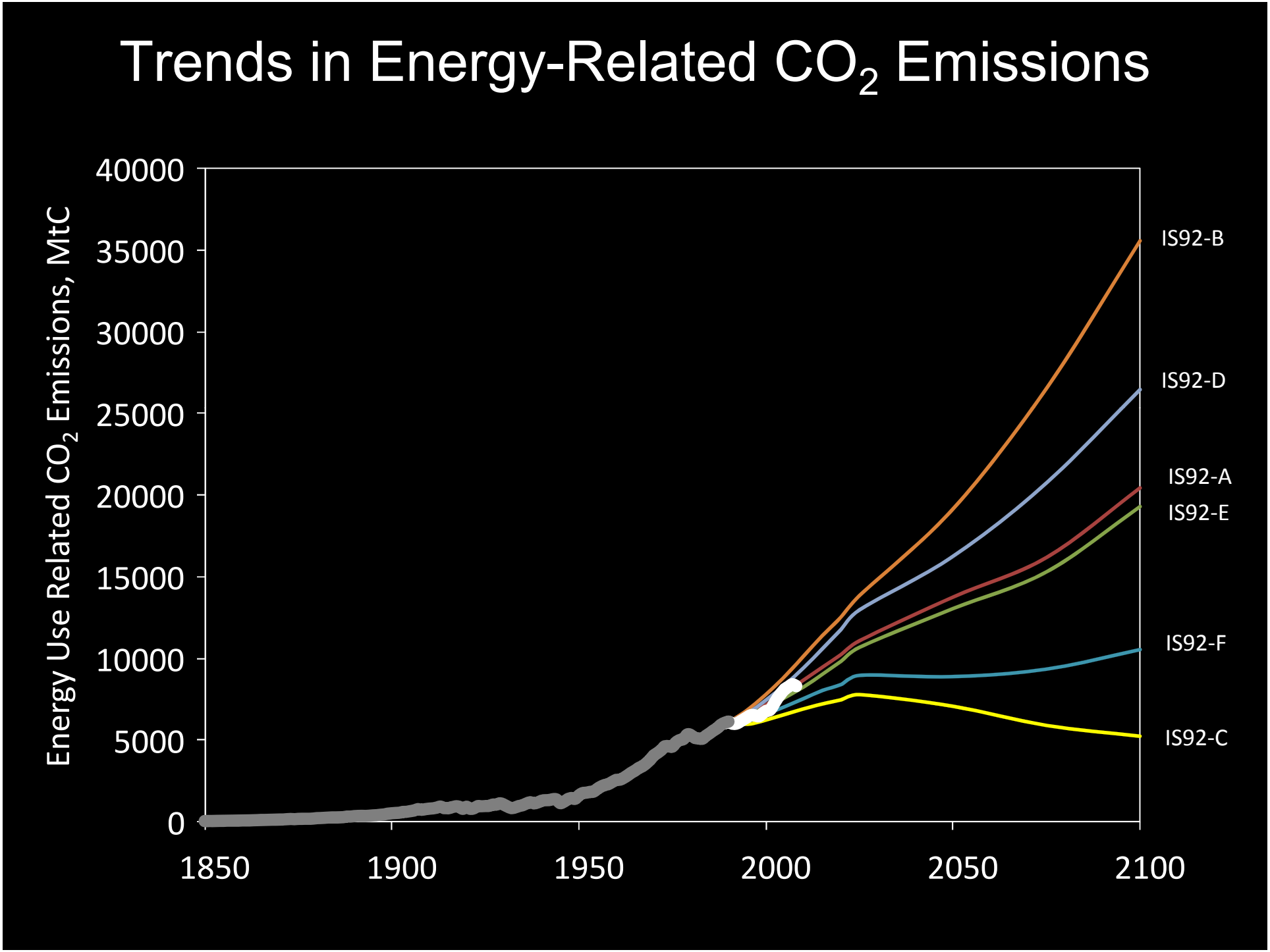
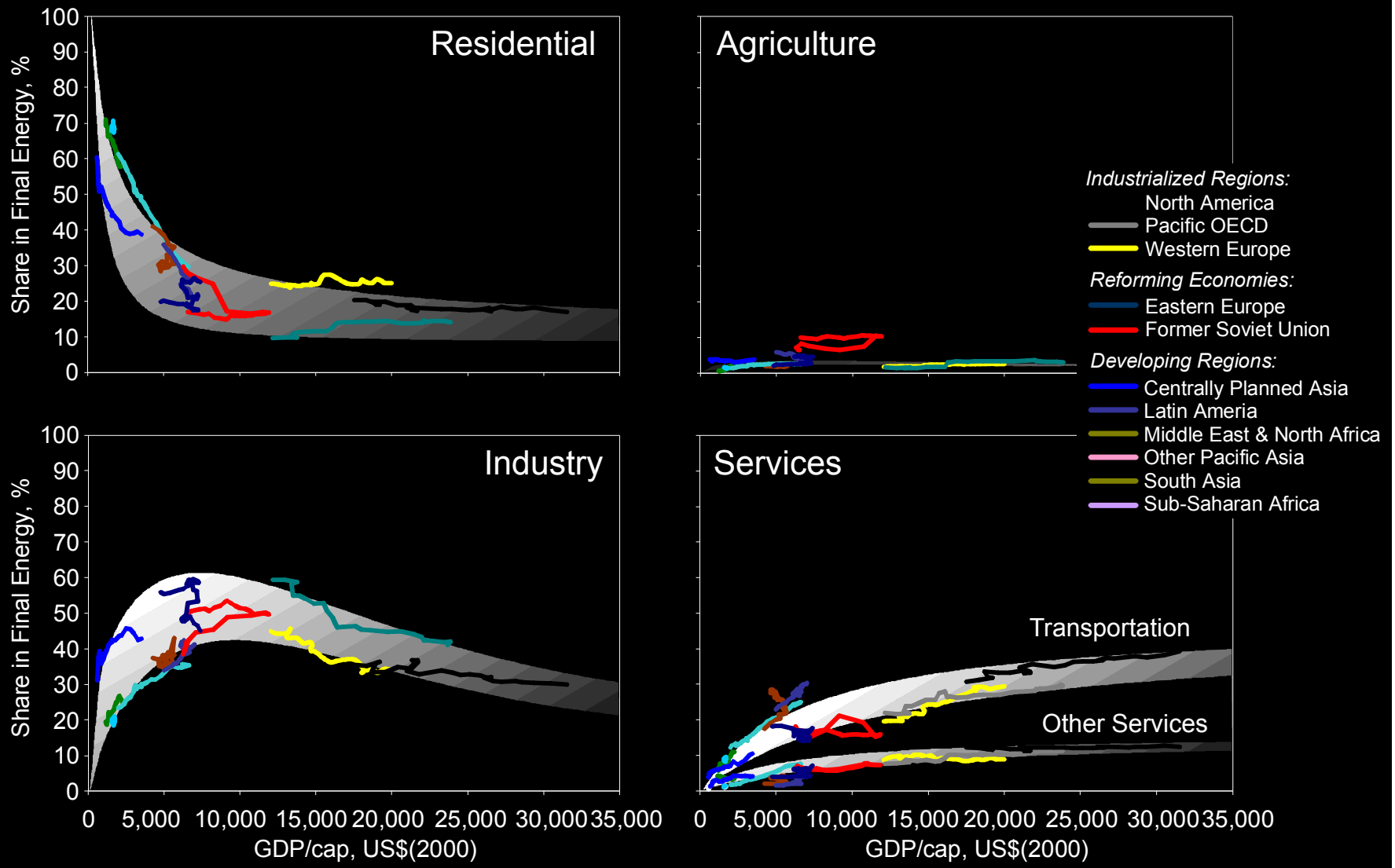
Trends in Energy-Related CO_2 Emissions



Structural Change in the Energy System

(Time series data from 1971 – 1998)

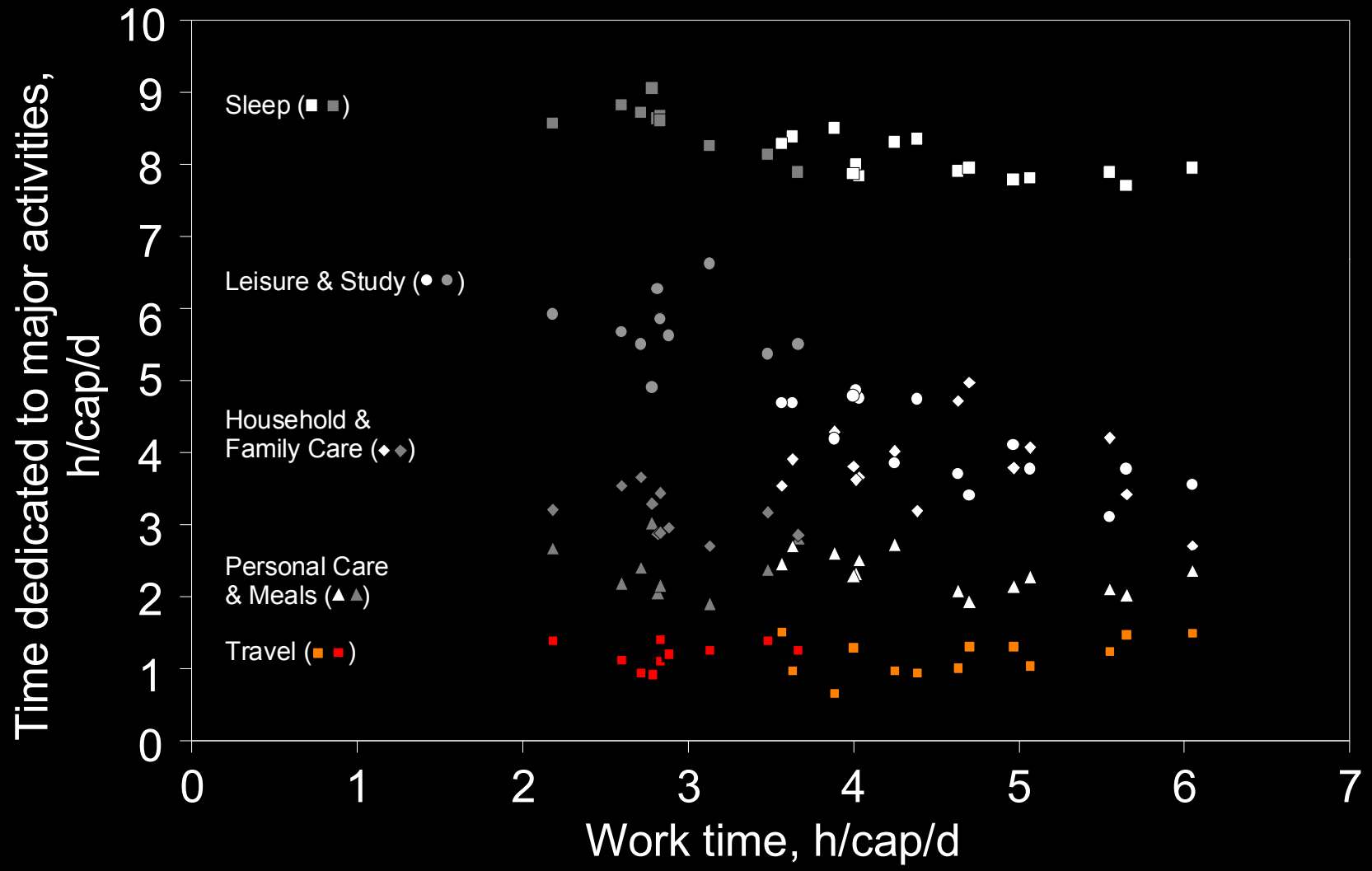


Greenhouse Gas Emissions: Identity

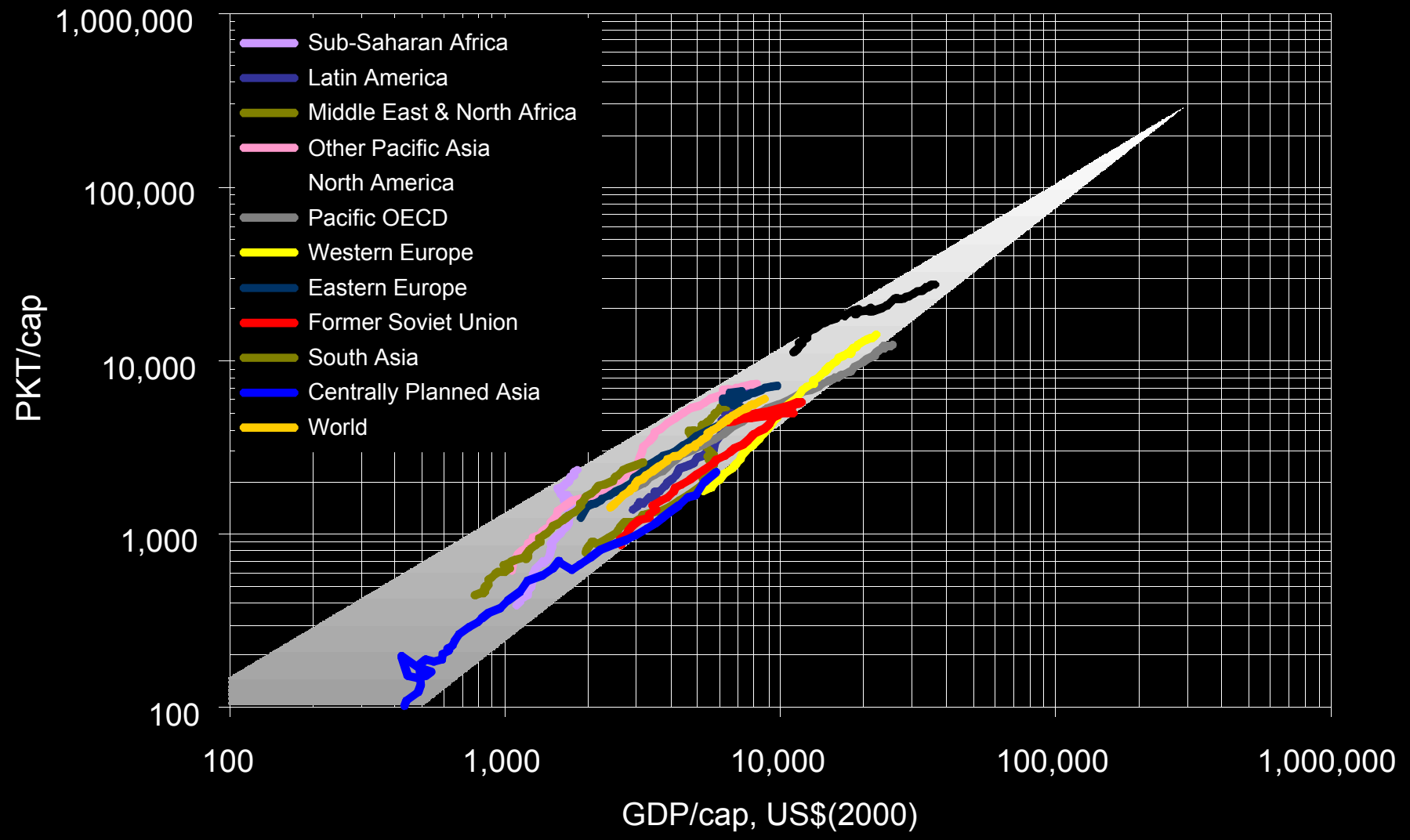
$$GGE = \frac{GGE}{E} \cdot \frac{E}{PKT} \cdot PKT$$

Travel Time Budget: Stability

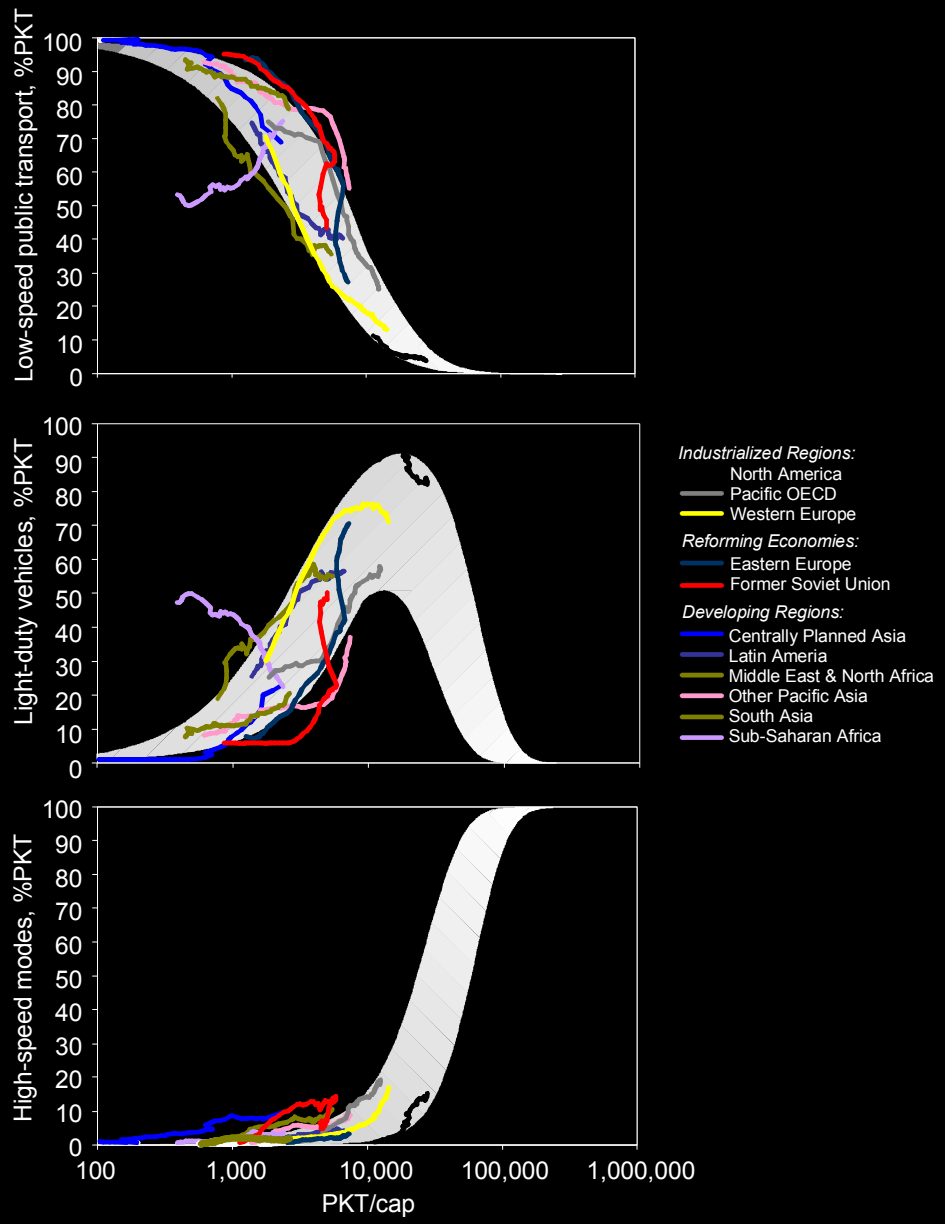
Time-use surveys, 1965/66 and early 2000s



Growth in Global Mobility (1950-2005)



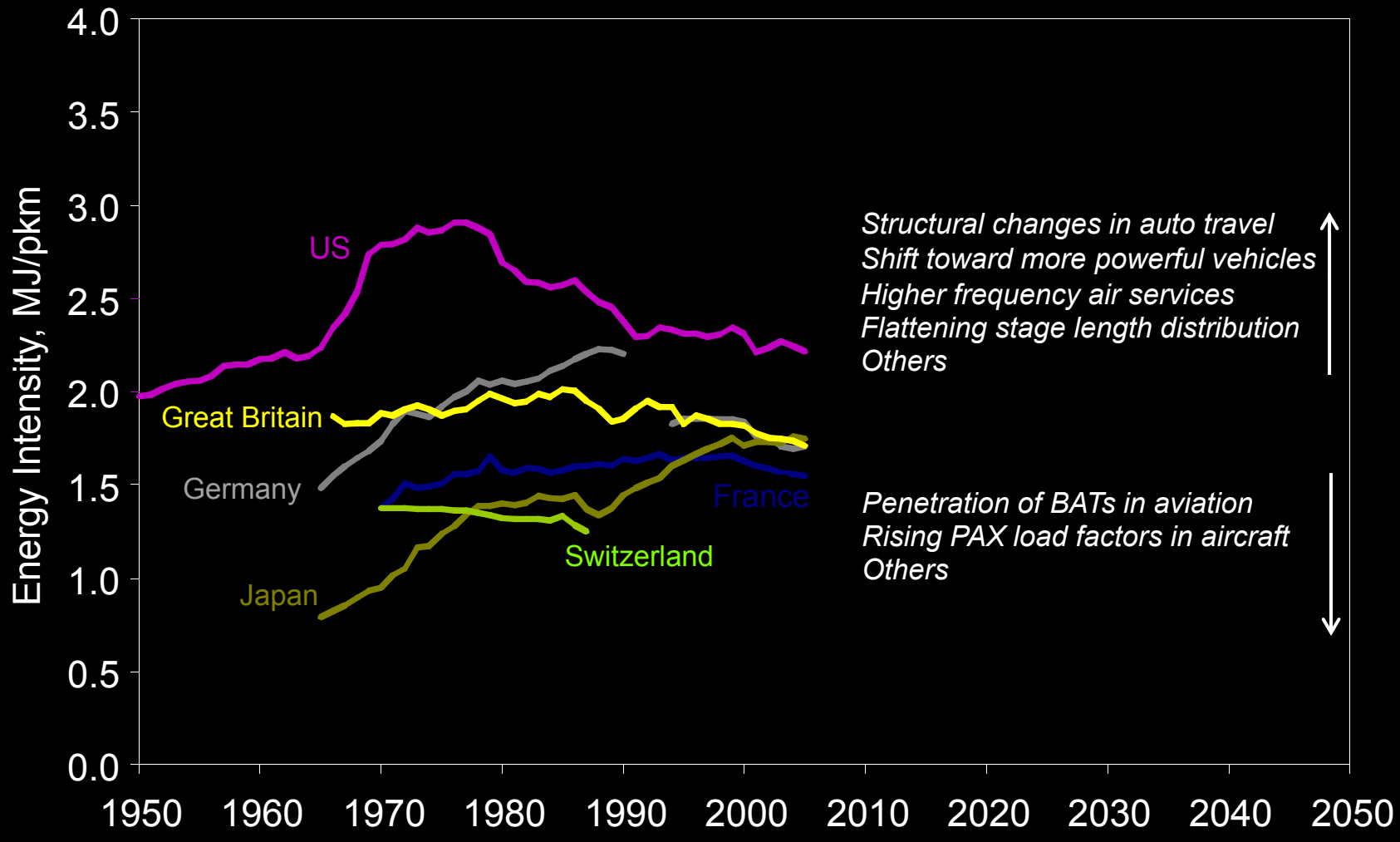
Shift from Slow to Fast (1950-2005)



Energy Intensity

$$GGE = \frac{GGE}{E} \cdot \frac{E}{PKT} \cdot PKT$$

E/PKT: Trends in Energy Intensity



Opportunities for Reducing E/PKT

Road Vehicles:

$$\frac{E}{VKT} = \frac{1}{\eta_{Propulsion\ System}} \cdot (A + D + R)$$

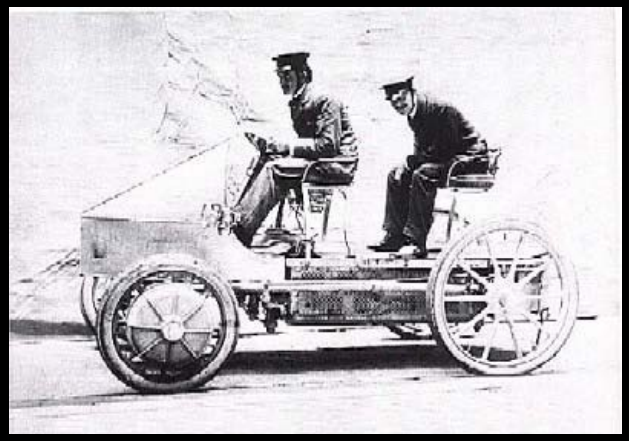
Jet Aircraft:

$$\frac{E}{PKT} = \frac{Q\ \ SFC}{PAX\ \ V\ \ (L/D)} \cdot \frac{W_F}{\ln \frac{W_0}{W_0 - W_F}}$$

Constraints to Reducing E/PKT

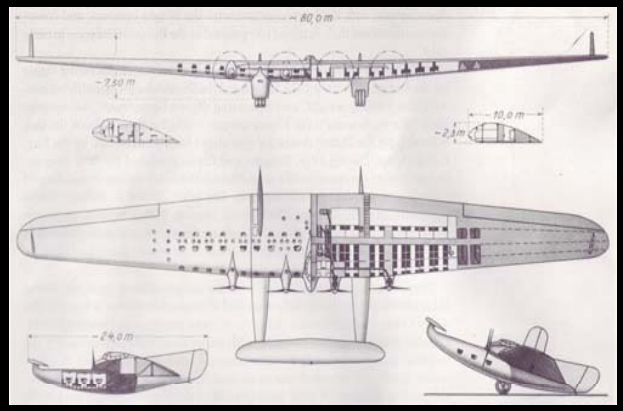
- Engineering trade-offs
  - Occupant safety vs. automobile weight, etc.
  - Larger aircraft wingspan (to increase L/D) vs. increase in aircraft weight, etc.
- Consumer acceptance
  - Battery-electric vehicles vs. range, etc.
  - Turboprop aircraft engines vs. passenger comfort, etc.
- Development costs of new (road and air) vehicles several billion dollars → existing, proven designs
  - Evolutionary process implies that many fuel-saving technologies have long history

Long Technology History

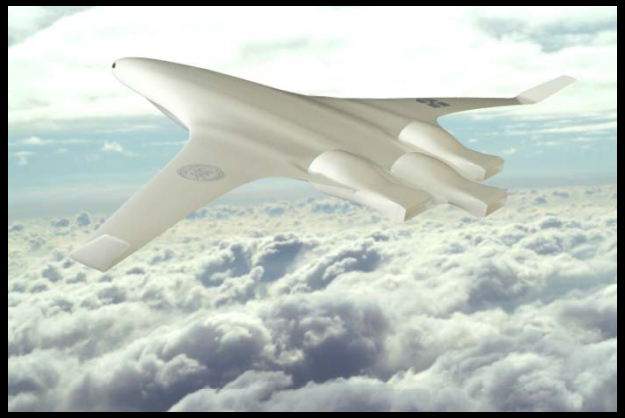


95 years

Racing version of the front wheel driven, petrol-electric Lohner "Porsche“ in 1900.
http://www.hybrid-vehicle.org/hybrid-vehicle-porsche.html



100+ years?



Hugo Junkers' 1924 design for a giant flying wing. The wing was to accommodate 26 cabins for 100 passengers, carry a crew of 10, and have enough fuel for 10 hours of flight.
http://www.century-of-flight.net/Aviation%20history/flying%20wings/Early%20Flying%20Wings.htm

Opportunities for Reducing E/PKT: Summary

(while maintaining current performance characteristics!)

- By mid' 2020s

  E/PKT reduction potential ≈ 30-50%

  (for the average new LDV or aircraft

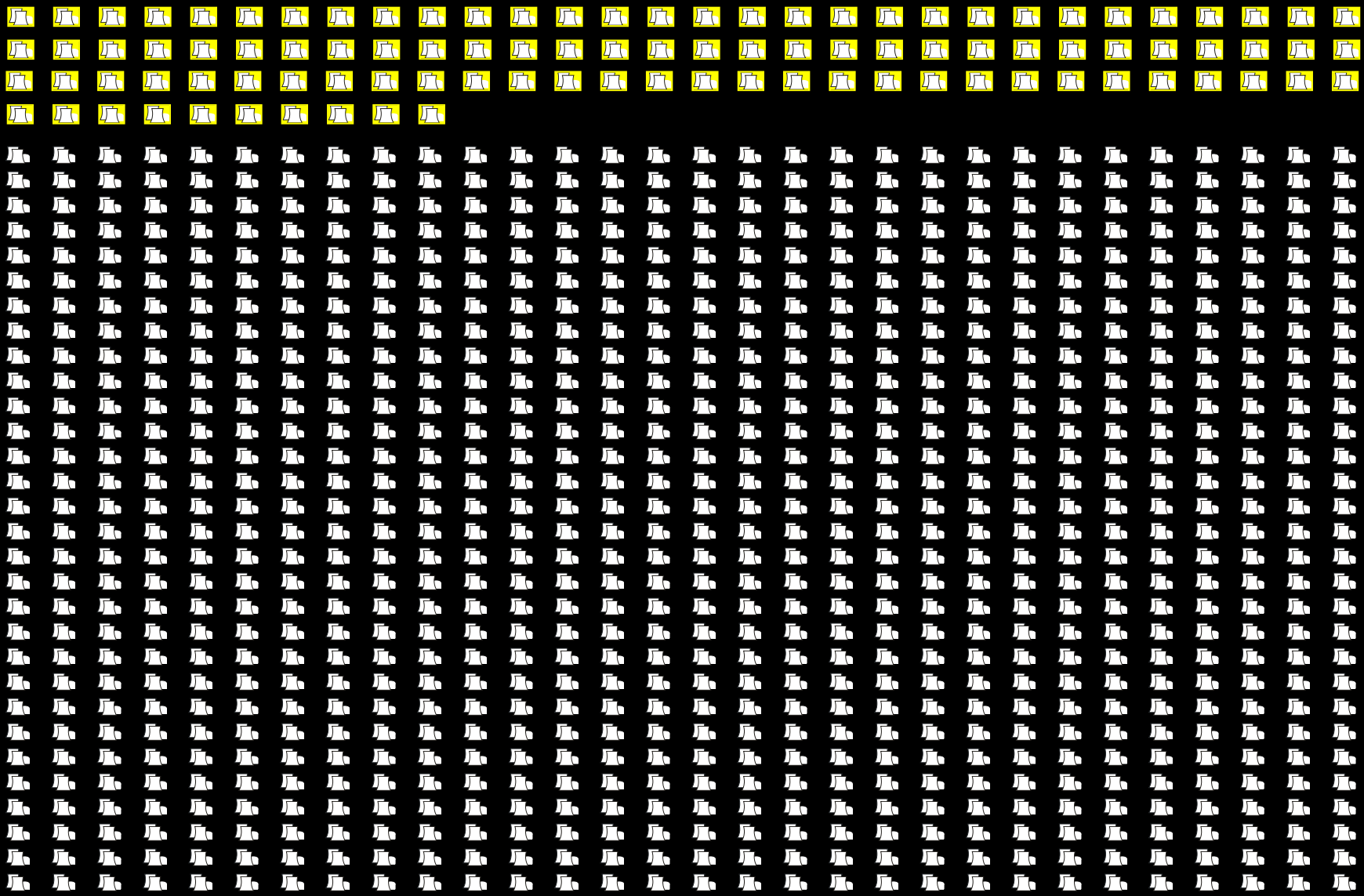
  in early 2000, using technologies

  currently under development)
- By midcentury

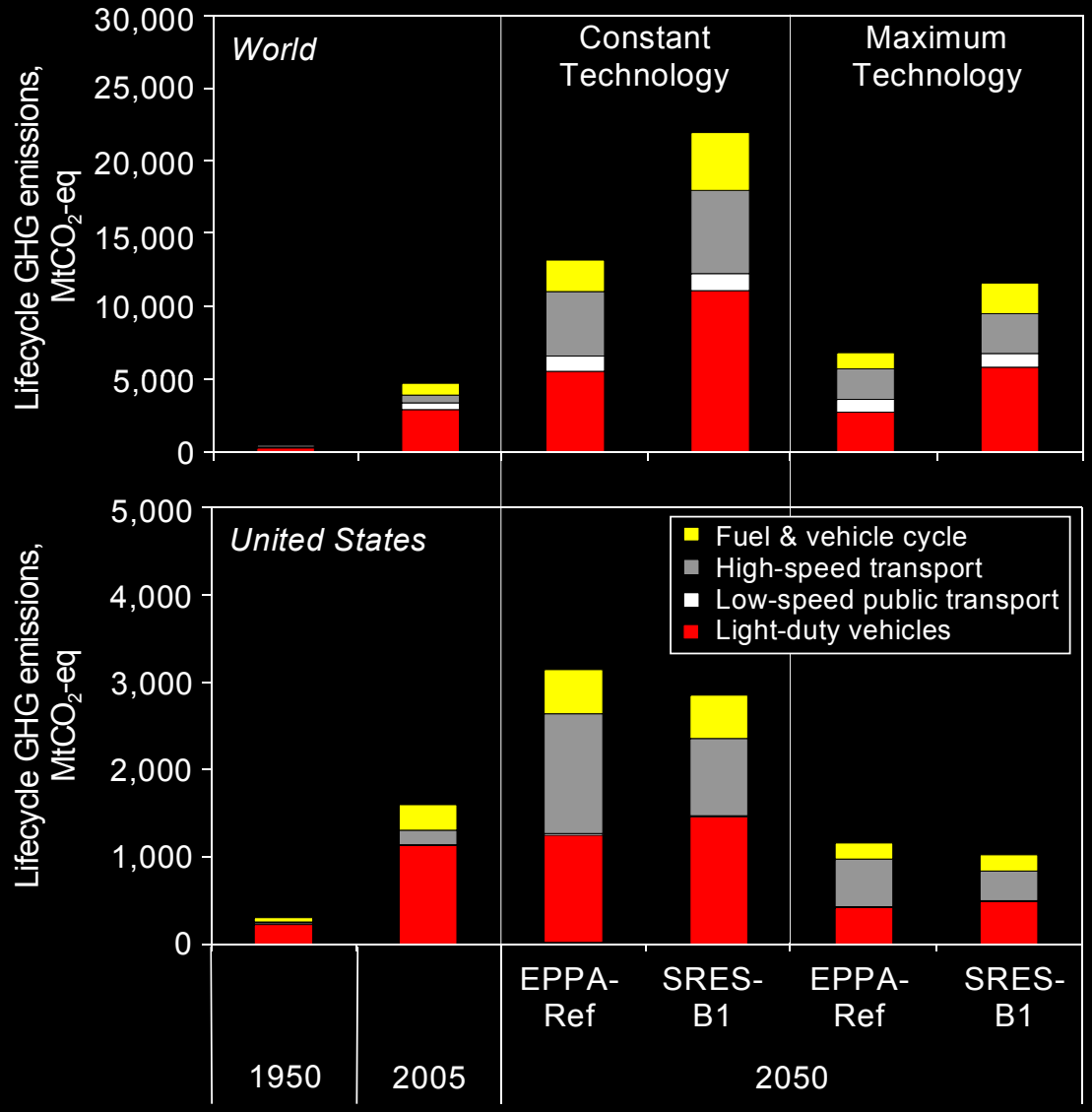
  Natural fleet turnover would translate these reductions to the vehicle fleet
- BUT: Global automobile and air travel may triple or quadruple over the same time horizon!

Challenge: Transport System Scale

No. add. 1GW$_{el}$ nuclear reactors to satisfy 2005 US LDV energy demand via water electrolysis-based H2



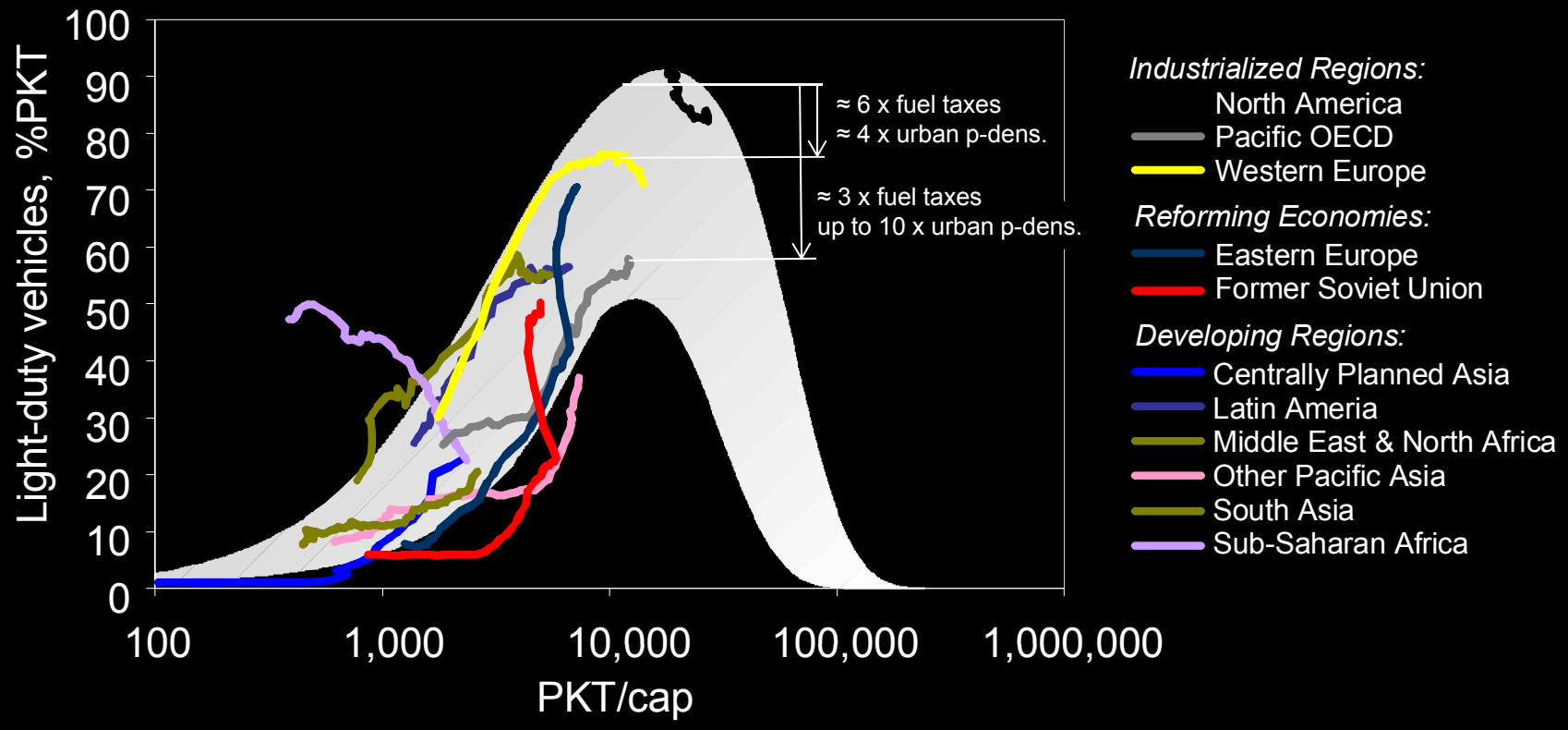
Technical Potential for Reducing GHG Emissions



The Choices Ahead

- Government
  - Type of policy measure to change consumer and industry choice of new vehicle attributes (market-based / regulation / both)
  - Single policy approach vs. some portfolio of measures
  - Economy wide vs. passenger transport only
  - R&D investments
- Industry action depends upon government policy, BUT …
  - GHG emission problem will not fade away (see structural change in energy use)
  - R&D investments (also) into reducing fuel consumption
    - Satisfies climate change *and* oil dependence
    - Importance of improving mainstream technology
- Need for behavioural change

Main Causes of Differences in Mode Shares



Similar differences in total travel

Behavioral Change in Transportation

- Ultimate Goal: Reduce automobile & aircraft vehicle-km travelled
- Key Opportunities:
  - Telecommunication substitutes
  - Land-use changes
  - Pricing measures (societal marginal costs of transport: 4-10 cents/L + 5-30 cents/km)
- Important: Combination of these measures

Behavioral Change in Transport & E3 Models

- Review of 13 Energy/Economy/Environment Models with transportation sector representation
  - 4 bottom-up / systems-engineering models
  - 1 top-down / macro-economic model
  - 7 hybrid models
  - 1 econometric model
- Results:
  - Assume continuation of historical trends
  - Reliance on technology-only solutions
  - Few models include required specs for considering behavioral change and *already* could analyze impact of behavioral change
  - If combined with elements of existing macroscopic transportation model specs, most behavioral change policies can be simulated
  - Room for innovations still exists

www.TransportAndClimate.com

Andreas Schäfer, John B. Heywood, Henry D. Jacoby and Ian A. Waitz

TRANSPORTATION IN A CLIMATE-CONSTRAINED WORLD

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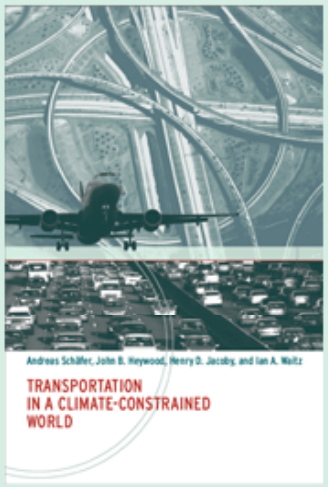

Transportation in a Climate-Constrained World

Andreas Schäfer, John B. Heywood, Henry D. Jacoby and Ian A. Waitz

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6 x 9, 384 pp., 30 illus.
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Short

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MIT Press

In the nineteenth century, horse transportation consumed vast amounts of land for hay production, and the intense traffic and ankle-deep manure created miserable living conditions in urban centers. The introduction of the horseless carriage solved many of these problems but has created others. Today another revolution in transportation seems overdue. Transport consumes two-thirds of the world's petroleum and has become the largest contributor to global environmental change. Most of this increase in scale can be attributed to the strong desire for personal mobility that comes with economic growth.

In *Transportation in a Climate-Constrained World*, the authors present the first integrated assessment of the factors affecting greenhouse gas (GHG) emissions from passenger transportation. They examine such topics as past and future travel demand; the influence of personal and business choices on passenger travel's climate impact; technologies and alternative fuels that may become available to mitigate GHG emissions from passenger transport; and policies that would promote their adoption. And most important, taking into account all of these options, they consider how to achieve a more sustainable transportation system in the next thirty to fifty years.

[transport and climate home page]

NEWS

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