Technologies in a Dangerous World
A Somewhat Different Slant

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A Different View of Danger

- How does the world grow in the future in a manner that evens inequalities between rich and poor?

- Avoids oncoming Conflicts over resources?

- Deals with the damages caused by growth to the environment and social structure?

- In problems that technology has created, can it now provide answers?

- It is very difficult to teach MIT students about this.

ALLIANCE FOR GLOBAL SUSTAINABILITY
(Founded 1996)

- A Partnership established by MIT, The Swiss Federal Institutes of Technology and the University of Tokyo to focus on problems of Sustainability; new partner - Chalmers University of Technology

- Over 60 tripartite research projects worldwide - 300 students

- Funded by industry, foundations, government, individuals

- Research in: Technologies for Sustainability, Climate Change, Water and Natural Resource Depletion, Advanced Materials, Food and Agriculture, Sustainable Energy Supply and Use, Mobility, Cleaner Technologies, Mega-Cities, New Institutions and Instruments for Change, Industry as an Agent for Change.

- Building the next generation's international network on sustainability. Major emphasis on education and outreach, especially in the Developing World
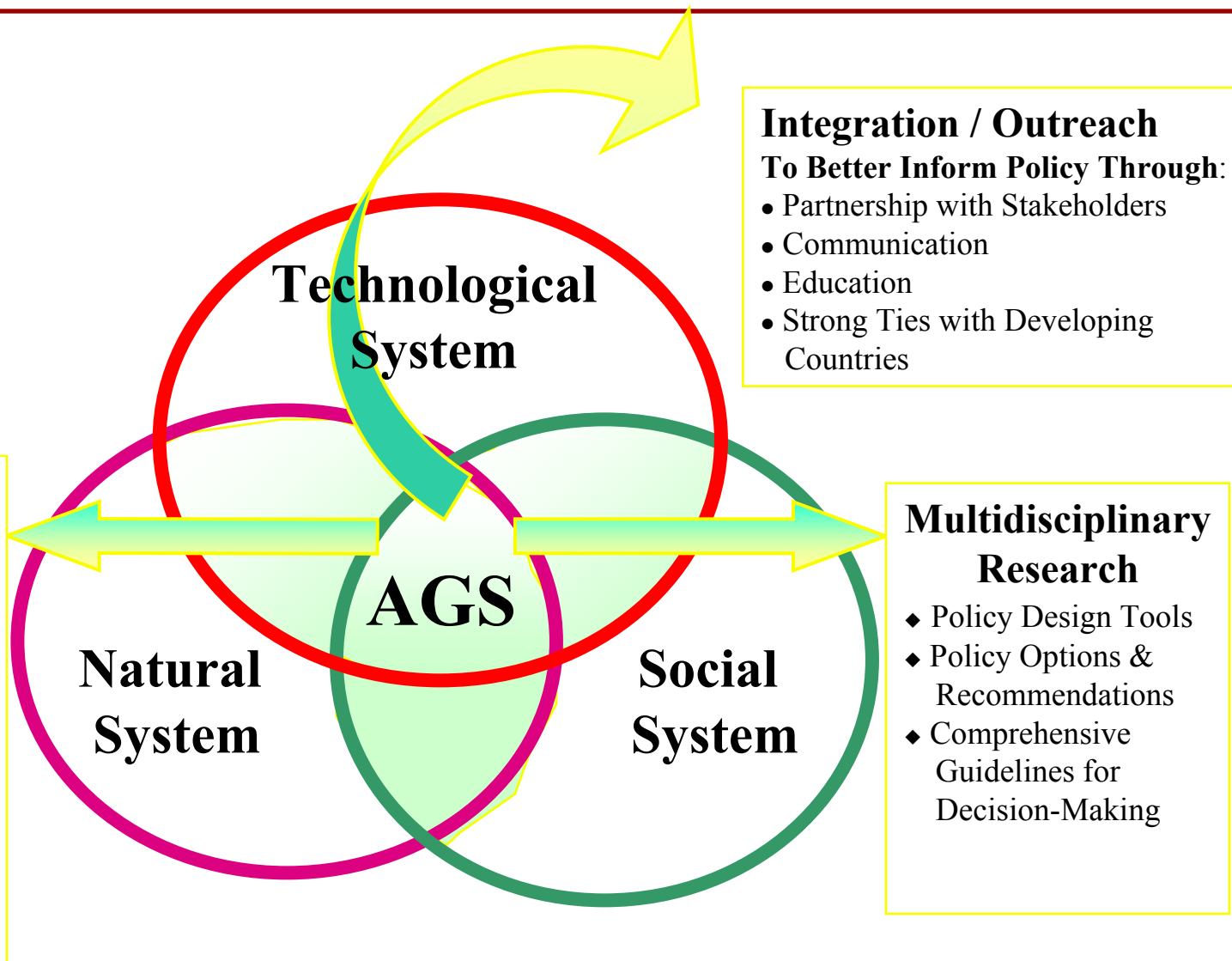
Sustainability

- Systems as well as components of a System…
  - Requires thinking about impacts along all three axes and about behavioral issues
  - Requires thinking about how the growing divide between the haves and have-nots impact on the future of governments, industries, societies
  - Reduction in Energy and Resource Intensity is a key step
- How to…
  - Requires thinking about new institutions for management
  - Requires thinking about what are the levers that impact on consumer preferences for consumption world wide

AGS STRATEGY

Integration / Outreach
To Better Inform Policy Through:
- Partnership with Stakeholders
- Communication
- Education
- Strong Ties with Developing Countries

Technological System

Multidisciplinary Research
- System Oriented
- Design & Evaluation Tools
- Filling Data Gaps
- Creating New Knowledge
- Integrated Modeling
- Developing & Assessing Technological Options

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Natural System

Social System

Multidisciplinary Research
- Policy Design Tools
- Policy Options & Recommendations
- Comprehensive Guidelines for Decision-Making

A Better Title might be "Herding Cats"

- Universities are built along traditional disciplinary lines, which is both a strength and a weakness.

- This means disciplinary research and education flourish.

- But the interesting problems are increasingly at the interfaces. How do we organize and educate for these?

- Is there a wider audience for our education and research?

Learning to be a Matrix Organization

- At MIT we are trying some interesting new experiments in educational and research structure.

- Traditionally Departments hire faculty, admit students, teach curricula materials and grant degrees. In the School of Engineering we have two new organizations:
  - Engineering Systems Division
  - Biotechnology and Environmental Health Division
  - "If it walks like a Duck, and quacks like a Duck, it must be a Duck"

- Laboratories and Centers-
  - Research Organizations that attract faculty to larger, more cross-cutting research.
  - "Own" no faculty, admit no students, but have space and in some cases outside core funds.
  - Serve as home to key research staff for project management, in-depth commitments to research infrastructure.
  - Focus on areas that cross the disciplines - energy, environment, productivity, manufacturing,etc
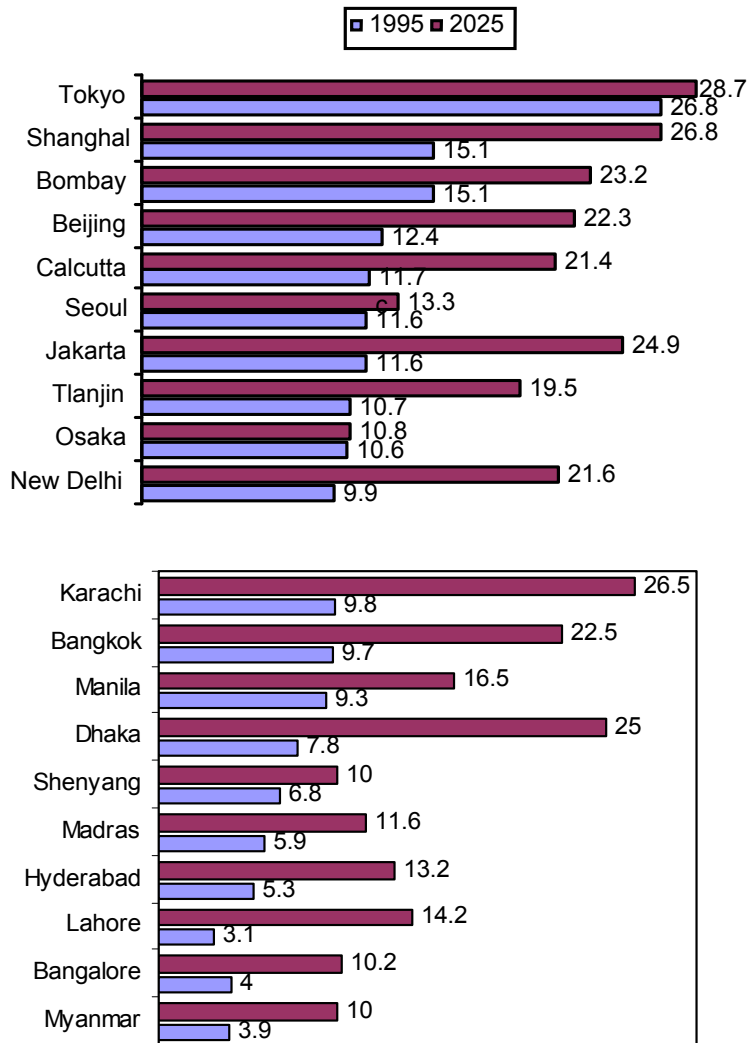
Rapid Urbanization

- Share of population living in urbanized areas is increasing

	Year		
	1950	2000	2030(p)
Total population (billions)			
World	2.5	6.1	8.1
More developed regions	0.8	1.2	1.2
Less developed regions	1.7	4.9	6.9 +2.0
	30%	47%	60%
Urban population (billions)			
World	0.8	2.9	4.9
More developed regions	0.5	0.9	1.0
Less developed regions	0.3	1.9	3.9 +2.0

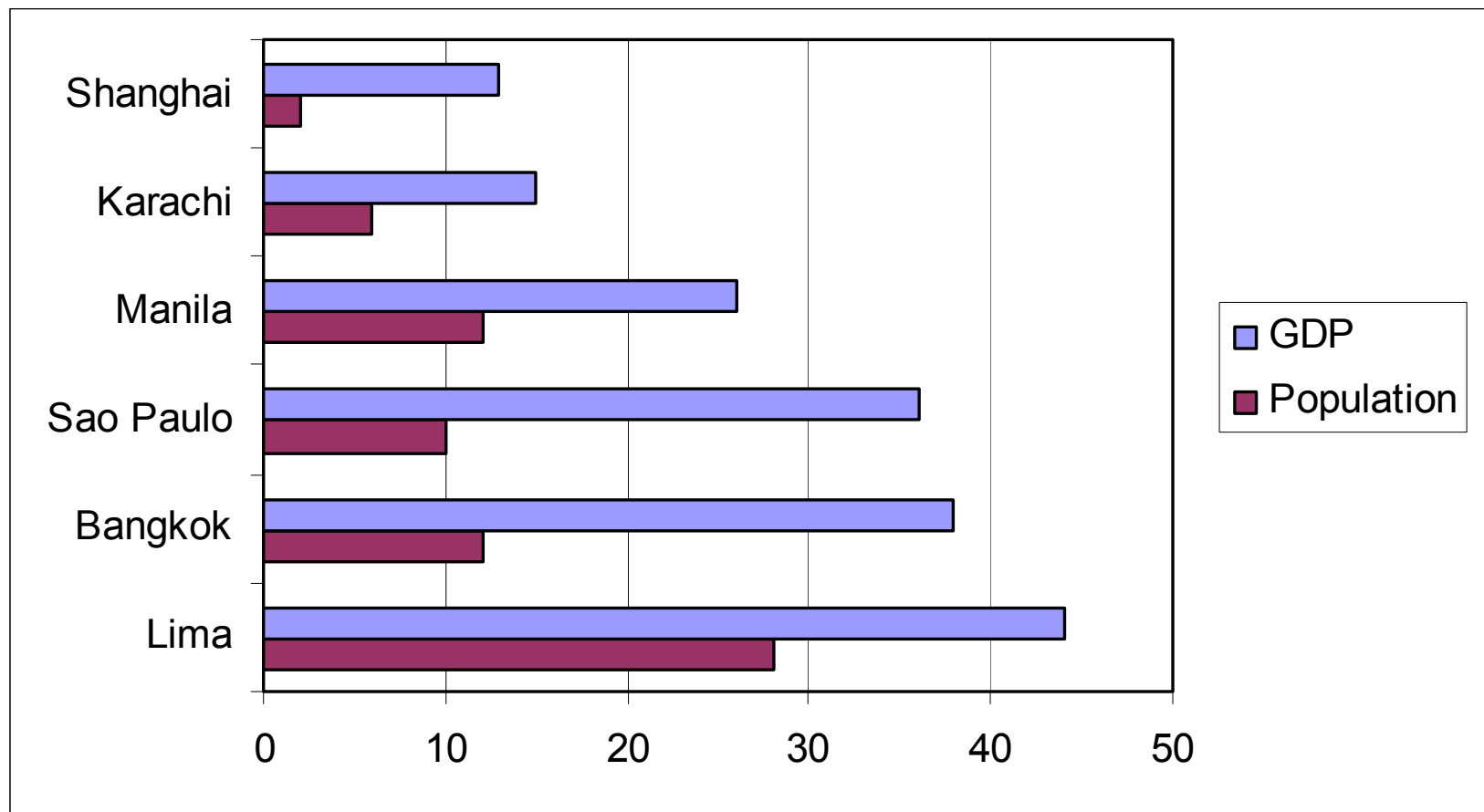Source: UNPD, *World Urbanization Prospects: the 1999 Revision*
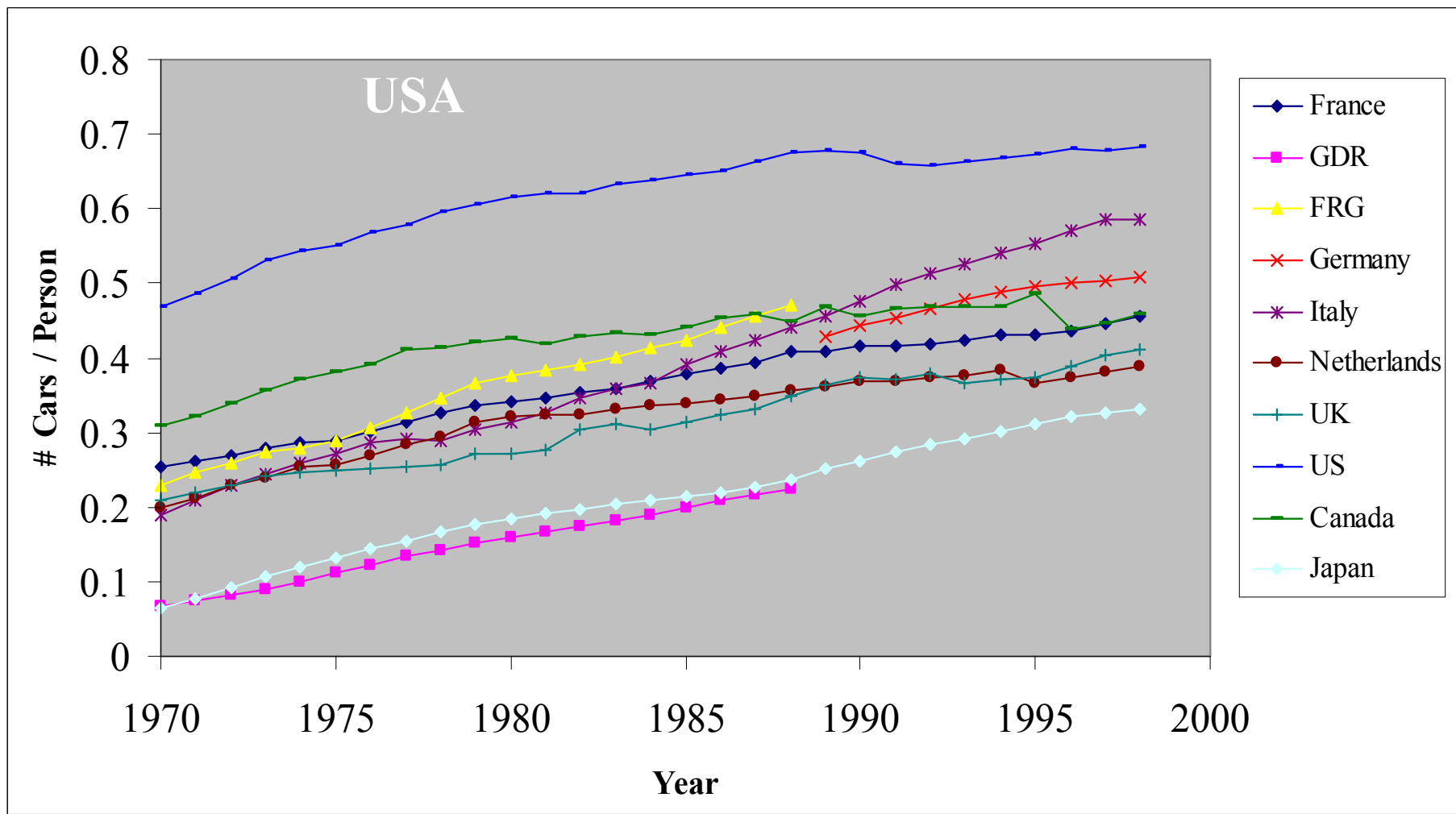
Emerging Asian Megacities

Chart 1 — Population (legend: 1995, 2025):

City	2025	1995
Tokyo	28.7	26.8
Shanghai	26.8	15.1
Bombay	23.2	15.1
Beijing	22.3	12.4
Calcutta	21.4	11.7
Seoul	13.3	11.6
Jakarta	24.9	11.6
Tlanjin	19.5	10.7
Osaka	10.8	10.6
New Delhi	21.6	9.9

Chart 2:

City	2025	1995
Karachi	26.5	9.8
Bangkok	22.5	9.7
Manila	16.5	9.3
Dhaka	25	7.8
Shenyang	10	6.8
Madras	11.6	5.9
Hyderabad	13.2	5.3
Lahore	14.2	3.1
Bangalore	10.2	4
Myanmar	10	3.9

Cities vs. Nations

- Cities' Share of National Totals

Cars per 1000 Population

World Energy Consumption by Fuel Type, 1970-2020

History   Projections

Quadrillion Btu

250
200
150
100
50
0

Oil
Natural Gas
Coal
Renewables
Nuclear

1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
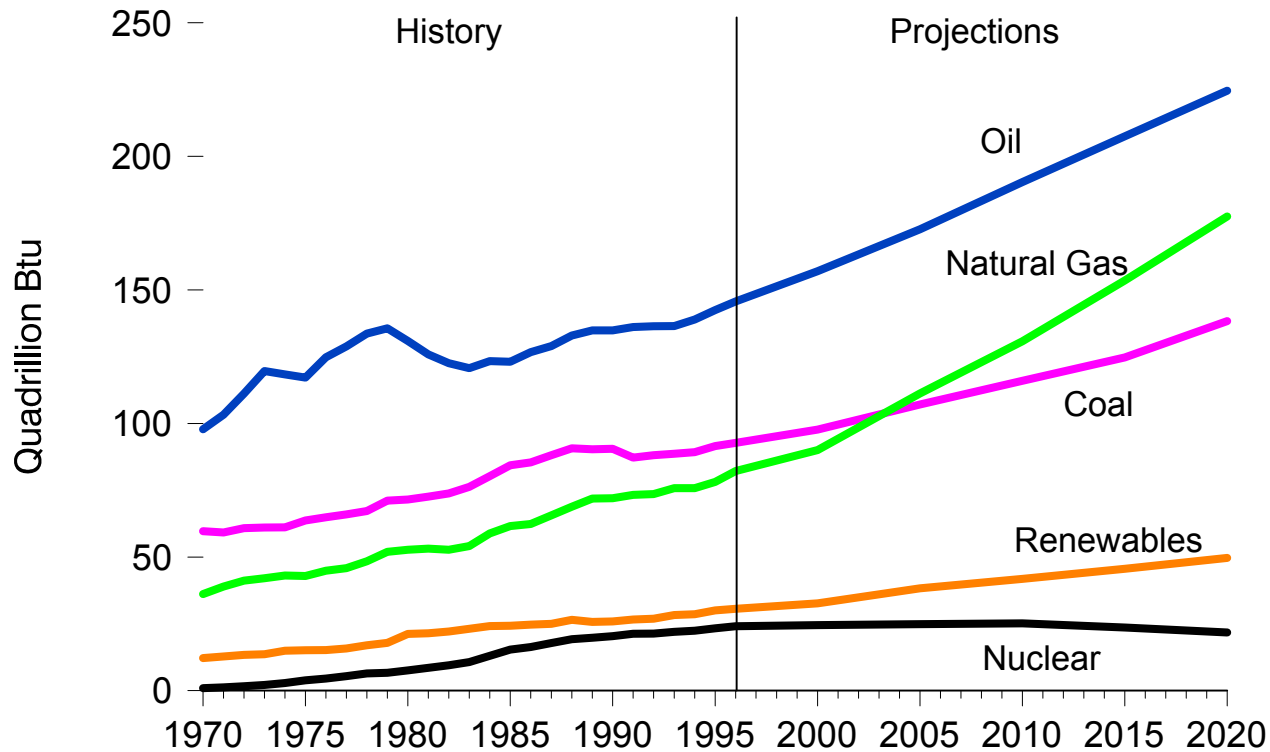
Source: EIA, International Energy Outlook 1999

Petroleum Use for Transportation and Other Purposes, 1980-2020
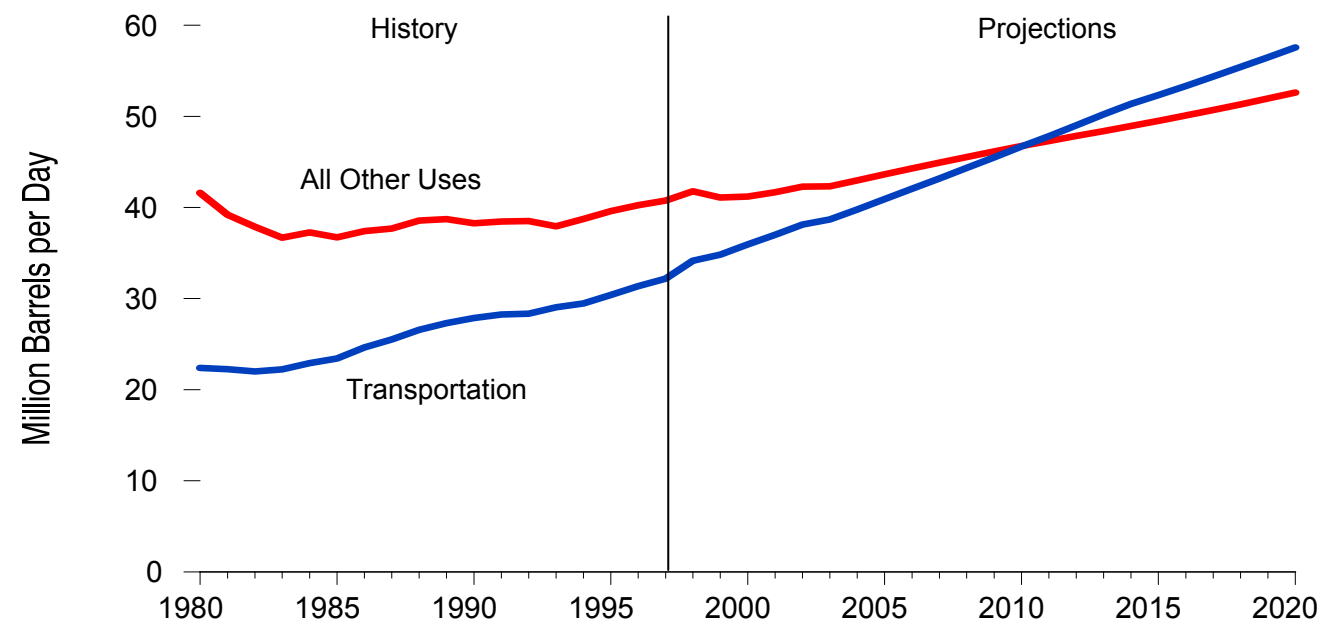
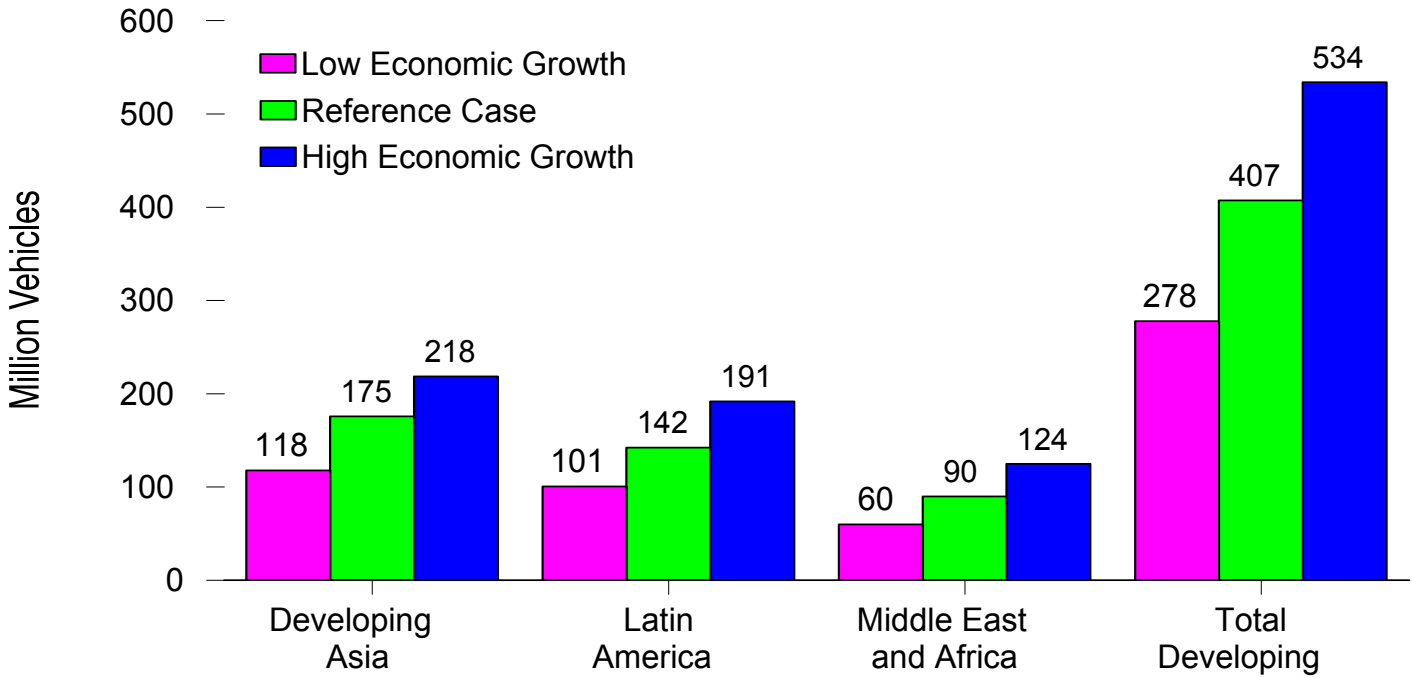Source: EIA, International Energy Outlook 1999

Motorization Trends in Selected Developing Countries, 1980-2020
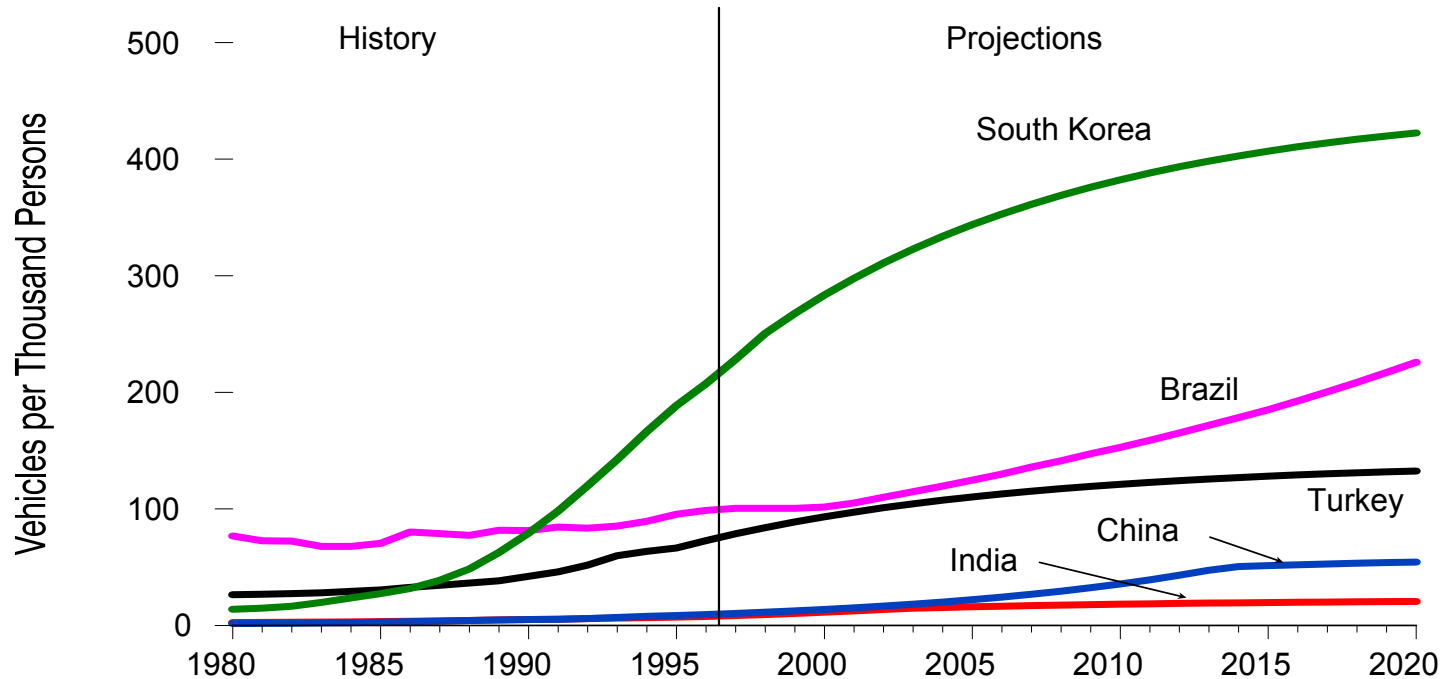
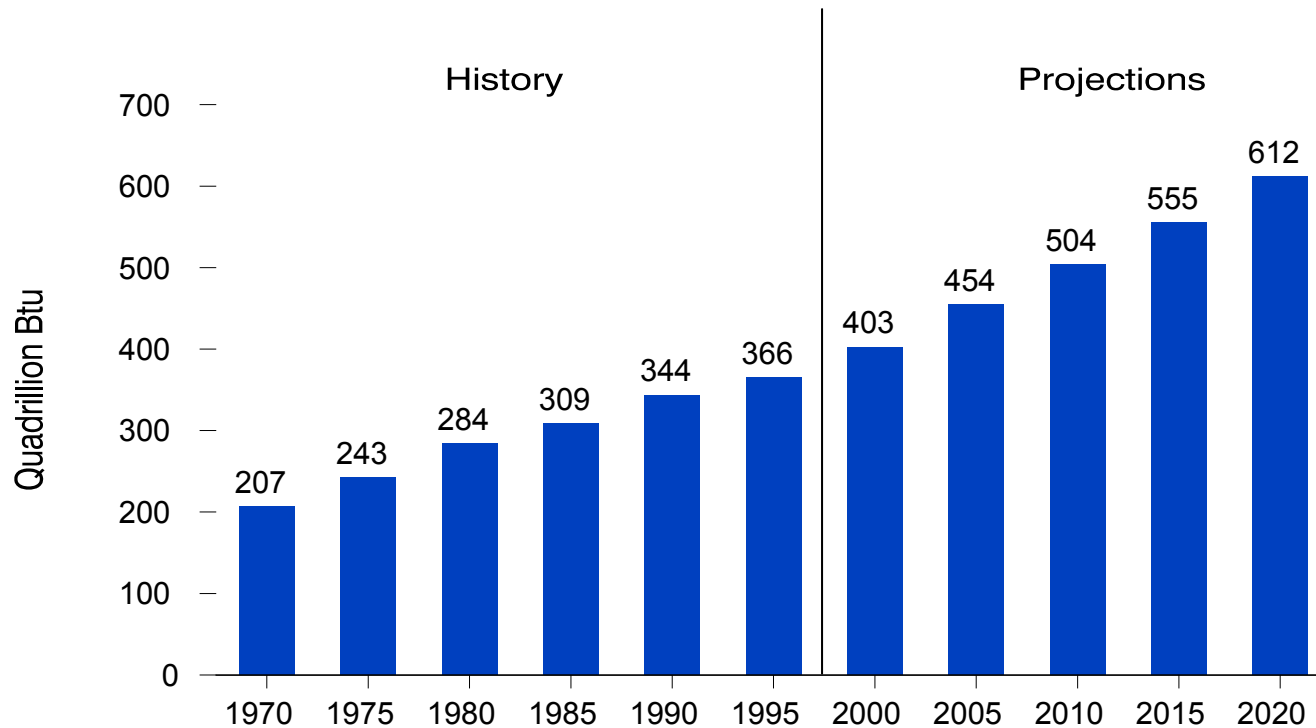Source: EIA, International Energy Outlook 1999

Vehicle Population in Three Economic Growth Cases, 2020

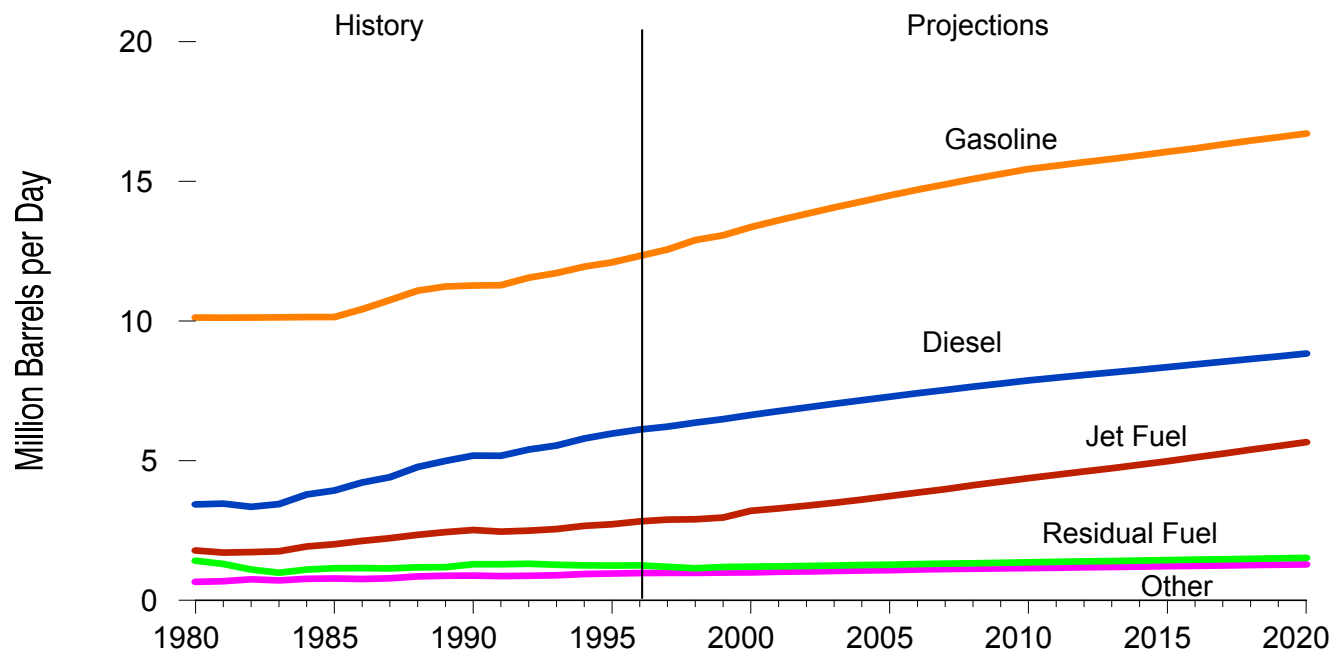Source: EIA, International Energy Outlook 1999

World Energy Consumption, 1970-2020

Source: EIA, International Energy Outlook 1999

Transportation Energy Use in the Industrialized Countries, 1980-2020

Source: EIA, International Energy Outlook 1999

- The transportation sector increases its share of world oil use over the next two decades. By 2020, transportation accounts for 51 percent of total oil consumption worldwide.

- Road vehicles maintain a dominant share of transportation energy use over the forecast, but air travel is the fastest growing mode of transportation. Energy use for air travel rises 3.7 percent per year between 1996 and 2020, compared to 2.4 percent per year for road energy use.

- The world population of road vehicles passes 1.1 billion by 2020, 425 million above the 1996 level.

- Highest grow rates of motor vehicle fleets are expected to occur in developing Asia and Central and South America which are projected to account for 52 percent of the increase in the world's vehicle population.

What Should Universities Do About This?

- Take On the Larger Problems
- Education- strengthen the professionals, give literacy to all
- Traditional Technologies
- Cross-discipline large-scale technologies and technology assessments and related educational and outreach programs.
- Outreach - Next generation leaders
- A Neutral Platform for the debate.

Scope of the LFEE

We work with 150 Graduate Students and Faculty from 14 MIT Departments

Topical Research AREAS

- Energy Supply (Fuels, Electricity, Delivery, etc.)
- Energy Demand (Transportation, Industry/Buildings, etc.)
- Emissions/Effluents (Air, Water, Solid Waste, GHG Management, etc.)
- Policies and Institutions (Regulation, Knowledge Networks)

Ecological REALMS

- Airsheds/Watersheds/Ecosystems (Biodiversity, Health, etc.)

Geographic REGIONS

- China, Mexico, Megacities, Regional Electricity...

Educational INITIATIVES

- AGS, Martin/Wallenberg Fellows, P-STEP

Grand Challenges

- Information Technologies and Sustainability
  - 13% of Electrical Energy Demand, 40% of recent growth
  - Substitution for other energy uses or a complement?
    - Mobility- people and freight
    - Energy Decentralization
    - Energy Demand Modifications, Efficiency
  - What does this mean for the electronics, information technologies industry?
  - MIT AGS Meeting/Workshop to formalize a major study

Grand Challenges

- Cleaner Sources of New Energy
  - The Shift from Petroleum - GHG issues will cause major shifts in our perception of Energy Supply-As will security issues
  - "Just as the Stone Age did not end from lack of Stones, the Oil Age will not end from lack of Oil"
  - But to what? Renewable, Nuclear, Gas to Electricity and Hydrogen carriers using Green House Gases sequestration, new approaches to vehicle propulsion?
  - Work in Smart Wells, Smart Fields.
    - Carbon Sequestration,Gas Conversion to Liquids

Grand Challenges

- Mobility
  - Rethinking the personal vehicle- fuels, size, materials, functions, ownership
  - Rethinking Freight - 43% of Transport Energy Usage, but more aggregated for greater opportunities ????
  - Congestion impacts on intercity movement of goods and services
  - Conflicts over freight and cars on urban infrastructure
  - Access for those who cannot or choose not to use personal vehicles

Mobility Work at MIT

- Sloan Automotive Lab - On the Road in 2020
- 42 Volt Consortium
- Cooperative Mobility Program - Observatory
- Safety
- Materials Selection, Lifecycle, Recycling
  Materials Systems Lab
- International Motor Vehicle Program
- Program on Aging
  Keeping people in cars longer
- Center for Transportation Systems-IVHS

Grand Challenges

- Increase Energy Efficiency in the Use Sectors
  - Smart or even not-so-dumb technologies for household and consumer users - Defeating the Vampires
  - Decentralized energy grids to encourage renewables. NIMBY becomes ok in my basement or garage
  - Rethink our major energy use systems
    - Transportation is half of energy use
    - Half of this is in Freight - and in the last three miles
    - Housing and Buildings is about 20%
    - How will Information Technologies aid all this?

Grand Challenges

- Understand Consumption Better
- Think now about the needed institutions for the future - The future generation of world-wide leaders needed to run them
- Think about Security of Energy Infrastructure
- Make sure that all are included in the better life
    - Present transportation systems exclude the old, young, disabled and poor.
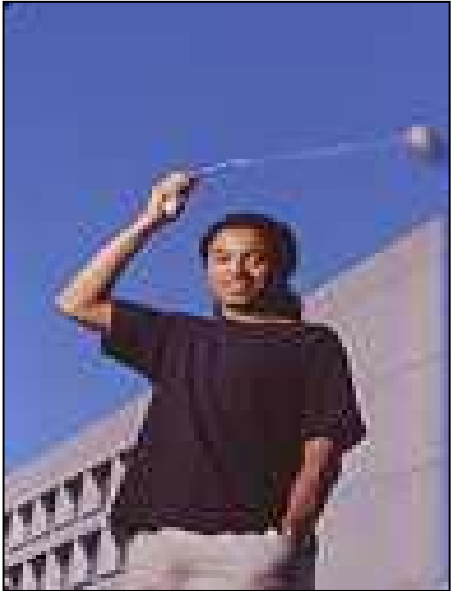   - 33% increase in world population in 2030. Almost all in the Developing World.

Design that Matters

MIT DTM 2001: Design Projects

- **Low-Cost Corrective Eyewear***
- **Cholera Treatment Devices***
- **Hand-Powered Electric Generation**
- **Expressive Interfaces for Children with Special Needs**
- **The Roma Reader: Bilingual Education for Roma Gypsy Children**
- **Rural Community Radio**

MIT DTM 2002: Design Projects

- **Passive Incubator for Premature Infants***
- **Bio-sand Water Filters for Nicaragua***
- **Low-Cost Library**
- **Language Preservation Devices for Native American Communities**
- **Smart Canes for the Visually Impaired**
- **"Inspirational People" Video Series**