Comparison of emissions of CO_2 and local pollutants and health impacts of mitigation transport scenarios in three Indian mega cities – Delhi, Mumbai and Bangalore

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Outline

- Framework for evaluation
- Focus on CO_2 emissions and Health impacts due to $PM_{2.5}$ concentration
- Construction of policy packages for the case cities
- Scenarios for Delhi, Mumbai and Bangalore
- Comparison of CO_2 emissions for the 3 case cities
- Comparison of $PM_{2.5}$ emissions for the 3 case cities
- Mortalities due to $PM_{2.5}$ concentrations for the 3 case cities
- Electric mobility scenarios under different energy mix assumptions
- CO_2 emissions and health impacts with electric mobility scenarios
- Conclusions

Framework for evaluation (1)

Benefits

- Mitigation CO_2 emissions
- Reduction of local pollutants
- Health effects
  - *PM2.5*
  - *Other local pollutants*
- Changes in travel pattern due to a policy package
  - *Decrease in traffic congestion*
  - *Time savings and losses*
  - *Increased health effect due to walking and cycling*
- Potential reductions in traffic injuries and fatalities
- Improvement in case cities livability
- Energy security: Reductions in fossil fuel consumption

Framework for evaluation (2)

Costs

- New infrastructure investments
  - *Cycling and walking*
  - *Public transport*
  - *Road infrastructure*
- Improvements in the existing transport infrastructure
- Other infrastructures: IT infrastructures, recharging infrastructure for El-vehicles,....
- Cost of financing of investments

Focus on CO_2 and PM2.5 emissions

In this presentation we focus on:

- C02 emissions
- Health effects (mainly mortalities due to PM2.5) using WHO model

PM2.5 is the most important pollutant for health effects

Policy Packages adopted in the 3 case cities

Costs

The selected policy packages differ in the 3 case cities due to:

- Case city context
- Master transport plans
- Consultation with Stakeholders in workshops
- Delphi study among city and national stakeholders

The policy packages selected for each case city are hence more realistic for the horizon years

We consider these differences to be a strength of the study

Mumbai: Policy packages for mitigation

2 + 2 Policy packages:

- **Policy package 1:**
  - *BAU + Policy 3+ Policy 4*
  - *3. Transport Infrastructure Development*
  - *4. Travel Demand Management*
  - *Policy package 1 w/electric mobility*
- **Policy package 2:**
  - *Policy 2 + Policy 3+ Policy 4*
  - *2. Draft Mumbai Metropolitan Regional Plan 2016-36 scenario*
  - *3. Transport Infrastructure Development*
  - *4. Travel Demand Management*
  - *Policy package 2 w/electric mobility* ← Best package

Delhi: Policy packages for mitigation

3+2 Policy packages:

- **Policy package 1:**
  Planning: Increase in Transit Network + Transport Oriented Development (TOD)
- **Policy package 2:**
  Travel Demand Management: Congestion + Fuel + Car Share
- **Policy package 3:**
  Technology adaptation: BAU with Electric Mobility
- **Combination of Policy packages:**
  - *Planning Policy with Electric Mobility*
  - *TDM with Electric Mobility* ← Best package

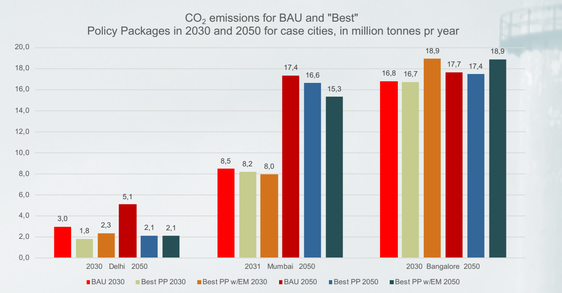
Bangalore: Policy packages for mitigation

3 +1 Policy packages:

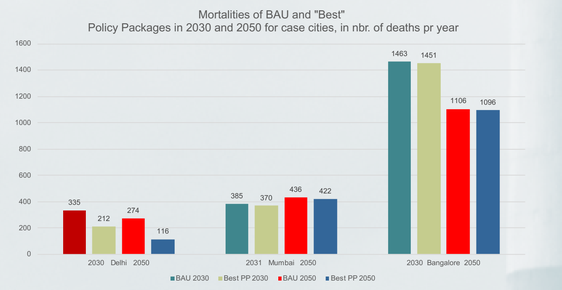
- **Policy package 1:**
  - *Increasing network coverage of Public Transit +*
  - *Cycling and walking infrastructure +*
  - *Additional tax on purchasing vehicles*
- **Policy package 2 :**
  - *Additional tax on purchasing vehicles +*
  - *Strict Vehicles inspection/ Improvement in standards for vehicle emission +*
  - *Increase in fuel cost*
- **Policy package 3:**
  - *Increasing network coverage of Public Transit +*
  - *Defining car restricted zones +*
  - *Congestion Pricing +*
  - *Park and Ride +*
  - *Cycling and Walking infrastructure +*
  - *Encouraging car-pooling and High Occupancy Lanes +*
  - *High density mix building use along main transport corridors*
- **Policy package 4:**
  - *Policy packages 1-3 w/electric vehicles*

Best package

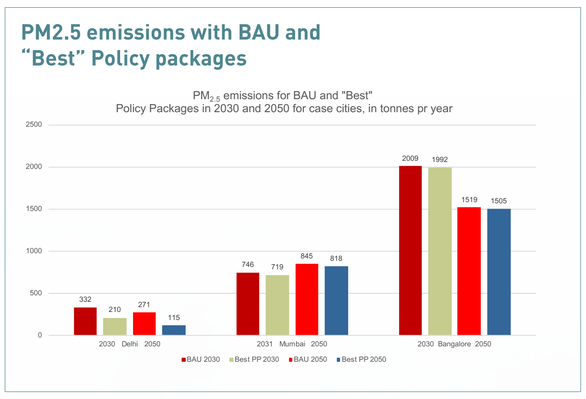
CO_2 emissions with BAU and "Best" Policy packages (*IEA, 2015 scenario)



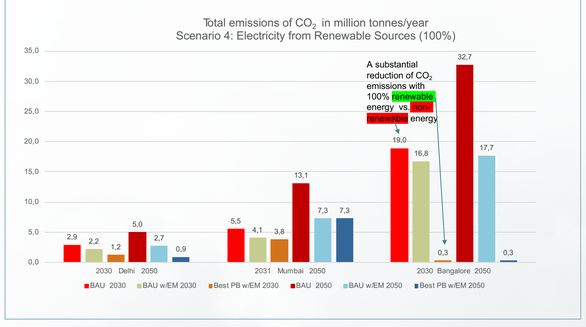
Moralities due to PM2.5 emissions reductions with BAU and "Best" Policy packages



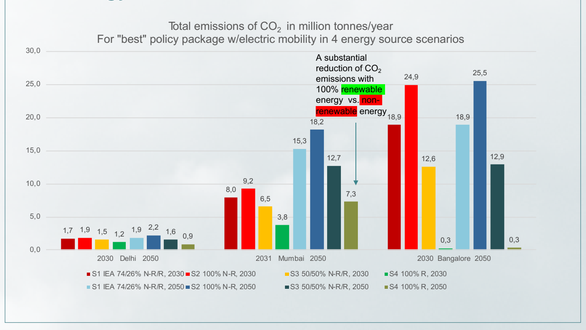
PM2.5 emissions with BAU and "Best" Policy packages



CO_2 emissions for BAU & "Best" Policy packages, for 100% renewable energy scenario (# 4)



CO_2 emissions for BAU & "Best" Policy packages in 4 energy source scenarios



4 scenarios for electric mobility under different energy mixes

- **Four different scenarios are based on different projections of the electric energy production in the horizon years:**
  - *Scenario 1: New Policies Scenario (IEA, 2015)–Non-renewable sources and Electricity (74% - 26%)*
  - *Scenario 2: Electricity from non-renewable sources (100 %)*
  - *Scenario 3: Half electricity from renewable and another half from non-renewable sources (50 % - 50 %)*
  - *Scenario 4: Electricity purely from renewable sources (100 %)*
- **The type of energy mix used has substantial impact on CO_2 emissions**

Effects of a 100% clean electric energy source (Energy scenario 4)

- In Delhi the estimated reductions compared to the BAU in 2030 is 58% through implementation of the best policy package and uptake of electric mobility. In 2050 the reductions are estimated to be as much as 82% in Delhi.
- In 2030 in Mumbai the CO_2 emissions can be lowered by 31% through implementing the best policy package combined with electric mobility, and in 2050 the emissions can be 45% lower.
- In Bangalore CO_2 emissions can almost be eliminated with the best policy package and electric mobility, with only 0.3 million tones of CO_2 in 2030, which is a 98% reduction compared to the BAU. In 2050 the reductions can also be as high as 98%.

Conclusions

- We have presented the evaluation results of mitigation policies in the passenger transport sector in three Indian cities – Delhi, Mumbai and Bangalore - with focus CO_2 emissions and PM2.5 emissions as well as health impacts estimated in terms of mortalities related to PM2.5 concentration
- The different policy packages have varying, however mainly positive, impacts on the different types of emissions compared to that of the BAU in the case cities.
- For both Delhi and Mumbai, a larger scale conversion of the vehicle stock into electric vehicles (EVs) will by far have the greatest impact on CO_2 emissions for both horizon years, compared to that of the BAU, given a renewable source of electricity production.
- In particular, this is the case when EVs are combined with the "best" performing policy package, i.e. policy package 3 for Delhi and policy package 2 for Mumbai.
- For Bangalore, the differences of some of the policy scenarios vs. the BAU scenario are small. When incorporating electric mobility in policy package 4, the results are much more pronounced, also for Bangalore.
- The positive impacts of electric mobility are highly dependent on the energy source for the electricity production, whether it is from renewable or non-renewable sources.
- In some cases, utilizing electricity from non-renewable (fossil-based) power sources can have little positive impact terms of CO_2 and other emissions, and sometimes do more bad than good.
- Notwithstanding, the energy source scenarios show that just a modest introduction of renewable power sources can have profound positive effects.
- The emission of local pollutants, including PM2.5 emissions, in all the case cities under electric mobility scenarios will be outside the city boundaries, with positive impact on the case cities air quality.
- The mortalities due to PM2.5 concentration can also be reduced in all the case cities by implementing the best policy packages. However, since the electric power production in most cases happens outside the city boundaries, local pollutants (PM) will not be affected by the type of energy source.

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