THE FUTURE OF HUMAN (URBAN) MOBILITY

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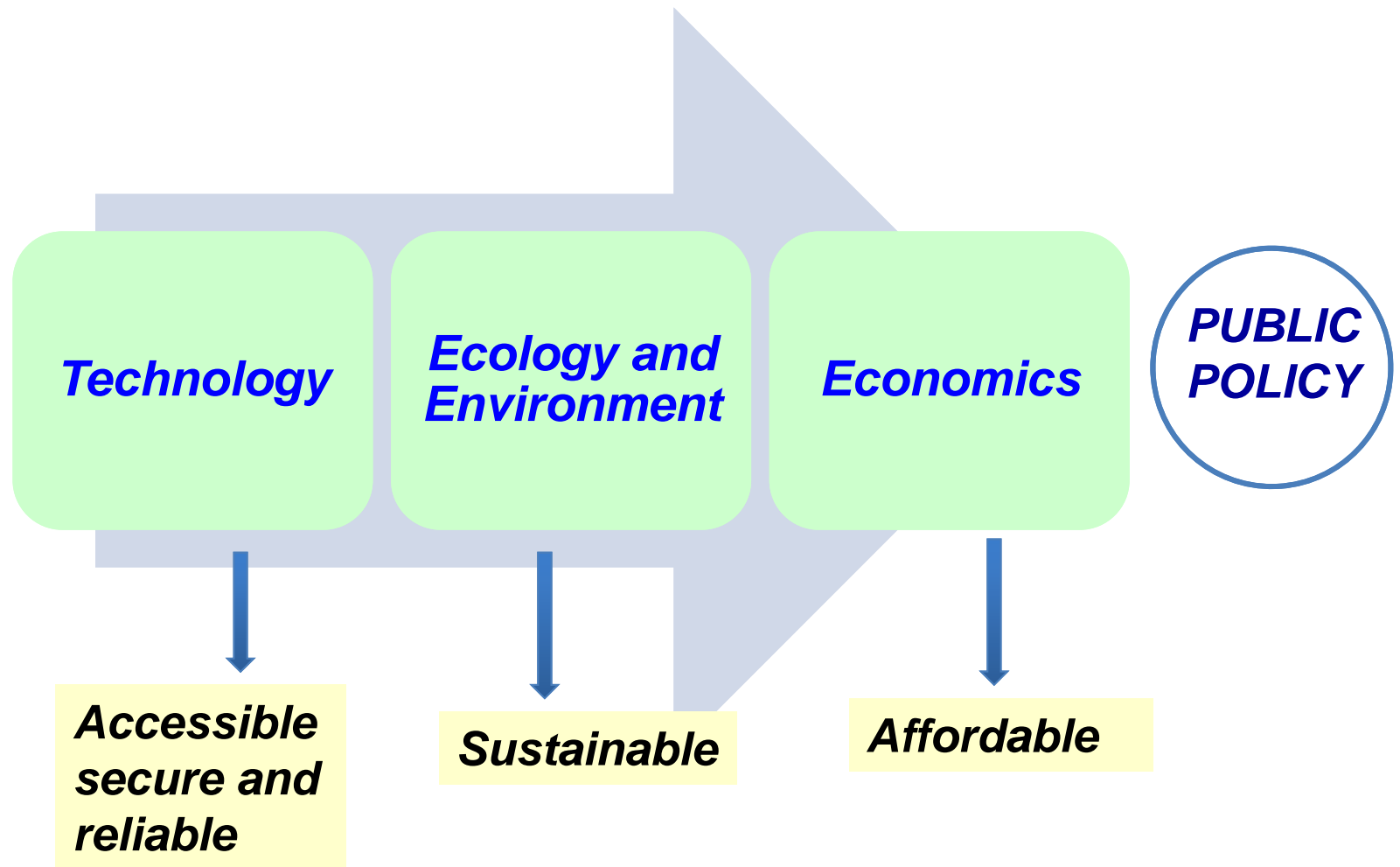## *MOBILITY IS VITAL TO HUMAN CIVILIZATION*

- Our ability to move is a core function of our being.

- Human mobility across the ages and continents has defined who we are, our cultures, attitudes and behavior.

- Yet seamless and effortless mobility is a recent phenomena, just about a hundred years old

Enhanced desire to be mobile among larger number of people has brought several challenges that threaten the concept of mobility itself. How will the future of mobility look like ? How will our urban spaces cope up with this insatiable desire? Will the solutions that came up at the turn of the 20th century be still relevant ?
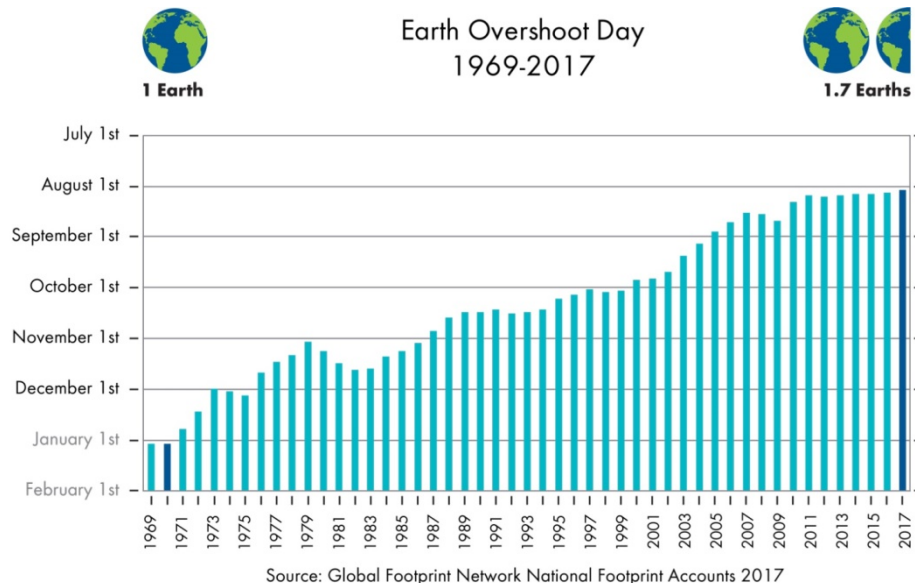
CHALLENGES TO SUSTAINABALE MOBILITY

- ➢ Population and earth's carrying capacity (> 9 billion by 2030)

- ➢ Irreversible changes in global climate (+2-3°C ⇧)

- ➢ Depletion of earth resources (excessive consumption and rapid urbanization)

- ➢ Access to affordable clean energy (social and quality of life inequities)

PUBLIC POLICY IN MOBILITY ISSUES ARE DEFINED BY …………

Technology

Ecology and Environment

Economics

PUBLIC POLICY

Accessible secure and reliable

Sustainable

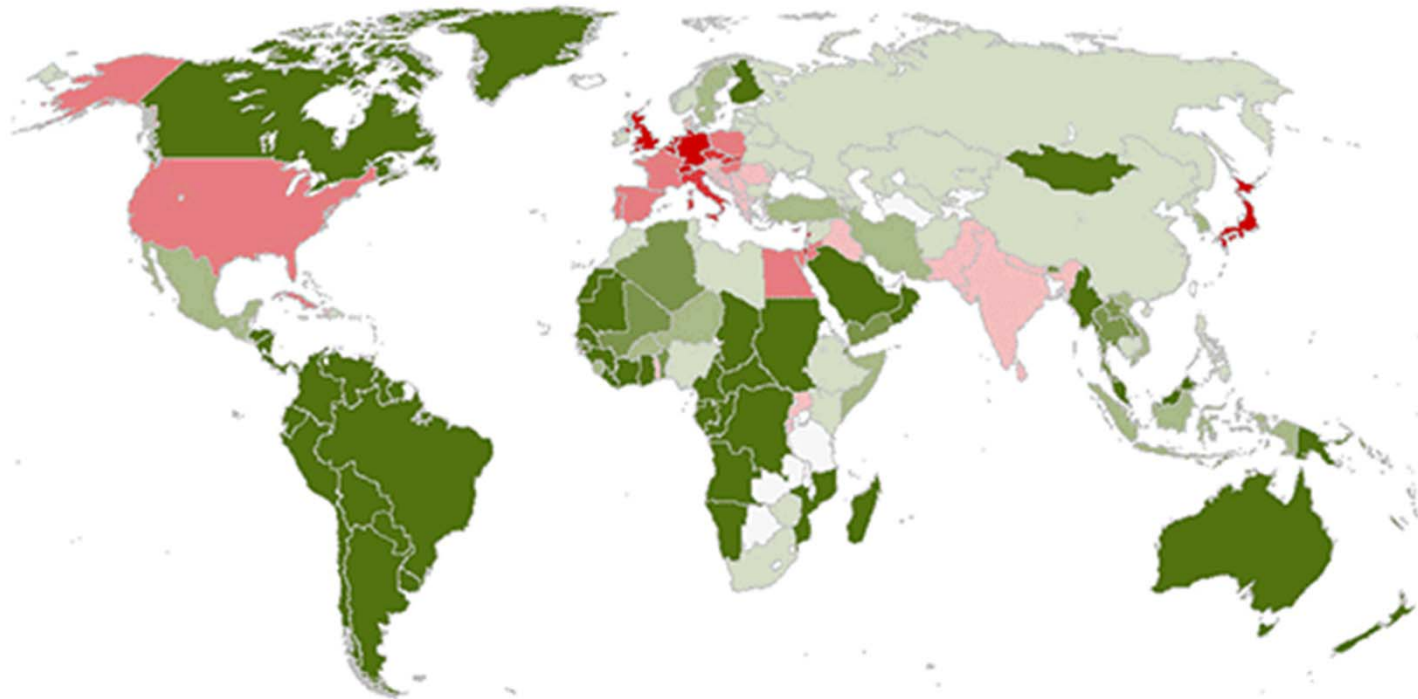Affordable

OUR INSATIABLE DESIRE TO CONSUME

- The world today is using up its resources 1.7 faster than they are being renewed
- The Earth Overshoot Day this year was on August 2, 2017, when we fully consumed our earth's resources of the entire year. We are now using next year's resource !

Forest land

Grazing land

Built-up land

Carbon Footprint

Cropland

Fishing grounds

Earth Overshoot Day
1969-2017

1 Earth

1.7 Earths

July 1st
August 1st
September 1st
October 1st
November 1st
December 1st
January 1st
February 1st

1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017

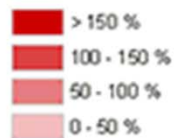Source: Global Footprint Network National Footprint Accounts 2017

Our planet is finite, but human possibilities are not. Living within the means of one planet is technologically possible, financially beneficial, and our only chance for a prosperous future

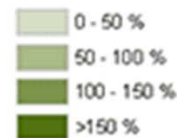# ECOLOGICAL FOOTPRINT AND THE CAPACITY OF OUR PLANET TO RENEW ITSELF

1961

Ecological Footprint of consumption exceeds biocapacity
- > 150 %
- 100 - 150 %
- 50 - 100 %
- 0 - 50 %

Biocapacity exceeds Ecological Footprint of consumption
- 0 - 50 %
- 50 - 100 %
- 100 - 150 %
- >150 %

Global Footprint Network®
Advancing the Science of Sustainability

Data from the National Footprint Accounts 2016 Edition. www.footprintnetwork.org
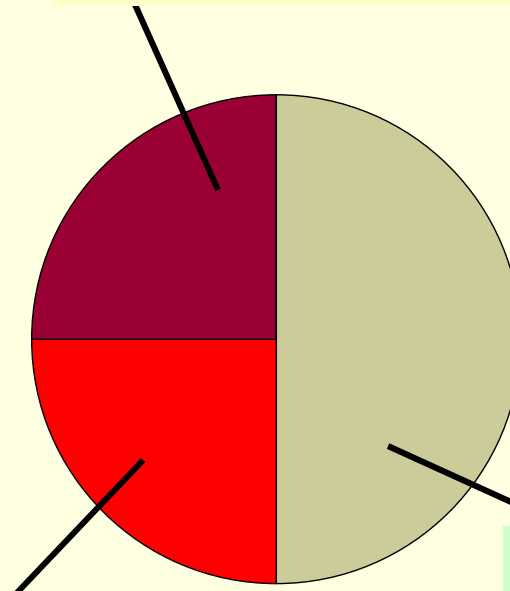
Source : www.overshoot.day

INDIA'S ENERGY FUTURE

- India's energy consumption will increase by an additional 1 billion tons of oil (equivalent) by 2040 accounting for 11 % of the world's energy consumption.

- India's electricity generation is predominantly dependent on coal, and that too of poor quality.

- Clean energy (Solar, Wind, Hydroelectric, Nuclear) amount to less than 10 % of our energy needs.

- India is the third largest oil consuming nation in the world amounting to 213 million tons in 2016 and growing at 8 % annum, the fastest in the world.

- India imports more than 80 % of our petroleum feed-stocks.
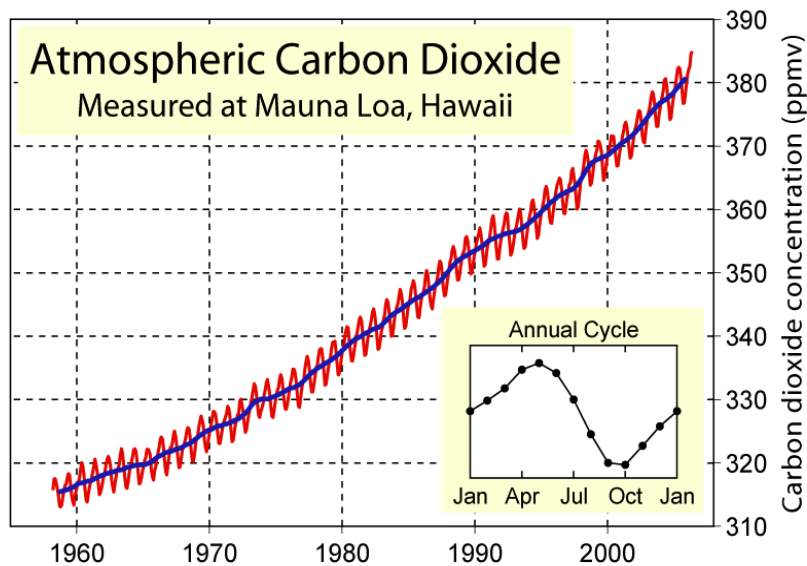
ANTHROPOGENIC CO$_2$ EMISSIONS

Cement production and Gas flaring

Fossil fuel burning

Land use change

Today we are at 410 ppm
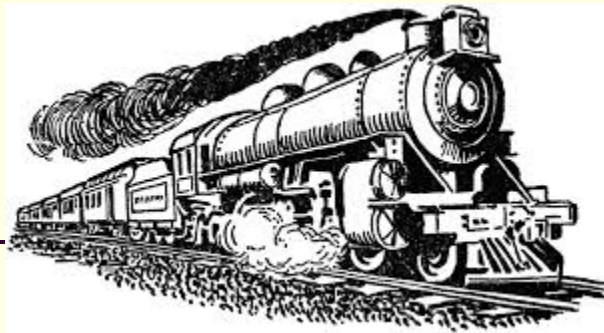
URBANIZATION OF INDIA

- India's urban population is growing at 6 % per annum against a population growth of 1.7 % per annum

- India is currently 30% urbanized; About 380 million people live in 8000 cities. By 2030, this number will roughly double

- 53 Indian cities have a population of over 1 million

- Land to population ratio has decreased four fold since 1950; India's cities are land starved

- Governance of Indian cities are challenged by multiple bodies overseeing the city governance, namely, municipality, state government and quasi state bodies with many overlapping functions and all not necessarily working in concert

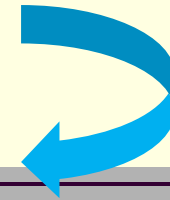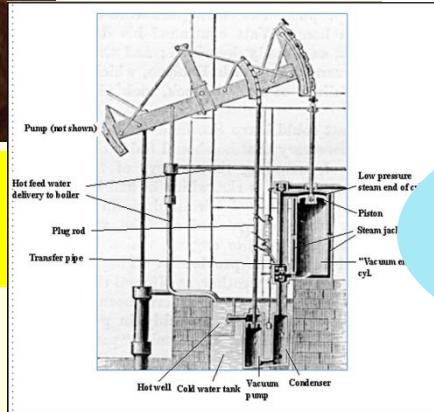*Source :The Economic Survey, 2017, Chapter 14, Government of India*
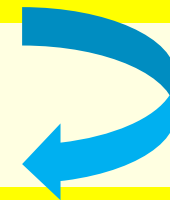
James Watt, 1763

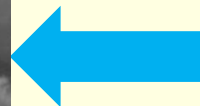Industrial Revolution

Steam Engine, 1820

Pump (not shown)

Hot feed water delivery to boiler

Plug rod

Transfer pipe

Low pressure steam end of cyl.

Piston

Steam jacket

"Vacuum end." cyl.

Hot well Cold water tank Vacuum pump Condenser
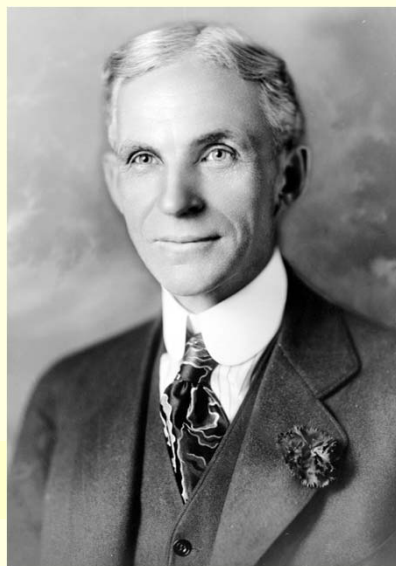
Technology transition in society is painfully slow !

First Petroleum well, 1859

Henry Ford 1907

Nikolaus Otta, ICE, 1861

FROM MODEL T TO AN ELECTRIC VEHICLE

1907

2030

2000

THE UNINTENDED CONSEQUENCES OF TECHNOLOGY

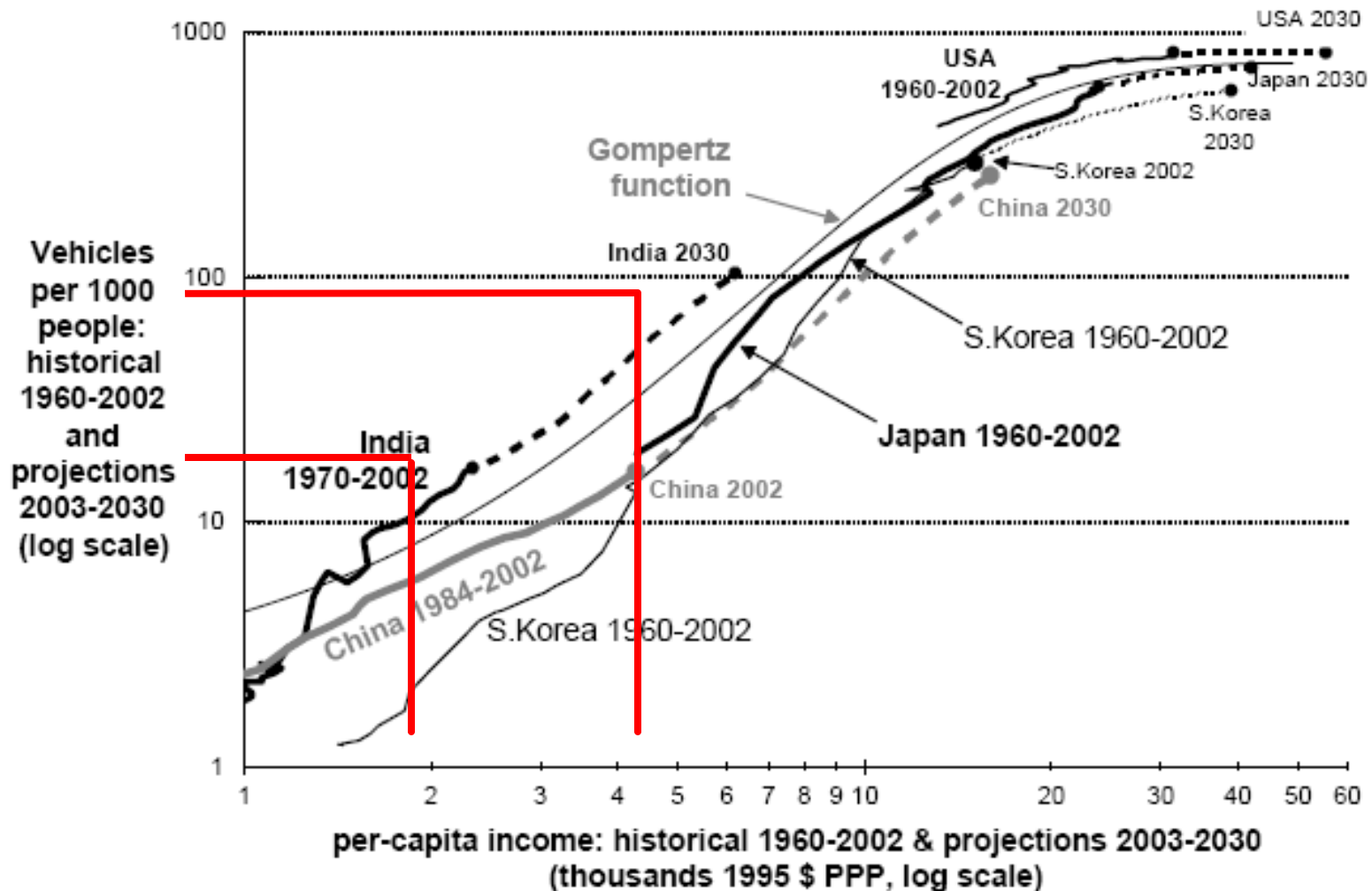*Dust and particulate reduce energy yield from solar panels by 20-25%*

➢ Carbon dioxide in the atmosphere now the highest since life began on our planet

➢ Atmospheric pollution emitted by automobile exhausts results in 150 to 300 deaths per 100,000 people in India

➢ More than 15 people per 100,000 lose their life on roads

TRAFFIC GRIDLOCK IN URBAN INDIA

- Our urban spaces are asphyxiating with traffic congestion
- The problem :   The sheer number of vehicles that are pouring out on our beleaguered roads
- The curious paradox is that the more people suffer on the streets, the more they opt for private cars and administrators and governments seek to address this latter need.
- The crux of the problem is vehicle ownership. Hitherto, all efforts at traffic management have been focused on easing the passage of cars on roads and governments have tried to achieve this by adding road surface.
- Building new roads and widening existing ones leads to additional traffic that continues to rise until peak congestion returns to the previous levels. Wider roads actually incentivize car ownership.
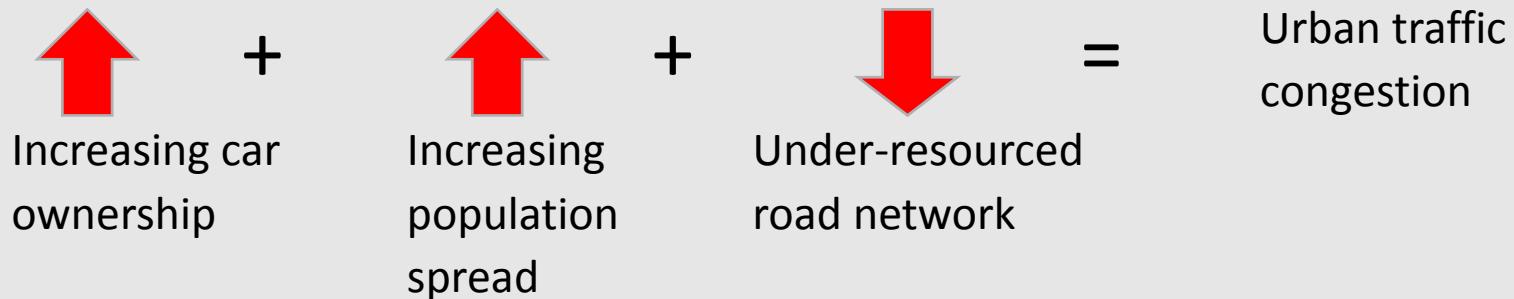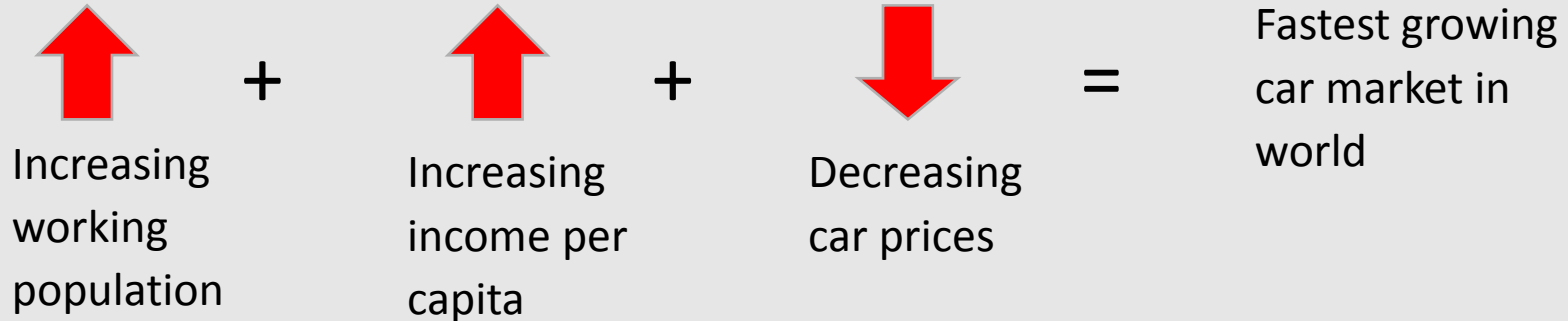
VEHICLE GROWTH FASTER THAN INCOME !

- Vehicle ownership grows **twice as rapidly as income** in $3,000-$10,000 per capita range
- Number of vehicles **will triple by 2030**

Source: Joyce Dargay, Dermot Gately and Martin Sommer, 2007, Vehicle Ownership and Income Growth, Worldwide: 1960-2030

THE CAUSE FOR MAYHEM ON OUR ROADS

↑ + ↑ + ↓ =

| Increasing working population | Increasing income per capita | Decreasing car prices | Fastest growing car market in world |

↑ + ↑ + ↓ =

| Increasing car ownership | Increasing population spread | Under-resourced road network | Urban traffic congestion |

➤ *Population spread*
   Rapid spatial growth and urban sprawl
➤ *Under-resourced road network*
   Between 1970-2000 road network increased 3x, vehicles increased 16x
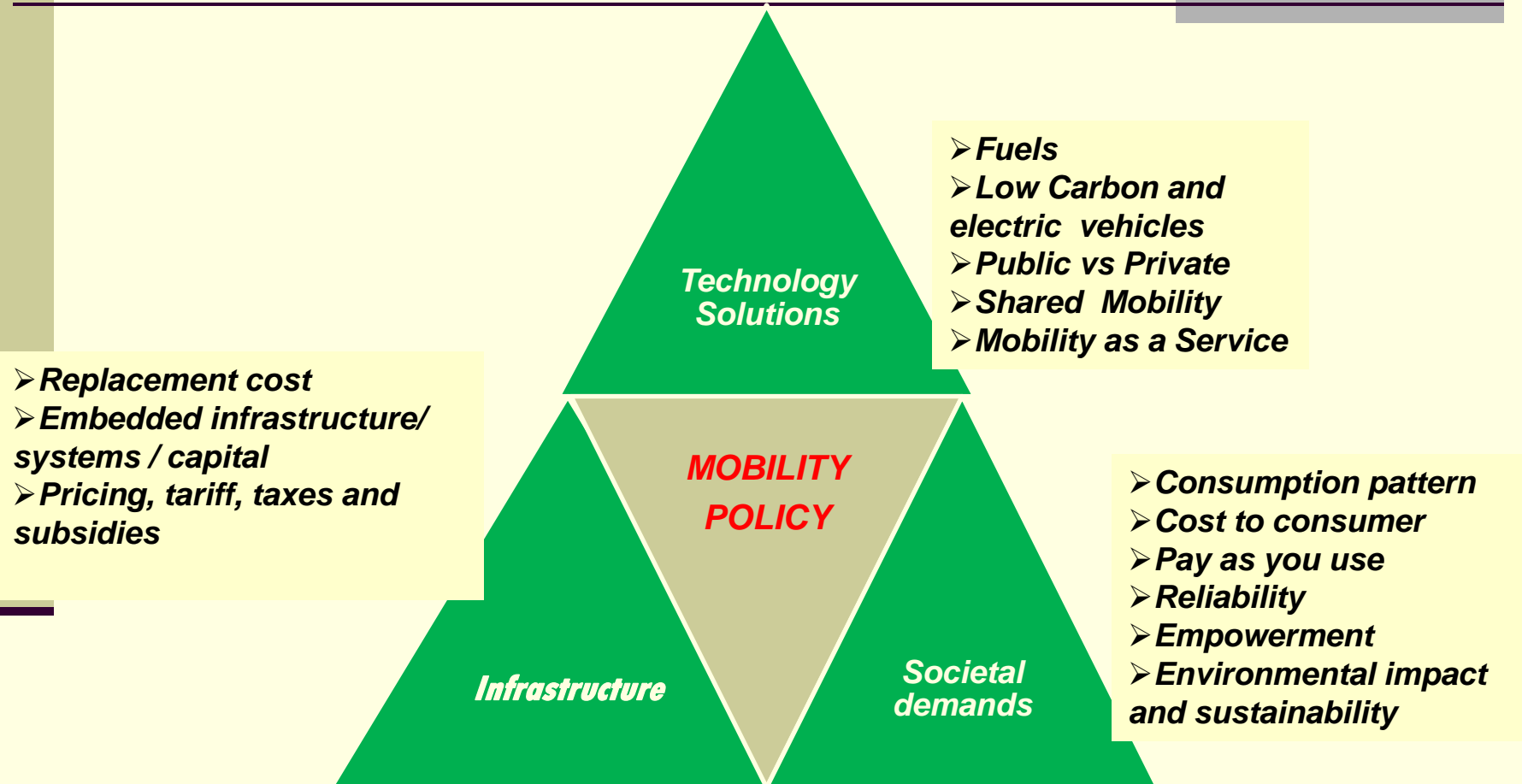   *Peak-time average speed 10-15 kph on main roads;*

THE ECONOMIC COST OF TRAFFIC GRIDLOCK

- Effects of Congestion
  - Fuel loss at signal intersections- Rs 995 crores per year, Rs 80 lakhs daily @ Moti Bagh crossing
  - Congestion delay costs Rs. 240 lakhs annually
  - Vehicles in congestion emit nearly four times more pollution
- Accidents and fatalities
  - More than 25 accidents and 5 fatalities per day in Delhi
  - India has 1% of the world's cars, but 10% of traffic fatalities
  - 5x fatalities of USA with 1/40x cars
- Loss of 2 % GDP (of a total GDP of US $ 30 billion) to a city like Bangalore
- Healthcare cost of citizens

Source: Delhi Traffic Police Dept , Economic Survey of Delhi 2002

MOBILITY INFRASTRUCTURE

Technology
Solutions

> Fuels
> Low Carbon and
electric vehicles
> Public vs Private
> Shared Mobility
> Mobility as a Service

> Replacement cost
> Embedded infrastructure/
systems / capital
> Pricing, tariff, taxes and
subsidies

MOBILITY
POLICY

> Consumption pattern
> Cost to consumer
> Pay as you use
> Reliability
> Empowerment
> Environmental impact
and sustainability

Infrastructure

Societal
demands

Radical changes are possible only when technology and infrastructure gets locked in synergistic embrace

SOME SOLUTIONS

- Improvements in the public transportation with last mile connectivity
- Prohibitive congestion charges, odd-even road usage, staggered working hours and holidays
- The more roads and parking you provide, the more cars will come in and there will be more congestion. The answer lies in reducing the roads and parking space drastically to discourage use of cars
- Self-contained neighborhoods with most places accessible by walking or cycling or short commute, both for work and leisure
- Technology embedded into the vehicles such that the intelligence and the decision-making on the roads is consistent and not dependent on the moods and vagaries of the driver
- Creating new urban spaces (hub and spoke cluster models)

Space is finite. We are fearfully close to the tipping point where we cannot build our way out of congestion.
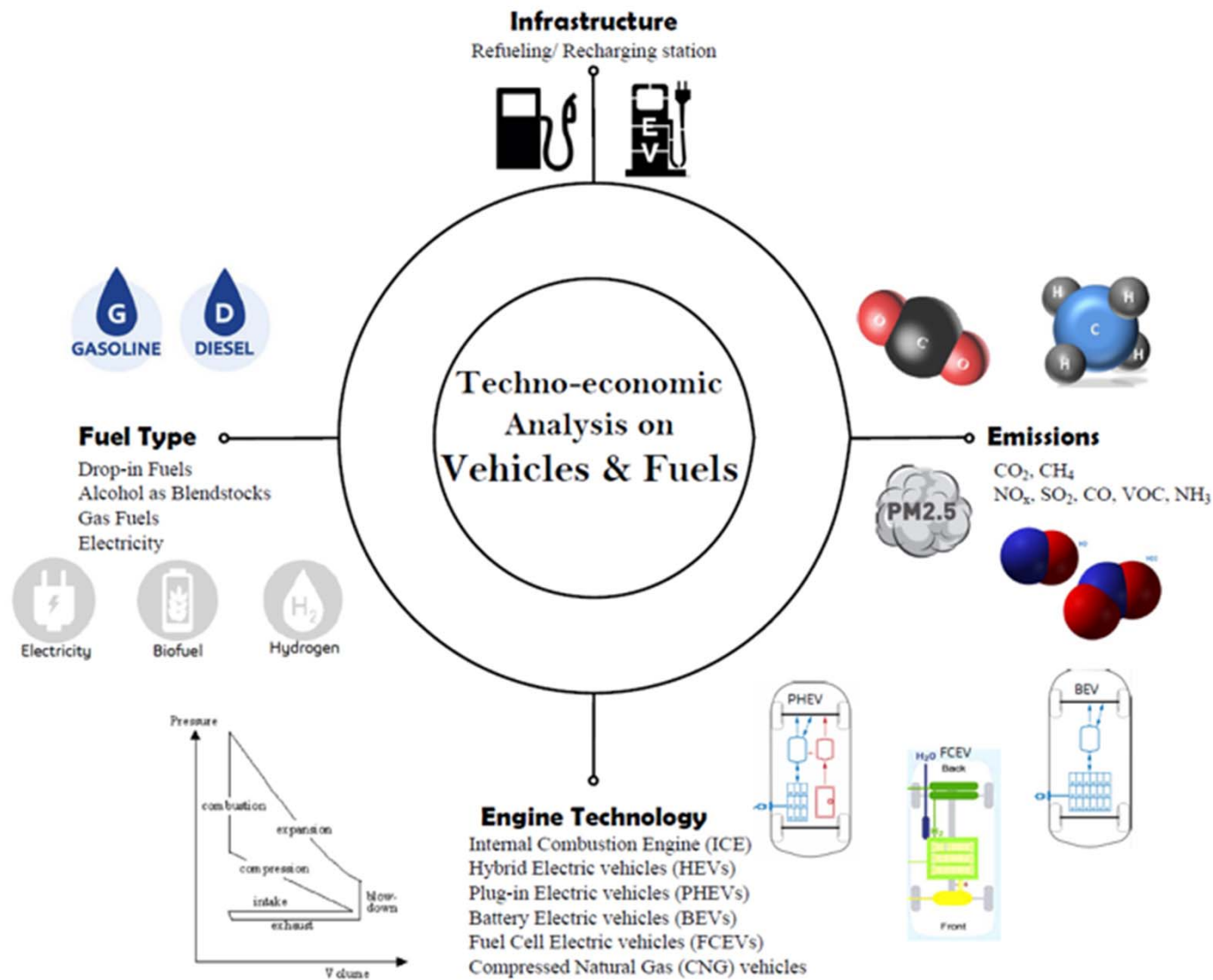
EMERGING TECHNOLOGIES TO THE RESCUE

- Vehicles with autonomous decision making (Intelligent vehicles)

- Mobility using cleaner fuels: CNG, hybrids (CNG +Electric), all electric and fuel cell (hydrogen as fuel)

- GPS coupled with real time information

- Intelligent roads

- Shared and networked mobility

- Mobility as a service (MAAS)

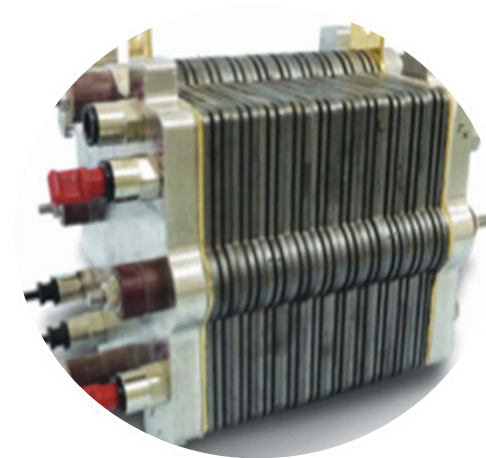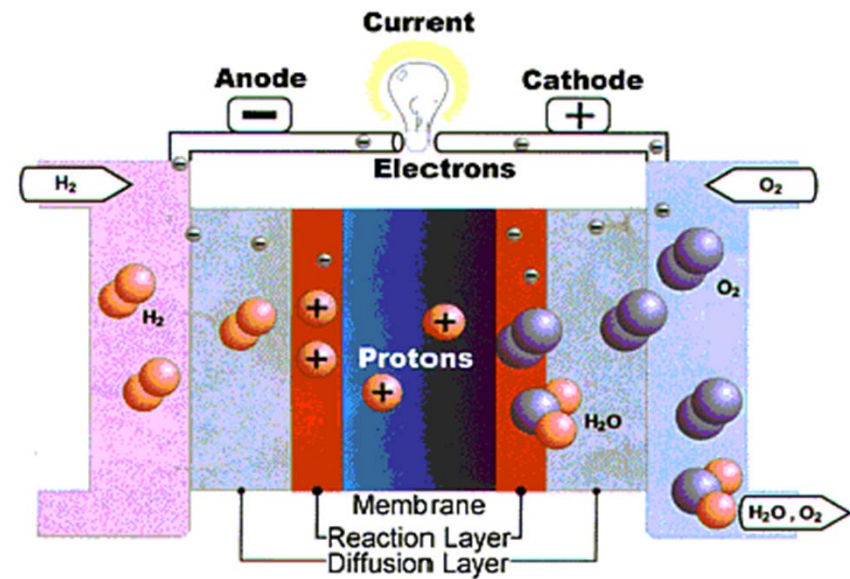- Enhanced occupancy per vehicle

Will all our private cars one day become public vehicles ?

www.energy.mit.edu/research/mobility-future-study

VEHICLES, FUELS AND EMISSIONS

TOYOTA MIRAI : FUEL CELL POWERED VEHICLES

www.toyota.com/mirai/fev

THE POWER BEHIND A TESLA

Tesla uses 18650 standard format cylindrical cells in Model S, 65 mm long and 18.6 mm dia, 7,104 cells per pack giving a total power of 85kWh
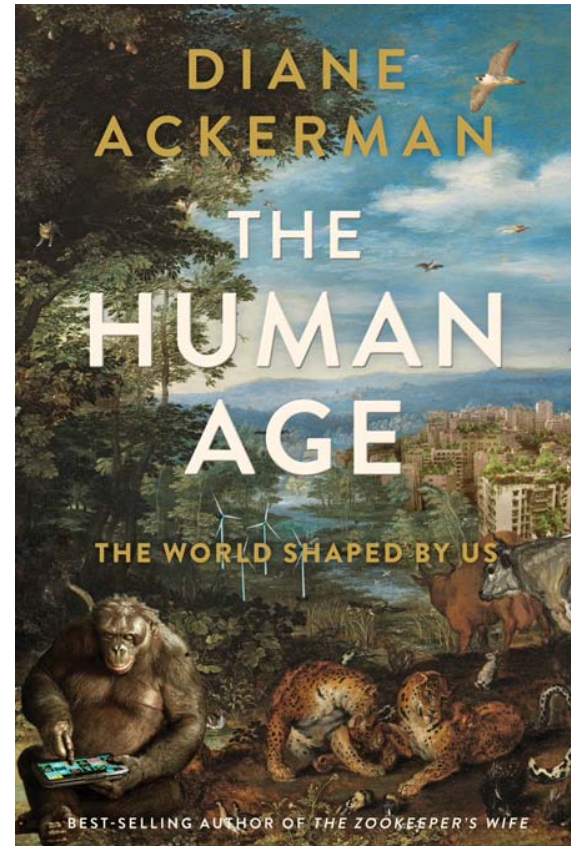
CLEANER FUEL IS ONLY ONE OF THE SOLUTIONS

- Electricity is a clean and sustainable fuel only if it is generated from renewable resources
- If electricity is generated from oil or coal, it increases the carbon load in the environment
- Coal or oil based base electricity used for mobility only shifts the problem from the tailpipe of the car to the smoke stacks/ flare stacks of a thermal or gas based power plant
- Hydrogen is also a clean fuel only if it is produced from a renewable resource.

The global efforts on sustainability will be won or lost in our cities where 70 % of the world population will live by 2050. Cities will have to learn to live within the planet's resource budget

THE HUMAN ANTHROPOCENE AGE

- Humans are leaving an indelible imprint on Planet Earth

  - Carbon cycle
  - Nitrogen cycle
  - Ocean pH
  - Extinction rate of species and habitats

- Human ingenuity and innovation capacity is also at an all time high

- However, emergence of technology alone is no guarantee that its benefit will tickle down to humanity at large.

DIANE ACKERMAN

THE HUMAN AGE

THE WORLD SHAPED BY US

2014

BEST-SELLING AUTHOR OF *THE ZOOKEEPER'S WIFE*

Our relationship with nature has changed radically, irreversibly, but by no means all for the bad. Our new epoch is laced with invention. Our mistakes are legion, but our talent is immeasurable."

"In the end, more than they wanted freedom, they wanted security. They wanted a comfortable life, and they lost it all - security, comfort and freedom. When the Athenians finally wanted not to give to society but for society to give to them, when the freedom they wished for most was freedom from responsibility, then Athens ceased to be free."

Edith Hamilton

THANK YOU