Air quality and health impacts of large-scale vehicle electrification in India

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Webinar
19 October 2021

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Outline

- Background and research questions
- Scenario design
- Modeling procedure
- Emissions modeling
- Emissions results
- Air quality modeling
- Air quality results
- Health impacts modeling
- Health impacts results
- Conclusions

Background and research question

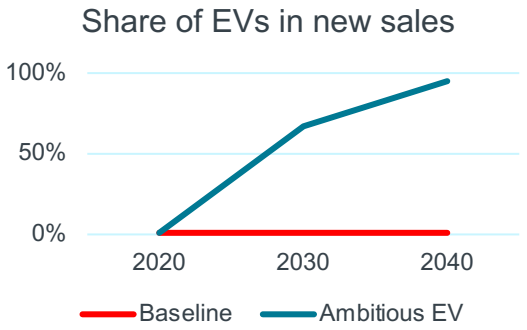
- Poor air quality in India due to local pollutant emissions has significant health impacts
- Transportation and power sector emissions account for more than half of the total emissions in India

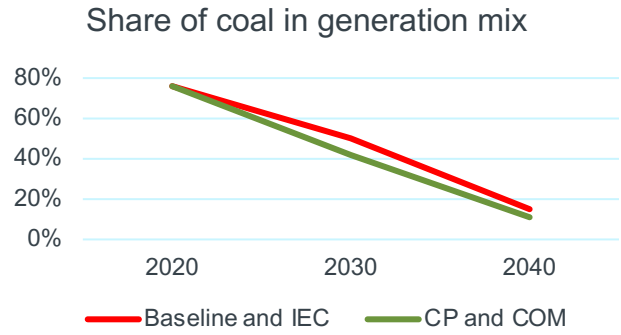
RESEARCH QUESTION

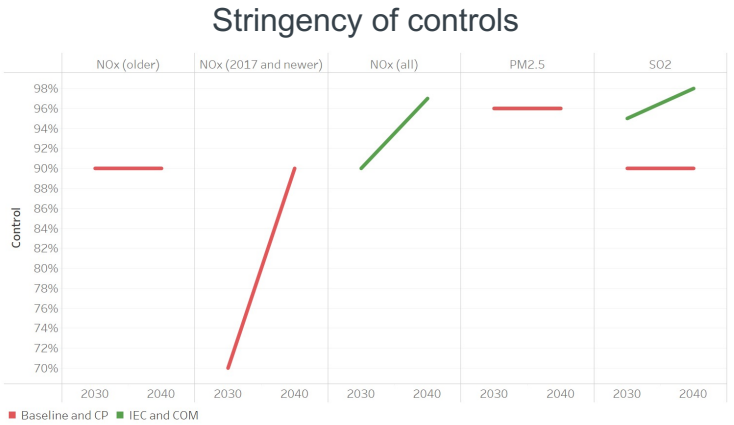
- Can ambitious vehicle electrification improve air quality?
  - Do power sector emission control and decarbonization amplify the effects on air quality?

Scenario design

Air quality scenarios	Vehicle electrification measures	Power sector measures
Baseline	Baseline	Baseline
Reference (REF)	Ambitious EV	Baseline
Improved emission control (IEC)	Ambitious EV	Improved emission control
Coal phaseout (CP)	Ambitious EV	Coal phaseout
Combined (COM)	Ambitious EV	IEC + CP







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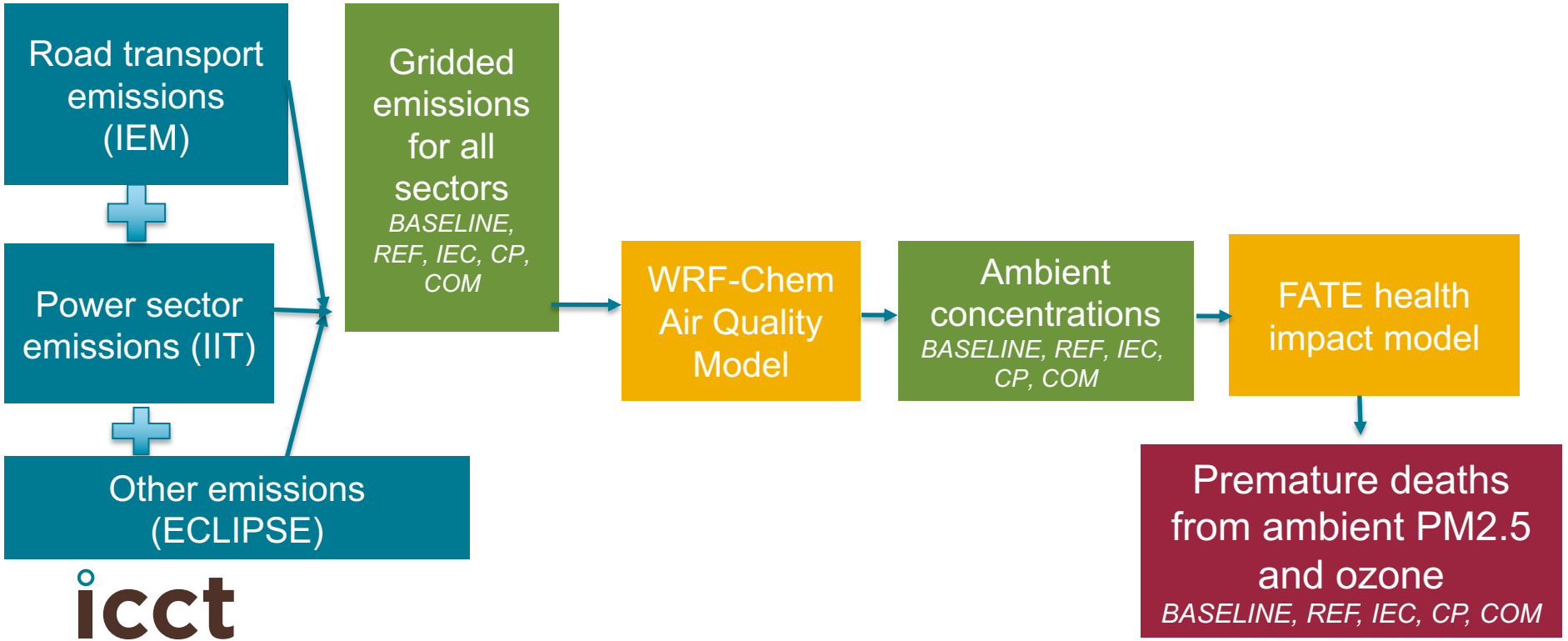
Modeling procedure



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Emissions modeling: Overview

- Transportation emissions for various scenarios at the national level were modeled using ICCT's India Emissions Model (IEM)
- Power sector emissions were estimated at the plant level using CEA and CPCB data by IIT Kanpur
- It is assumed that additional power requirements due to electrification are met through fossil fuel power plants

Emissions modeling: IEM and power sector calculations

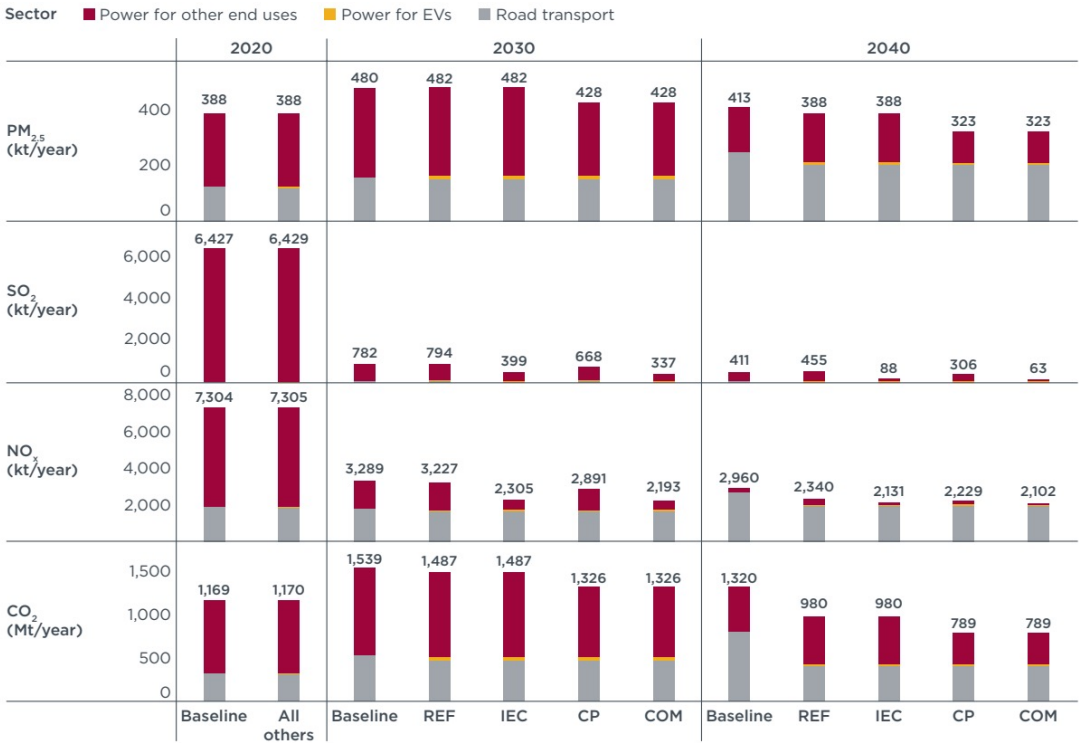
IEM

- IEM's vehicle fleet consists of 15 vehicle categories, 8 powertrain types, and 9 emissions controls
- Stock turnover from present day is calculated through BAU and scenario specific sales projections and survival curves
- Activity and emissions are calculated from stock using age and vehicle-specific mileage and emission factors respectively
- For additional EVs, IEM provides energy requirements in GWh, which are then used as an input in power sector modeling

Power sector model

- CEA's plant level capacity and generation data are used as the starting point
- Energy requirement data for additional EVs are added and generation is assumed to be fossil fuel-based
- Any adjustment to the baseline generation mix is made by retiring older/inefficient power plants
- Emission factors are obtained from CPCB and then multiplied with generation values
- Emission controls are then applied as per scenario design

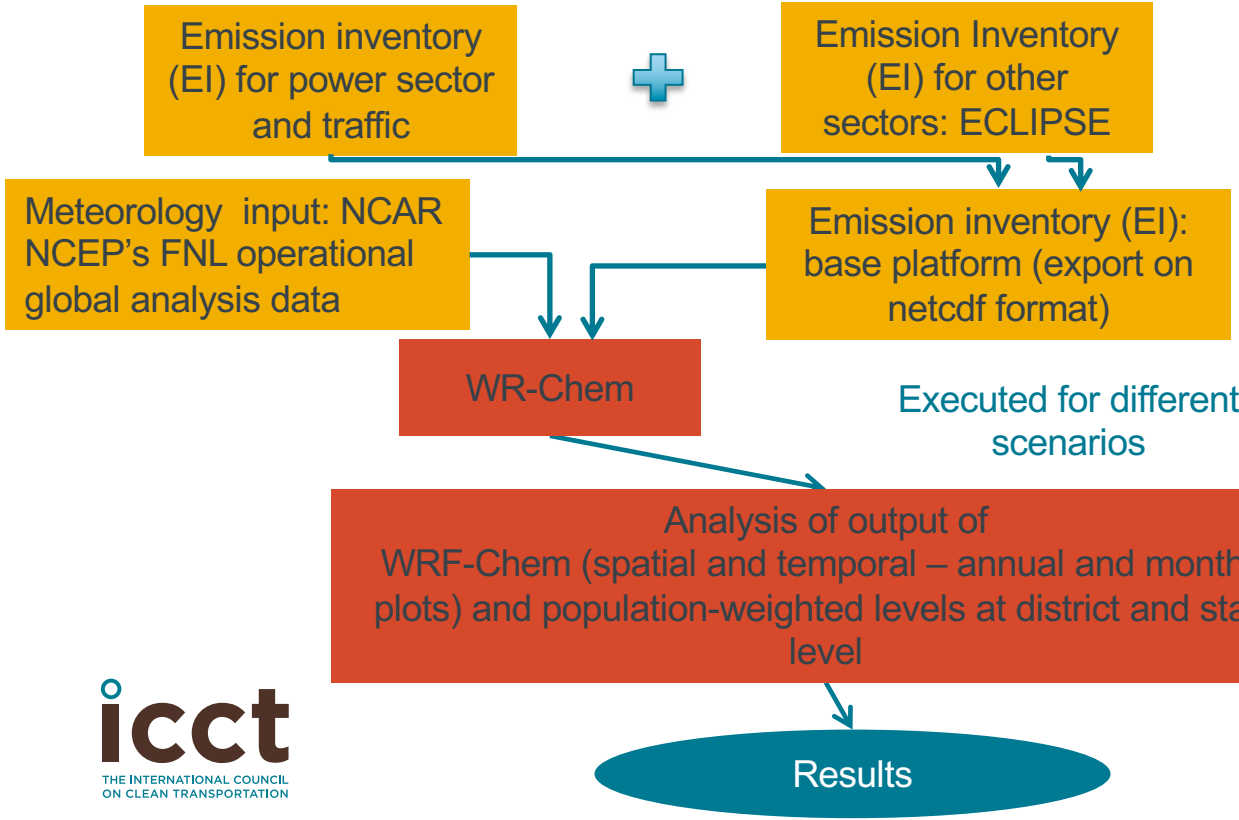
Emissions results



Air quality modeling: Overview

- National transportation emission data and power plant level emission data were gridded at a spatial resolution of 0.5º x 0.5º
- Emission data for other sectors were obtained from the ECLIPSE V5a project's Current Legislation Scenario
- Data was modeled using the comprehensive meteorological and chemical transport modeling system WRF- Chem
- Air quality is measured in terms of population-weighted concentration of pollutants at state and national levels

Air quality modeling: WRF-Chem model



Estimate the concentrations at district or state level from the gridded concentrations

$$C_i = \frac{\sum_{j=1}^{J} C_j \times A_j}{\sum_{j=1}^{J} A_j}$$

Population-weighted levels

$$\text{PW\_C} = \frac{\sum_{i=1}^{N} C_i \times P_i}{\sum_{i=1}^{N} P_i}$$

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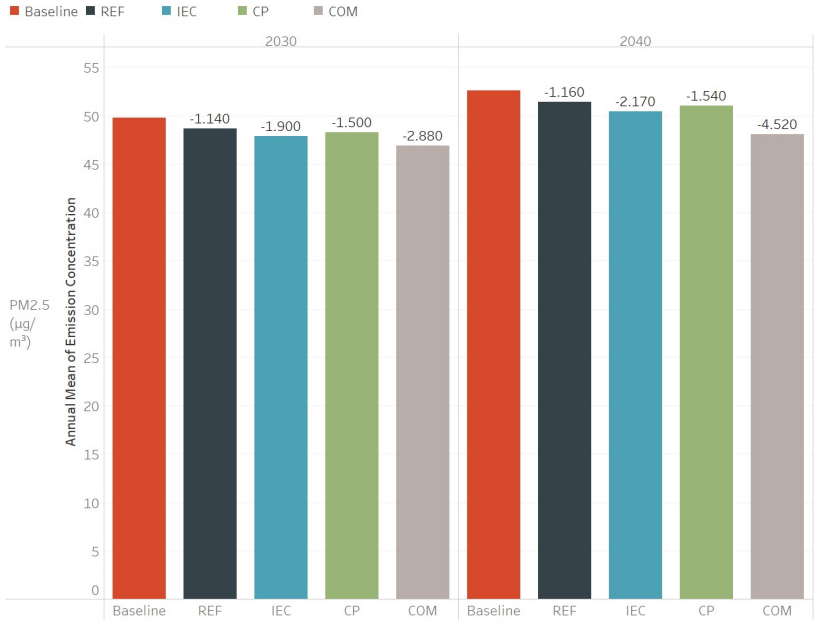
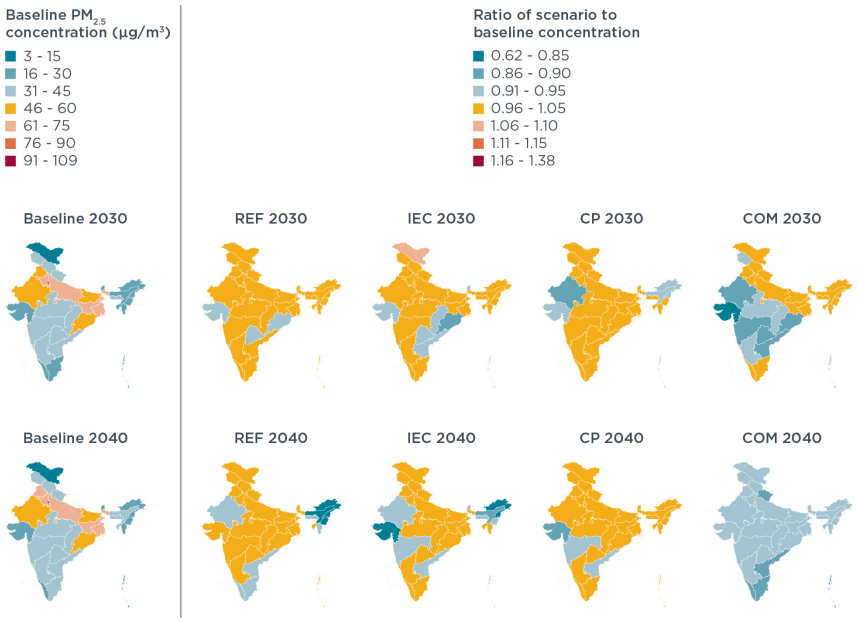
Air quality results





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Health impacts modeling: Overview

- National level air quality data was used to model health impacts in terms of reduction of premature mortality due to air quality using ICCT's FATE tool
- The health impacts associated with exposure to pollutants are calculated using methods consistent with the GBD 2019
- Health impacts are quantified in dollar terms using the Value of Statistical Life analysis from the World Bank

Health impacts modeling: Health outcomes and VSL calculations

Health Outcomes Considered
Stroke
Ischemic heart disease
Chronic obstructive pulmonary disease (COPD)
Lower respiratory infection
Lung cancer
Diabetes mellitus type 2

Equation to calculate health impacts by age i, geographic unit i, country c, and health outcome h

$$M_{a,i,h} = Pop_i \times Popfrac_{a,h} \times Y_{a,c,h} \times \left[\frac{RR_{a,i,h} - 1}{RR_{a,i,h}}\right]$$

Equation to Value of Statistical Life for country c, year y in 2020 dollars

$$V_{c,y,\$2020} = V_{default,2011,\$2011} * i_{2011,2020} * (G_c/G_{default})^{\wedge e} * (1 + g_{c,2011,2020}) * (1+ g_{c,2020,y})$$

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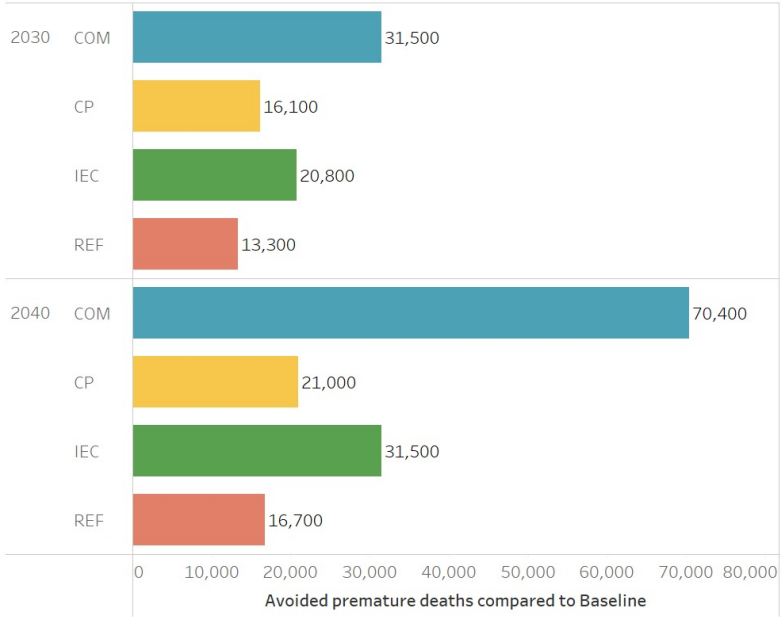
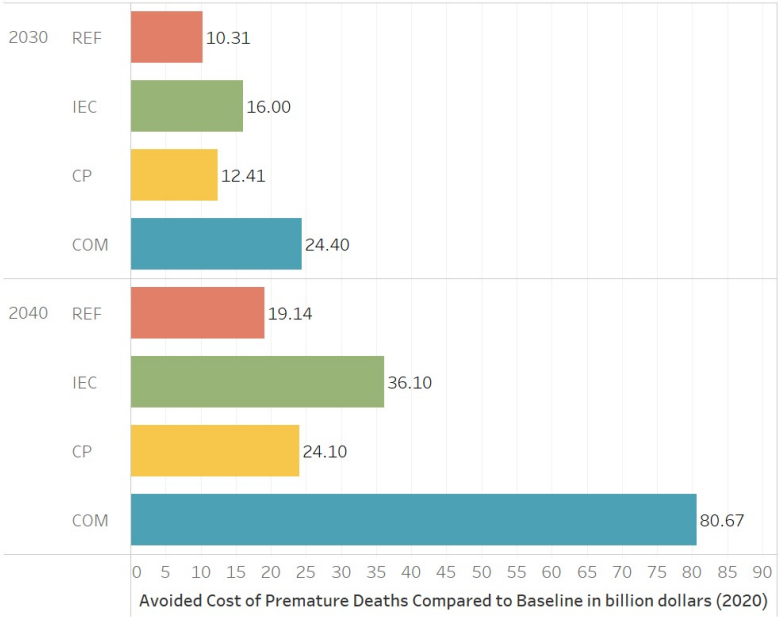
Health impacts results





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Conclusions

- Widespread vehicle electrification will yield net air quality and health benefits in India
- Additional policies to clean up India's electricity grid could amplify the air quality and health benefits of vehicle electrification
- These findings justify accelerating India's efforts to decarbonize its electricity grid and improve power plant emission controls independent of the level of vehicle electrification
- They also underscore that India need not wait to pursue a pathway of ambitious vehicle electrification; rather, vehicle electrification and grid policies should proceed in parallel

Questions?

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