Automobiles vs. 2050 IPCC Goals

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Automobile Emissions

57% decrease needed

Gross World Product

420% increase projected

Source: IPCC, DOE, Fuglestvedt, Carnegie Endowment
\[ I = P \cdot A \cdot C \cdot T \]

\[
Impact = \frac{\text{Population}}{\text{Population}} \cdot \frac{\text{Vehicles}}{\text{Vehicle}} \cdot \frac{\text{Distance}}{\text{Distance}}
\]
\[ I = p(t) \cdot \beta_v a(t)^\gamma_v \cdot \beta_d a(t)^\gamma_v \cdot \tau(t) \]

\[ a(t) \text{ affluence, GDP per Capita} \]
population

\[ I = p(t) \cdot \beta_v a(t)^\gamma_v \cdot \beta_d a(t)^\gamma_v \cdot \tau(t) \]
World Population Projections

- **High**: 8.8 billion
- **Most likely**: 8.1 billion
- **Low**: 7.5 billion

Source: United Nations
automobiles per capita

\[ I = p(t) \cdot \beta_v a(t)^{\gamma_v} \cdot \beta_d a(t)^{\gamma_d} \cdot \tau(t) \]
automobiles per capita

\[ \beta_v a(t)^{\gamma_v} \]

How will a country respond to newfound wealth?
The Big Three

China, US, India: 57% of the global GDP in 2050

Both charts to scale
Simulated 2050 Vehicle Demand

Source: DOE, stochastic simulations
distance per automobile

\[ I = p(t) \cdot \beta_v a(t)^{\gamma_v} \cdot \underbrace{\beta_d a(t)^{\gamma_d}} \cdot \tau(t) \]
USA:
Miles/Automobile vs. Wealth

Currently 11,000 miles/automobile every year
distance per automobile...

**US:** Increases slightly with income, could flatten out. Correlation less strong that vehicles/capita.

**China and India:** Few empirical studies, some predictions.
total demand

\[ I = p(t) \cdot \beta_v a(t)^{\gamma_v} \cdot \beta_d a(t)^{\gamma_d} \cdot \tau(t) \]
2050 projection:

25 trillion miles
(3.3 times today’s demand)

we will need a

770%

increase in efficiency to meet goals.
(30mpg → 230mpg)
what if everyone in the world drove a Smart Car in 2050?
4.8x

Smart Car

Goal

1.6 Gt CO₂

Sources for all auto emissions data: DOE, EPA
Aptera 2e

The epitome of efficiency...

• ultralight fiberglass body
• low 0.15 drag coefficient
• easily mistaken for a Cessna
Aptera 2e

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1.7x the 2050 goal
(filed for bankruptcy December 2011)

Source: Aptera
to meet the goals and demand, we would **all** have to...

- use 82% renewables
- or
- travel 63% less
- or
- replace 57% auto travel with **public transit**
- and every car in the world would have to be electric.
Realistic and aggressive strategy...

1. Use **20% renewable** energy sources
2. Replace **15%** of auto travel with **public transit**
3. Remaining travel...
   - 50% small gasoline cars and trucks
   - 15% hybrid
   - 20% electric

4. 2x the 2050 goal
“Above all, innovations and technical fixes cannot provide a lasting resolution.”

- Vaclav Smil