Transport Externalities as related to Energy and Environment

Sanjivi Sundar
Distinguished Fellow
The Energy & Resources Institute, India
What is an Externality?

- External effects/impacts of activities in one market on another market without compensation
- An externality is the cost or benefit that affects a party who did not choose to incur that cost or benefit (Buchanan et al, 1962)
- Externality is "an effect of a purchase or use decision by one set of parties on others who did not have a choice and whose interests were not taken into account“ - Economics (2007)
- Externalities refers to situations when the effect of production or consumption of goods and services imposes costs or benefits on others which are not reflected in the prices charged for the goods and services being provided. (OECD org)

Externality can be Positive or Negative

2. http://economics.about.com/cs/economicsglossary/g/externality.htm
What Are Transport Externalities?

- Congestion
- Local air pollution
- Noise pollution
- Threats to energy security
- Climate change and its impacts
- Others: Oil spills, light pollution and Ozone depletion
- Accidents and safety hazards
Instruments to Curb Transport Externalities

Why should externalities be valued and internalised?
- External costs are costs to society and are not taken into account by the transport users.
- Internalisation would make these part of their decision making process.

What are the instruments available to curb externalities?

1. Regulatory Interventions
   - A predictable regulatory environment enables stakeholders to plan their investments.
   - Regulation is not affected by market failures and problems in valuing externalities and mechanically incorporating them into a pricing mechanism.

2. Economic Instruments
   - Send out price signals which have a greater influence on human behavior and offer users a choice.
   - Encourage efficient use of transport systems.

Need for an appropriate mix of instruments to obtain optimum results.
What are the difficulties in valuing externalities?

- Inadequate data, especially in respect of road transport, and difficulty in collection and collation of data;
- Different assumptions and methodologies;
- Difficulty in ascribing monetary values to different externalities;
- Difficulty in regularly updating the cost of externalities and incorporating them in a pricing mechanism.
1. Congestion
Congestion

- External to individual motorists but also largely internal to motorists as a group
- Traffic congestion leads to
  - Loss of time and productivity
  - Higher exposure to vehicular emissions
  - Loss of fuel on idling
  - Stress and road rage

Represents a “market failure as individual benefits are less than the marginal social costs
Leads to the construction of more road space than socially justified
How is Congestion Measured?

Methods used to assess congestion include:

- Determination of the user’s willingness-to-pay to reduce traffic volumes to optimal road capacity
- Calculation of the marginal costs a road user imposes on other road users
- Congestion is usually calculated as the difference in travel times during the whole day and peak periods and travel times during non congested periods (free flow). This is an engineering approach and could result in over supply of roads.
- An economist’s approach recognises an optimal level of congestion as the base traffic in order to ensure the optimal utilization of roads.
## Congestion

<table>
<thead>
<tr>
<th>City</th>
<th>Peak hour traffic index</th>
<th>Time taken during in peak hour congestion for a 30 minute free flow trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moscow</td>
<td>126</td>
<td>68</td>
</tr>
<tr>
<td>Istanbul</td>
<td>108</td>
<td>62</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>99.5</td>
<td>60</td>
</tr>
<tr>
<td>Tianjin</td>
<td>91</td>
<td>57</td>
</tr>
<tr>
<td>Mexico City</td>
<td>88.5</td>
<td>57</td>
</tr>
<tr>
<td>Hangzhou</td>
<td>87</td>
<td>56</td>
</tr>
<tr>
<td>Sao Paulo</td>
<td>80.5</td>
<td>54</td>
</tr>
<tr>
<td>Chongqing</td>
<td>78.5</td>
<td>54</td>
</tr>
<tr>
<td>Beijing</td>
<td>76.5</td>
<td>53</td>
</tr>
<tr>
<td>Brussels</td>
<td>75</td>
<td>53</td>
</tr>
</tbody>
</table>

Data Issues

- Data needed for congestion analysis is seldom available; most estimates are based on simplified models that measure incremental delay, vehicle operating costs and emissions over some baseline. Monetized values are assigned to the additional time and emissions.
Approaches to Curb Congestion

- Regulatory interventions such as plying restrictions, odd and even number plates, restricted registrations, low emission zones

- Market based Instruments to send out price signals
  - Congestion pricing being increasingly adopted by cities to internalise congestion costs
  - Singapore, London

http://www.ncpa.org/pub/ba725
Singapore’s Electronic Road Pricing

- Based on a pay-as-you-use principle, motorists are charged when they use priced roads during peak hours.
- Rates vary for different roads and time periods depending on local traffic conditions. This encourages motorists to change their mode of transport, travel route or time of travel.
- Rates are determined by a quarterly review of traffic speeds of priced roads and during the June and December school holidays.
  - Optimises usage of the road network
  - Minimises traffic volume
  - Provides a fair price for motorists
  - No more monthly/daily licences
  - No human error
- Makes motorist more aware of the true cost of driving
- Singapore uses a package of strategies

Electronic Road Pricing
Public transport systems
Facilities for NMT
Vehicle quota system
High parking charges
2. Energy Security
The transport sector accounted for 27% of global energy use.

The number of light-duty vehicles—the ‘global fleet’—is expected to more than double from about 800 million in 2010 to about 1.7 billion in 2040.

In 2010, about 75% of the world’s vehicles were in OECD countries. Looking ahead, about 80% of the growth in the global fleet will come from non-OECD countries led by China and India.

Emerging Asian countries expected to account for 45% of the total world oil use increase through 2025.

These trends have serious energy implications.
Global energy demand

Quadrillion BTUs

Transportation demand by sector
Millions of oil-equivalent barrels per day

*Mexico and Turkey included in key growth

Key World Energy STATISTICS, 2014, IEA
Energy Security - India

- Growing dependence of road transport on fossil fuel
- In India, Transport accounts for 17% of the total energy consumed, second largest after the industry sector.
- Continuous shift of passenger and freight traffic from the railways to road transport
- In the BAU scenario the oil import dependency is expected to increase from 73% of 141mt in 2012 to 93% of 731mt by 2031.

There is no agreed methodology to price dependence on fossil fuel. In an unstable geo-political scenario, these raise important concerns about national security for countries like India and emphasize the need for reducing dependence on fossil fuel in road transport.
Approaches to Improve Energy Conservation

• **Avoid-Shift-Improve (ASI)**
  - *Avoid* – Reduce/ avoid trips and trip lengths through integrated transport and land use planning and use of ICT
  - *Shift* – Shift to or maintain share of energy efficient modes
  - *Improve* - Improve energy efficiency of transport modes
  
  Achieve System and Trip efficiency.
  
  • Encourage use of renewable sources of energy especially solar energy

3. Pollution
Typical Pollutants from Vehicles and their Effects

- Greenhouse Gases: \( CO_2, N_2O, HFC \)
- Methane
- Ozone
- Black Carbon
- Particles (PM\(_{10}\)/PM\(_{2.5}\))
- Gaseous pollutants: \( SO_2, CO \)
- NO\(_x\), NMVOCs
- Diesel particles
- Benzene
- Heavy metals

Impact
- Climate
- Agriculture
- Buildings
- Health
Impacts

- Respiratory, cardiovascular and chronic diseases.
- Global Burden of Disease (GBD) attributed 3.7 million deaths globally to ambient air pollution; about 0.6 million mortalities were attributed to ambient air pollution in India in 2010.
- Effects on vegetation, visibility, ecology etc. Ozone estimated to have caused a loss of 36% in wheat yields in India in 2010 (Burney and Ramanathan, 2014)
- Impact on a country’s image
Approaches to Curb Vehicular Pollution

- Improve fuel quality
- Tighten ambient air quality and emissions standards
- Foster development of new engine management technologies
- Reduce toxic emissions from off-road vehicles used in construction, mining and other industries
- Encourage retrofitting of existing vehicles with exhaust filters / emission reduction devices and installation of fuel efficient tyres and aerodynamic devices
- Upgrade testing of on-road vehicles
- Encourage fleet modernization
- Introduce cleaner alternate fuels and Increase penetration of electric and hybrid vehicles
- Shift transportation of passengers to environment friendly modes like public transport and non-motorized transport, and of freight to rail and water transport
- Avoid/ reduce need for travel through improved integrated land-use planning and use of ICT
- Use ITS and telematics to reduce congestion
Estimation and Valuation of Pollution Related Externalities

- Understand the cause and effect relationship
- Establish extensive monitoring network
  - In India, AQ monitoring takes place only in about 200 cities out of about 8000. Regular Noise monitoring has just started
- Database of emission inventories of air pollutants, and GHGs
  - Does not exist in many developing countries
- Source apportionment studies
  - In India source apportionment studies have been carried out only in 6 cities. Limited studies in developing nations.
- Modeling capabilities
  - Limited modeling capabilities in many developing nations to predict concentrations/levels at appropriate spatio-temporal resolutions, assess the receptor’s exposure to pollutants and the impact of emissions on air quality.
Estimation and Valuation of pollution related externalities

- Application of dose response relationships
  - Most epidemiological or clinical conclusions are based on studies in the developed world and not always relevant to the developing world
  - Poorly maintained health data sets

- Valuation techniques
  - Limited studies in developing world for valuation of environmental impacts
  - Most of the values are from International literature
Valuation of Human Life

- Estimates of the cost of mortalities are usually based on the:
  - Human capital approach: the economic contribution of an individual to society over the lifetime of the individual. Economic loss is approximated by the loss of all future income of the individual.
  - Value of statistical life approach: based on preferences for reducing mortality risk by a small amount. Willingness to pay for reducing mortality risk (due to accidents, pollution etc) is the basis for estimating the social cost of mortality risk.

- Estimates of the cost of morbidities are based on costs of medical treatments and loss of time.
  - Disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death.
4. Climate change
Climate Change

- Vehicles emit
  - Green house gases: CO₂, Methane, N₂O
  - SLCPs: Black carbon, NOₓ (which forms O₃)
- Black carbon which is a dominant part of PM from diesel engines exhausts is now known to have the second highest radiative forcing (Bond et al., 2013)
- Very few countries have Fuel efficiency standards, hence high energy consumption and GHG emissions
In 2004, the transport sector accounted for 23% of world energy-related CO2 emissions (6.2Gt) which is projected to grow to about one third by 2050.

The share of Non-OECD countries is 36% now and will increase rapidly to 46% by 2030 if current trends continue.

CO2 emissions may double between 2010-2050.
Transport about 20% in total energy based GHG emissions

Source: Turkey’s submission to UNFCCC
Approaches to estimating the cost of climate change mitigation

Difficult to value the cost of climate change

- Climate change is a global issue
- Greenhouse gases live long in the atmosphere and cause damage in the distant future.
- The long-term impacts of greenhouse gases are difficult to predict.

The two broad approaches

- The cost of damage - difficulty in predicting the impact of climate change and establishing a cause–effect relationship between climate change and extreme weather events.
- The cost of avoidance – the least cost option to achieve a targeted reduction in GHG emissions. Consistent with national policies and voters preference.
The aggregate economic costs of mitigation vary widely and are highly sensitive to model design and assumptions as well as the specification of scenarios.

Global studies of the costs and benefits of climate change mitigation make use of Integrated Assessment Models (IAMs). These models cover the cause-and-effect chain of climate change which includes:

- the anthropogenic activities that cause GHG emissions,
- the effect of these emissions on GHG concentrations in the atmosphere and the oceans,
- the changes in temperature and other parameters due to the increased concentrations, and
- the impact of these changes on ecosystems and the economy.
Approaches to Curb Emissions of Warming Agents From Transport Sector

- Reduce CO₂ emissions by improving energy efficiency of transport systems and adoption of “AVOID” “SHIFT” and “IMPROVE” approaches
- Reduce black carbon and Ozone precursor emissions by introduction of tail-pipe devices and through advancement of standards
- Carbon trading mechanisms to encourage mitigation of GHGs
5. Accidents
1.24 million deaths in 2010 in the world, 3,400 deaths per day!! = Road Safety a public health issue

91% of the world's fatalities on the roads occur in low-income and middle-income countries, even though these countries have approximately half of the world's vehicles.

50% fatalities were pedestrians, cyclists and drivers of motorized 2-wheelers - most vulnerable – Road Safety an equity issue.

An estimate carried out in 2000 placed the economic cost of road traffic crashes at approximately US$ 518 billion. National estimates indicate that road traffic crashes cost countries between 1–3% of their GNP.
Conclusions

• Externalities are important and should be accounted for.

• Inclusion of costs of externalities will allow the decision makers to make informed policy decisions.

• Costing and pricing externalities will send out price signals to road users to make behavioral changes.

• Reducing transport externalities is necessary to put transport on a sustainable and low carbon path.
Way Forward

- Developing countries must recognise that transport externalities can be contained without affecting economic growth.

- Countries must integrate sustainable low carbon transport in their sustainable development policies and strategies, and in the global climate dialogue.

- Reduction of transport externalities call for technology and resources, both human and financial.

- Developed countries must provide the technology and resources to the developing world, and build capacity to adopt the ASI approaches.
THANK YOU