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Help or Hindrance?

Energy & Carbon Impacts of Vehicle Automation

Zia Wadud

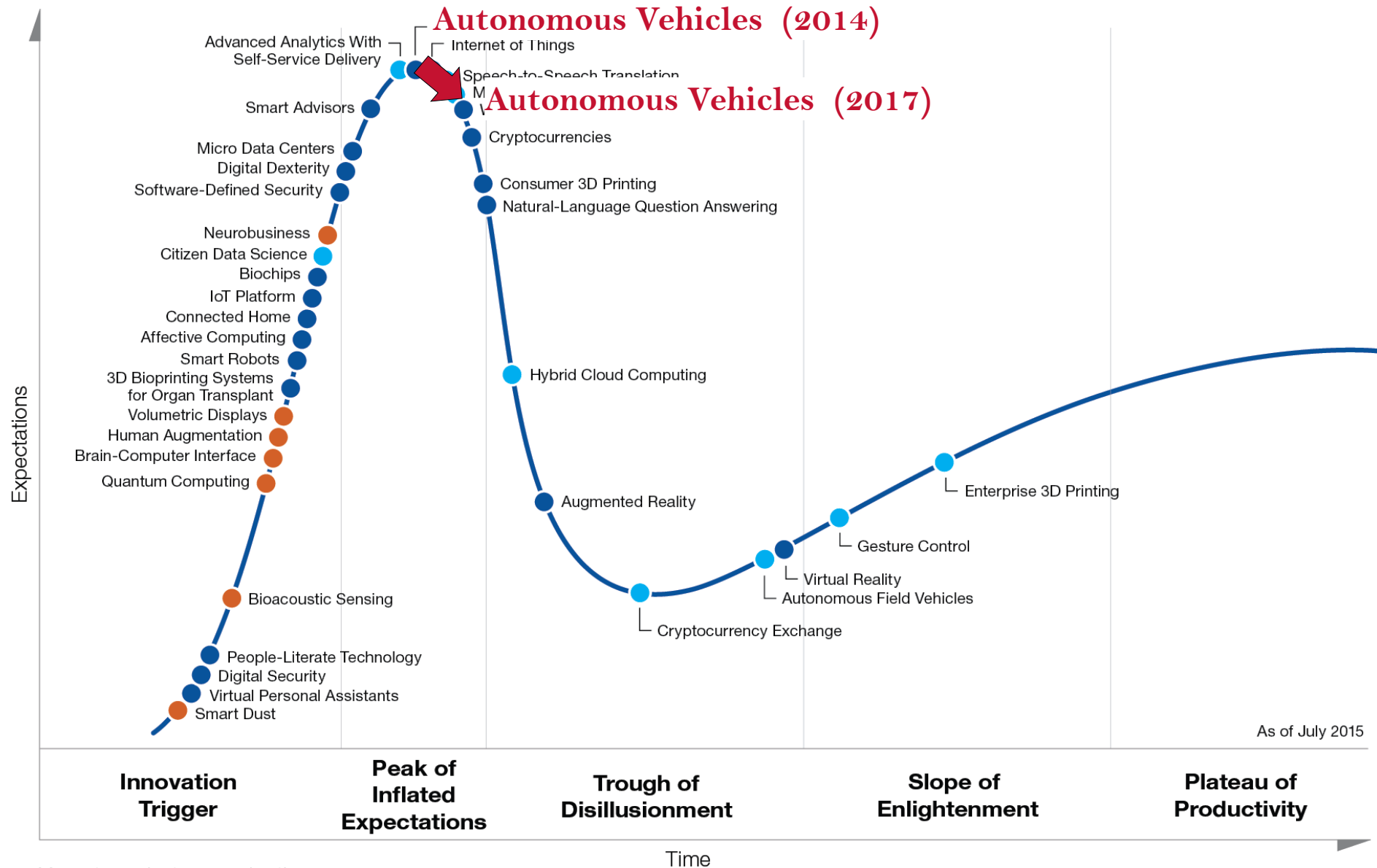
Centre for Integrated Energy Research & Institute for Transport Studies

With Don MacKenzie, Paul Leiby, Jillian Anable, Fuad Huda

Technology Hype Cycle!



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Making All Cars Driverless Would Reduce Emissions By 90 Percent

The green argument for driverless cars

Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles cars?

Zia Wadud ^{a,*}, Don MacKenzie ^{b,1}, Paul Leiby ^{c,2}

Ease traffic jams

The New York Times

Will Robot Cars Drive Traffic Congestion Off a Cliff?

THE  TIMES

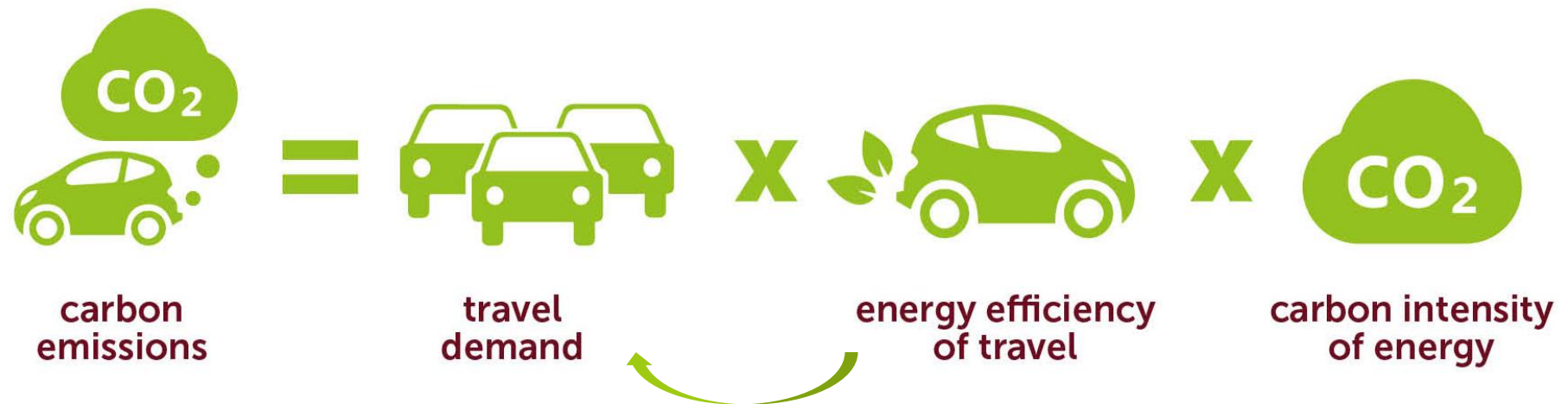
Road chaos feared as young and old swap bus for a driverless car

To **bound** the potential **energy** and **carbon** impacts of **self-driving**/highly automated vehicles?

To identify the **key areas** that require **attention** from policymakers?



Analysis Framework



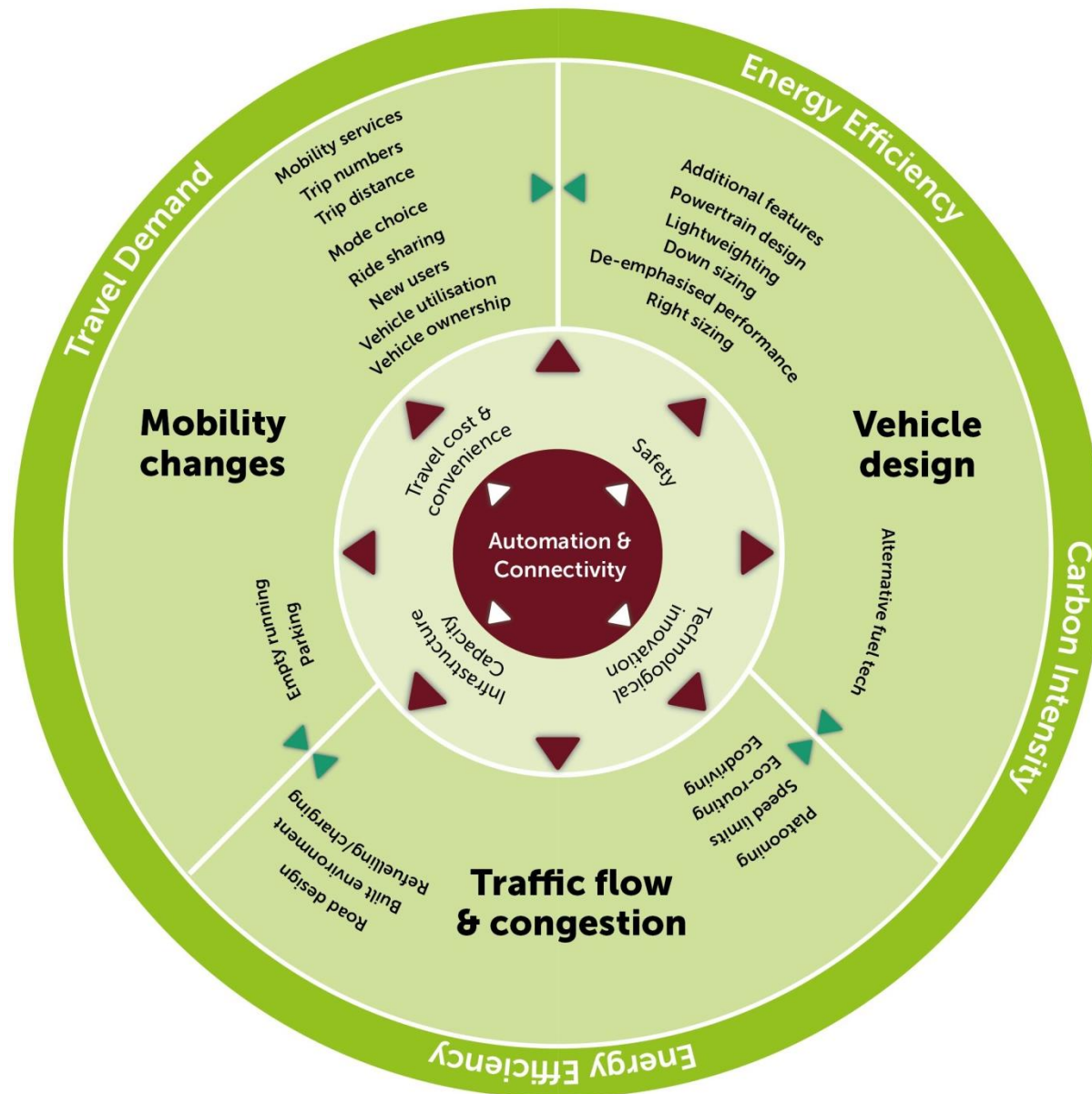
Method




Identify mechanisms for change

Literature review, simplified calculations, rational assumptions

Scenario building

(... not about uptake, about impacts when commonplace)



| Mechanisms | Energy effects | Automation level | Connectivity level |
|--------------------------|----------------|---|--------------------|
| Traffic flow improvement | ✓ |  | V2X |
| Eco-routing | ✓ ✓ |  | V2X |
| Eco-driving | ✓ |  | V2X |

SE Early benefits from connectivity and connectedness

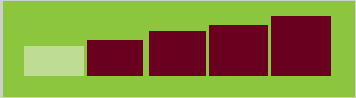
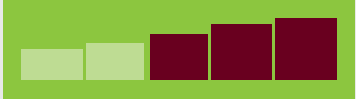




P Potentially large benefits at high levels of automation and connectivity,

..... but these benefits are highly uncertain, too

..... and depends on innovations in other areas

..... Energy use in computing, data storage, 5G???

| | | | |
|-------------|-------|---|----------|
| Long-term | ▼ ▼ |  | V2X |
| Rightsizing | ✓ ✓ ✓ |  | V2I, I2V |

| Mechanisms | Energy effects | Automation level | Connectivity level |
|-----------------------------|----------------|--|--------------------|
| Distances (location choice) | XX |  | I2V |
| Modal shift | XXX |  | I2V |
| Trip number | X |  | I2V |
| New user groups | X |  | I2V, V2I |
| Mobility on demand, MaaS | ✓✓✓ / X |  | I2V, V2I |
| Empty running | X |  | I2V, V2I |

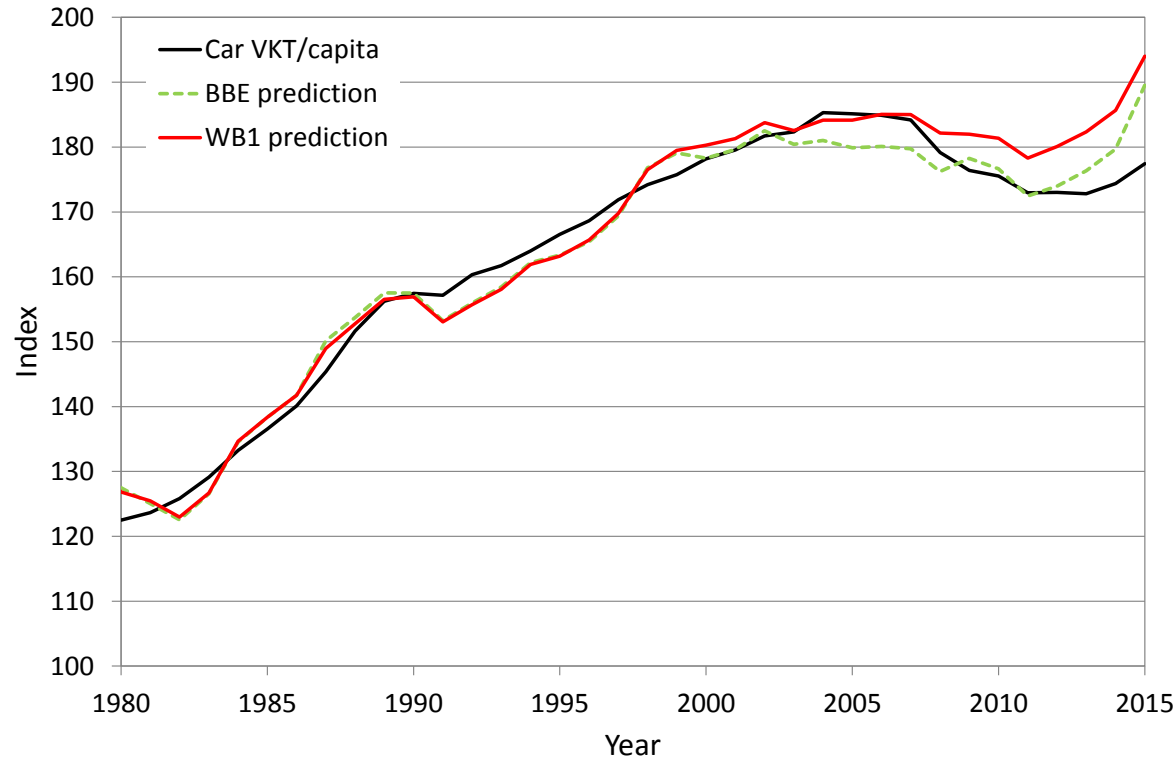
- Small impact at low levels of automation
- Step changes at high levels of automation
- Large uncertainty at high levels of automation

Automation challenges two important hypothesis

Marchetti constant/
Zahavi Travel time budget



Peak car



MoD: Marginal cost pricing – should curb demand in theory

Self-selected bunch

Empty running

pay-as-you-go or mobility packages?

Public transport to MoD? Vicious circle

VMT won't fall – unless “ridesharing” (still detours+empty runs);

Evidence of some sharing – but who uses MoD?

Some capacity benefits through
“rightsizing” MoD

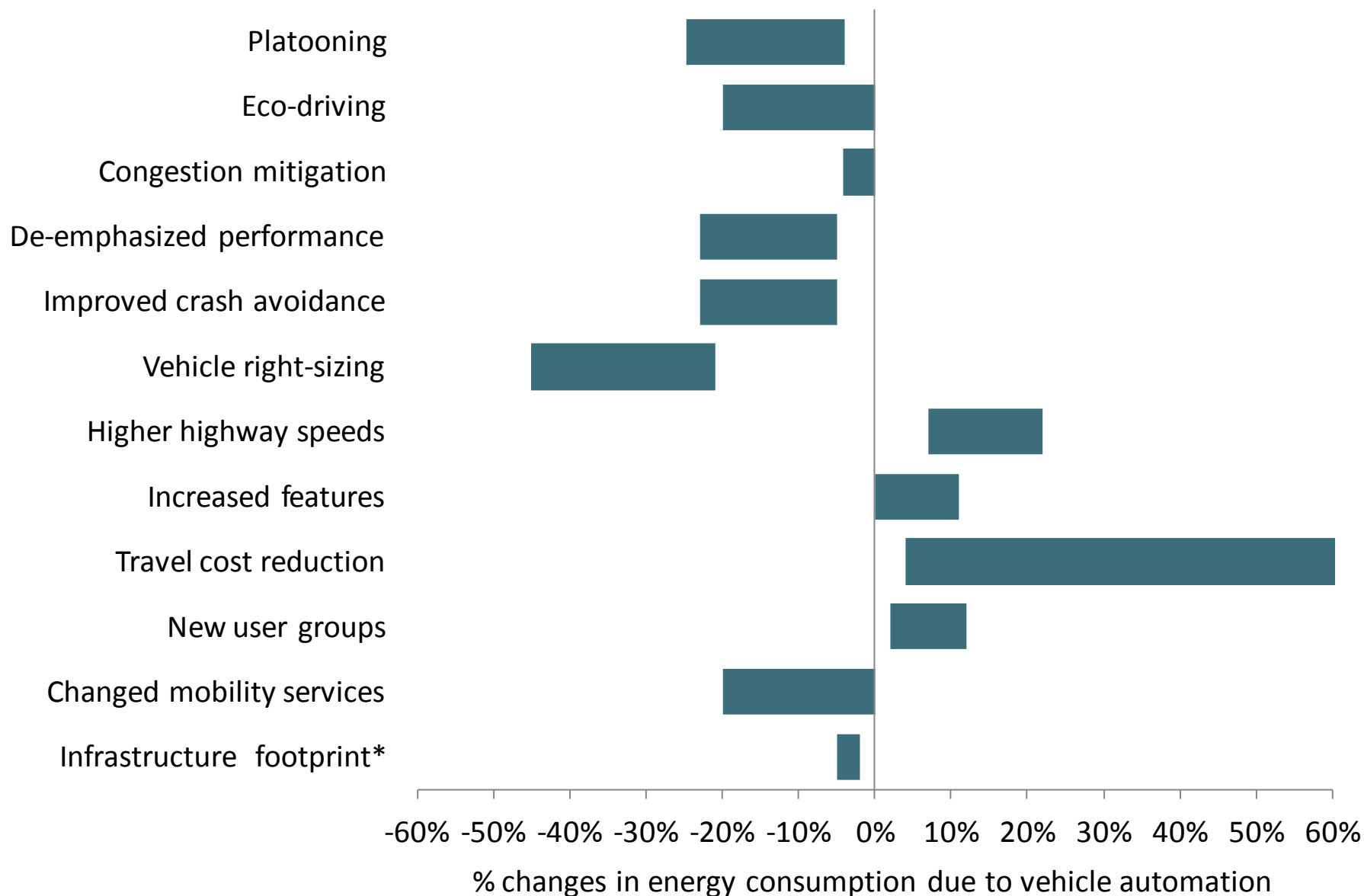
1 car club car removes 9 cars on street;
Does it matter for ‘running’ energy?



Results (USA)



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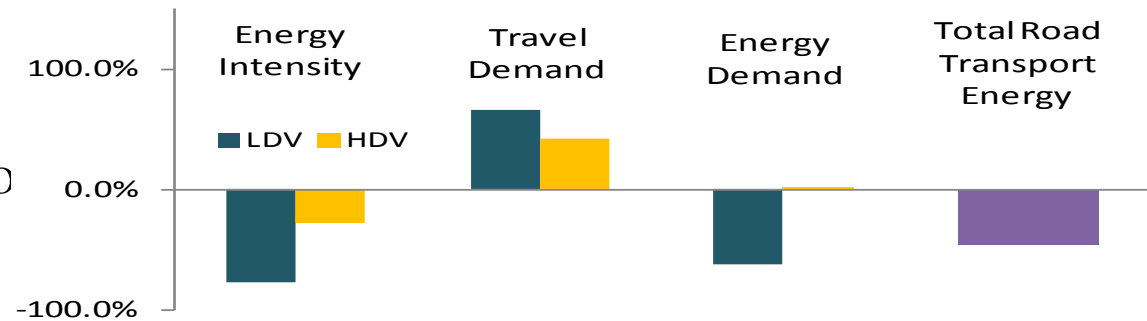


Four scenarios *(not predictions!)*

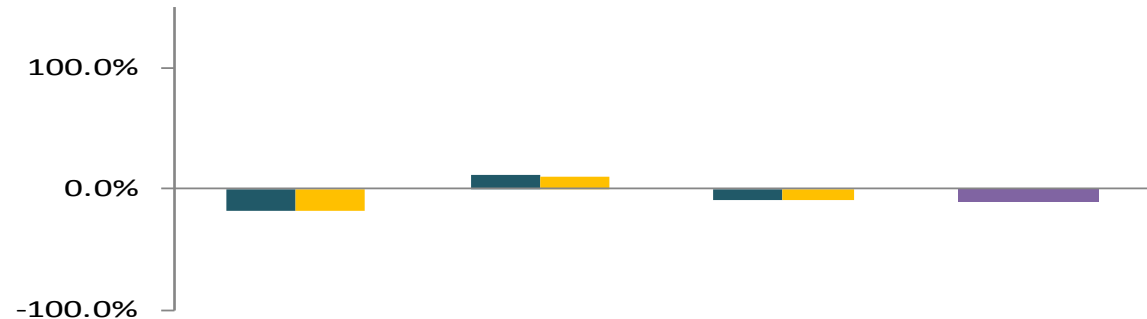


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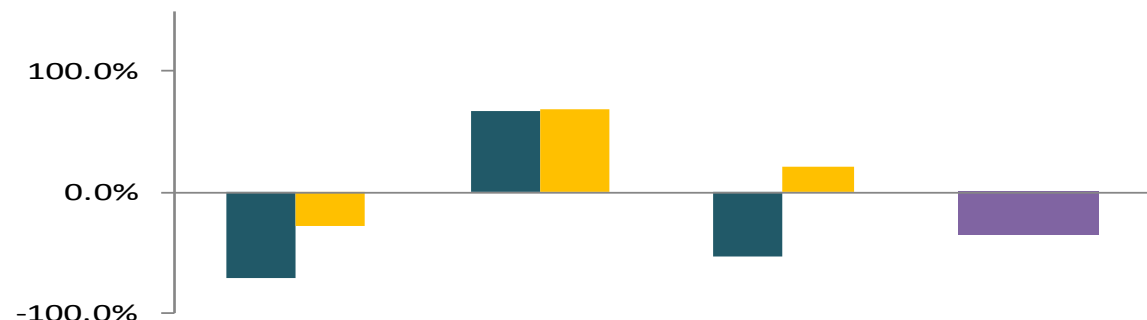
Have our cake & eat it too



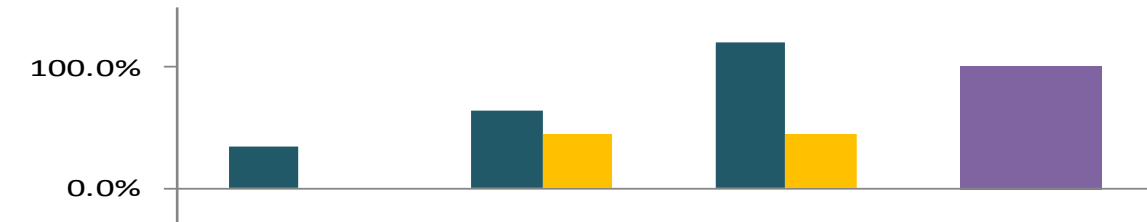
Stuck in the middle at L2



Strong responses



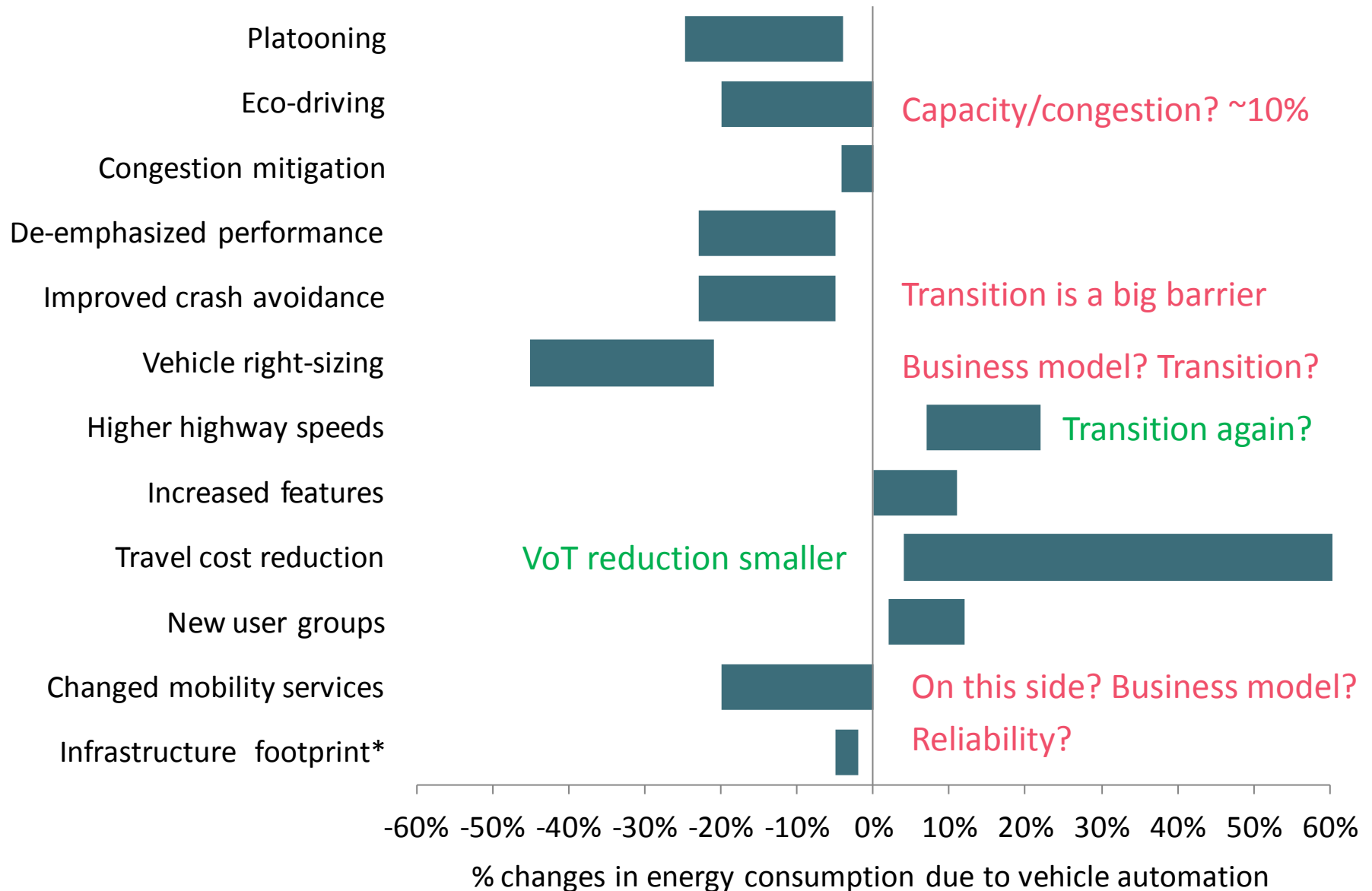
Dystopian nightmare



Narrowing the range



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Automation \neq EVs or FCVs

... but several synergies betⁿ automation and low carbon fuel

Computation uses electricity

Unattended refuelling/recharging: inconvenience reduced

High utilisation in a mobility services future: cost efficiency

Lightweighting allows more batteries: range anxiety reduced

... ... all related to full (driverless) automation

Computation power requirements + battery charging cycles



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AUTOMATED VEHICLES:
AUTOMATICALLY LOW CARBON?

Institution of
MECHANICAL
ENGINEERS

LowCVP
Low Carbon Vehicle Partnership

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Institute for Transport Studies

Thank you



The use and **usefulness of travel time** in fully automated vehicles, 2018 (under review)

Fully automated vehicles: A **cost of ownership** analysis to inform early adoption, 2017

Help or Hindrance? The **travel, energy and carbon** impacts of highly automated vehicles, 2016