# Canadian Energy Systems 101

## *Part C. Directing Disruption: Identifying Pathways to Canada's Energy Future*

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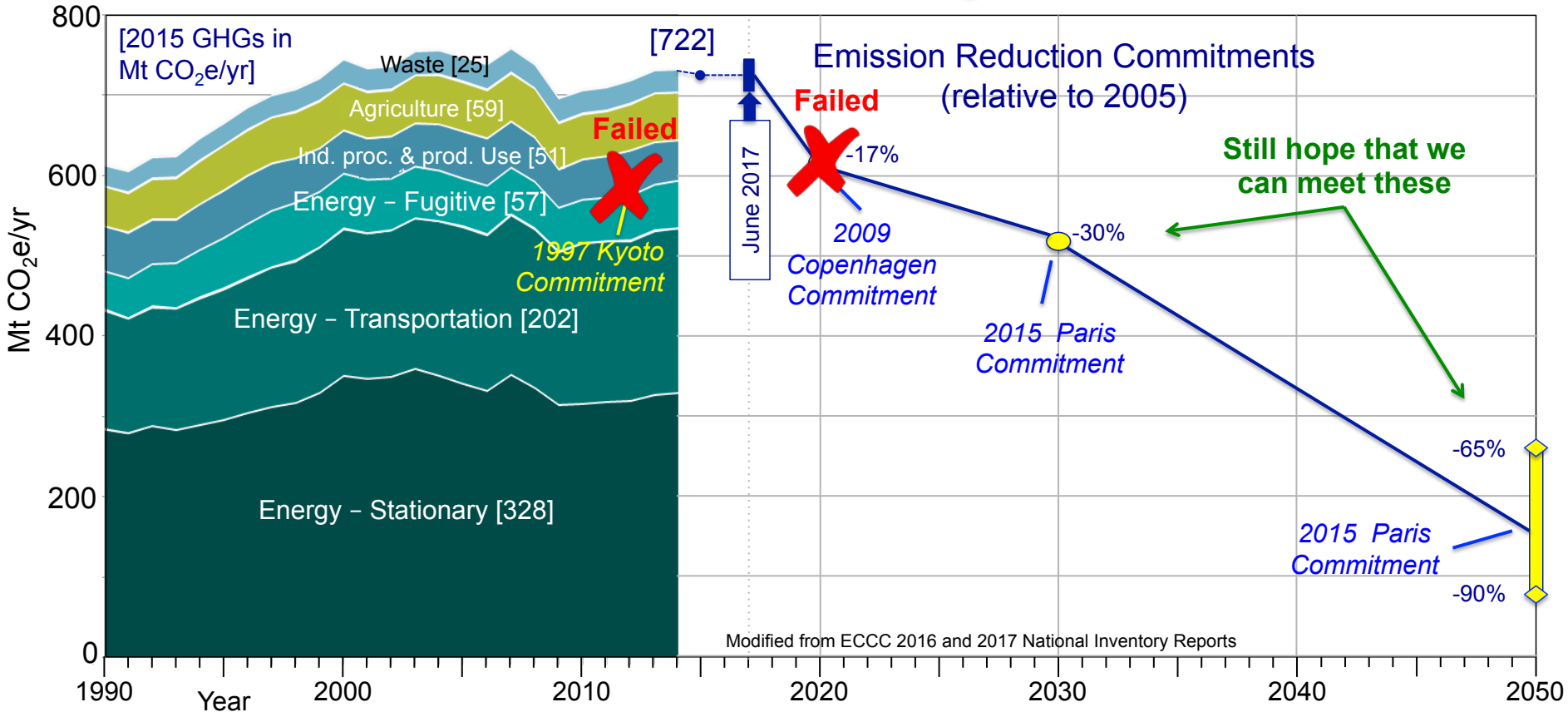
Thanks to **Jenessa Fett BSc** (CESAR Energy Systems Analyst) for her assistance with this presentation

Your Energy Future

Calgary, Alberta
June 13, 2017

# Canada's Greenhouse Gas (GHG) Emissions & Targets



# Why did we Fail?

- Targets were set in the absence of a **Vision** and/or a **Strategy** for how to reach the objectives;
- The **Strategy** needs to include quantitative, evidence-supported details of the **Pathway(s)** envisaged to achieve the objectives. *This includes the nature and timing of technological, infrastructure and behavioural changes.*
- Lack of political will and public support
- …

**Why Pathways?**

- *To create tools for public engagement;*
- *To define the necessary timing and conditions for deployment;*
- *To identify potential winners and losers, and/or decision milestones;*
- *To provide metrics by which to measure progress towards the goal.*

*What about the Paris Commitments?*

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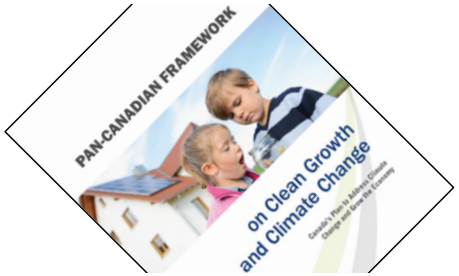
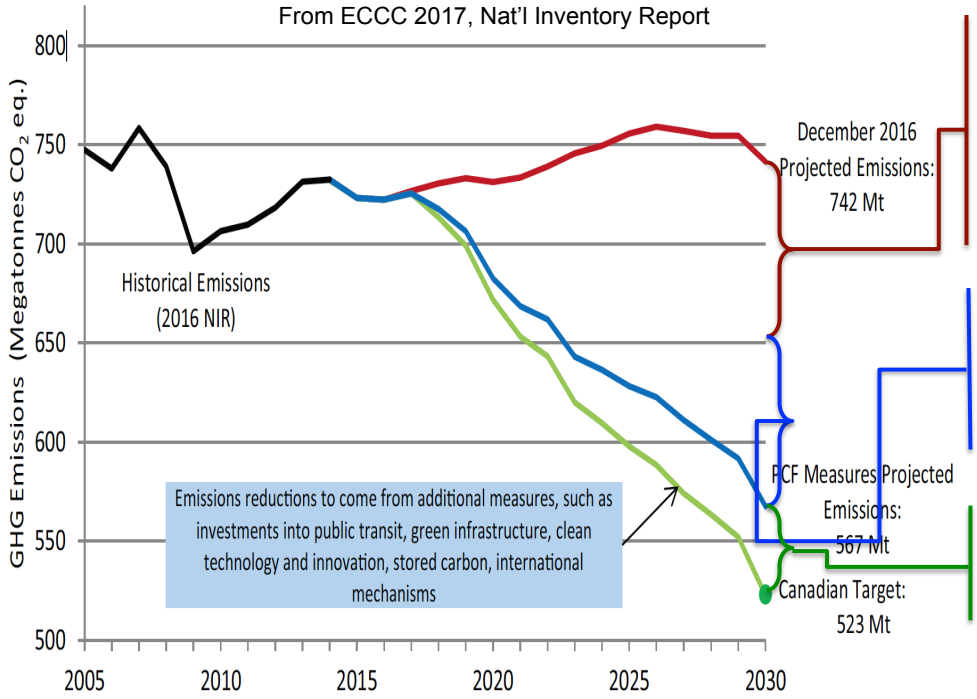
2–25 Pathway to Canada's 2030 target

# Pan-Canadian Framework




CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH




**Announced measures** as of Nov 1, 2016 (-89 Mt/yr)

- Federal (e.g., HFCs, heavy duty vehicles, methane)
- Provincial (e.g., BC Climate Leadership Plan, SK renewables target)
- International cap-and-trade credits

**Pan-Canadian Framework** (Dec 2016) (-86 Mt/yr)

- Including measures for electricity (coal phase-out by 2030), buildings, transportation (federal clean fuel standard) and industry

**To Be Determined** (-44 Mt/yr)

- Public transit, green infrastructure, technology and innovation, & stored carbon (forests, soil, wetlands)

*While pointed in the right direction, this 'strategy' does not meet the need for well defined* ***Pathways*** *incorporating the necessary technology, infrastructure and behavioural changes.*

# The CESAR Pathways Project

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CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

**1. Understand existing anthropogenic energy and carbon systems:**
✓ Strengths & Weaknesses/unintended consequences (incl., but not limited to GHGs)

**3. Identify alternative technologies or business models**
✓ Esp. those that could address the unintended consequences

4. Create **Narratives** to describe a **compelling Vision** for a improved energy future

**Five Narratives:**

A. Personal Mobility
B. Supply Chain
C. Industry
D. Smart Grids & Efficient Space
E. Biological Solutions

**2. Build a comprehensive, technology-rich model of Canada's energy systems.**

CanESS

by whatIf? Technologies Inc, Ottawa, ON (CESAR partner)

*iteration*

**5. Identify 'levers' in the model that would need to be moved (how far and when) to realize the alternative energy future**

**6. Analyze modelled pathway(s)**
✓ assess costs, benefits & tradeoffs; readjust as needed

**7. Identify / recommend policy options**

*"We cannot predict the future, but we can invent it."*
Dennis Gabor, Nobel Prize in Physics (1971)

# E.g.: Personal Mobility

- A $10T dollar / year ‘mega-Sector’ that includes:
  - Global oil industry (70% of product is transportation fuel)
  - Production and maintenance of vehicles
  - Creation and maintenance of road network

- Personally-owned vehicles
  - Defined NA culture, way of life and urban design

*…but there have been some unintended consequeces*


The American Dream

# Personal Mobility System:
## *Things to Fix*

### 1. Death & Destruction

- Aka car accidents, over 90% human error;
- >1,800 fatalities + 9,600 serious injuries in 2014
- Societal cost of $62 billion in Canada in 2007, or the equivalent of 4.9% of GDP

### 2. (non) Productivity

- 11.4M Canadians commute an avg. 24 min to & from work about 240 d/yr = 4700 person years of unproductive time EVERY DAY
- RethinkX (US think tank) estimated commuting reduces the US GDP by **~$1T/yr**.

# Personal Mobility System:
## *Things to Fix*

### 3. Value for Money

- 15%: Avg household spending spent to purchase and maintaining personal vehicles (Fuel is extra)
- Vehicles only used ~4% of the time, and then with only 1.5 people /vehicle when there are seats for 5-7
- These are **not** well-used assets.

### 4. Parking and Roads

- Cars are parked 96% of time, using valuable land.
- In USA, 8 parking spots / vehicle on road
- Highly subsidized: Gas taxes, licensing fees, fines etc only pay for ~2/3rds of infrastructure cost

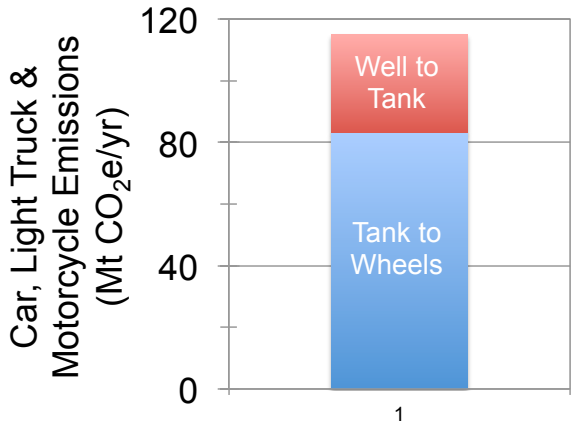
# Personal Mobility System:
## *Things to Fix*

### 5. Air Pollution

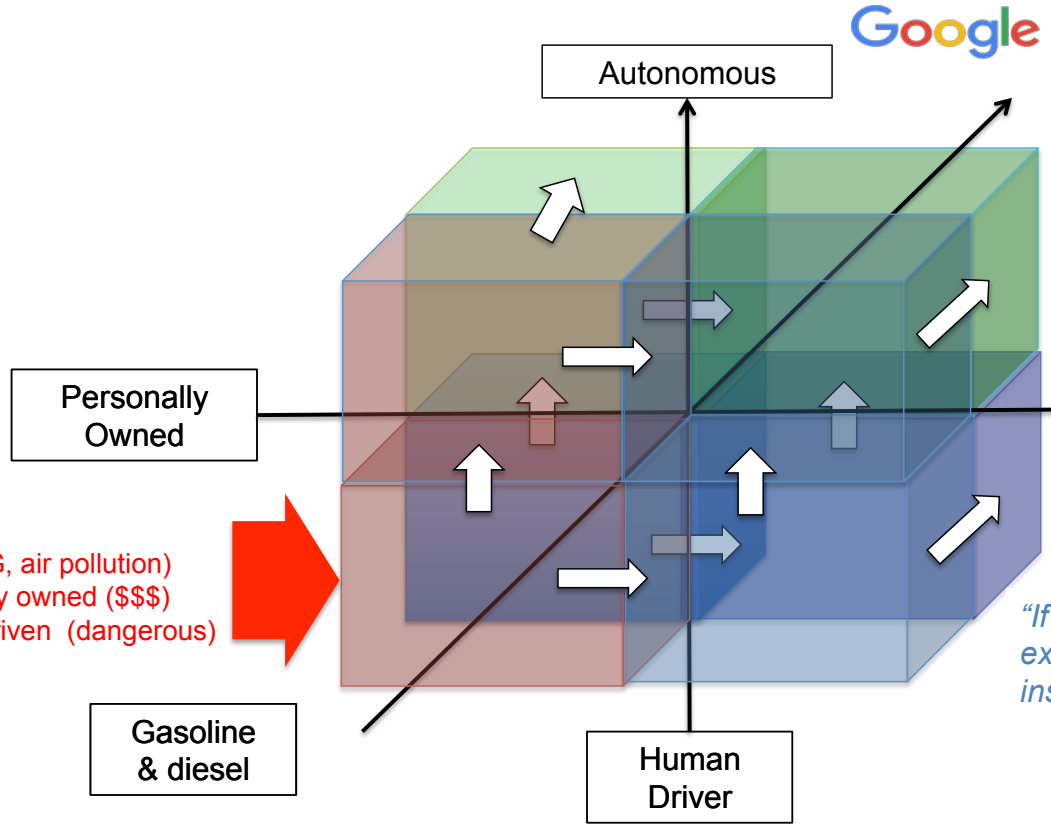
- Ground level ozone and PM; mostly from vehicles – estimated to cost $36B/yr in Canada (Robert Smith & Kieran McDougal 2017)


### 6. Greenhouse Gases

- Well to Wheels for all road Transportation: 240 Mt $CO_{2e}$/yr or ~33% of Canada's GHG emissions.
- Well to Wheels for Personal vehicle transport: 115 Mt $CO_{2e}$/yr or 16% of Cdn emissions.



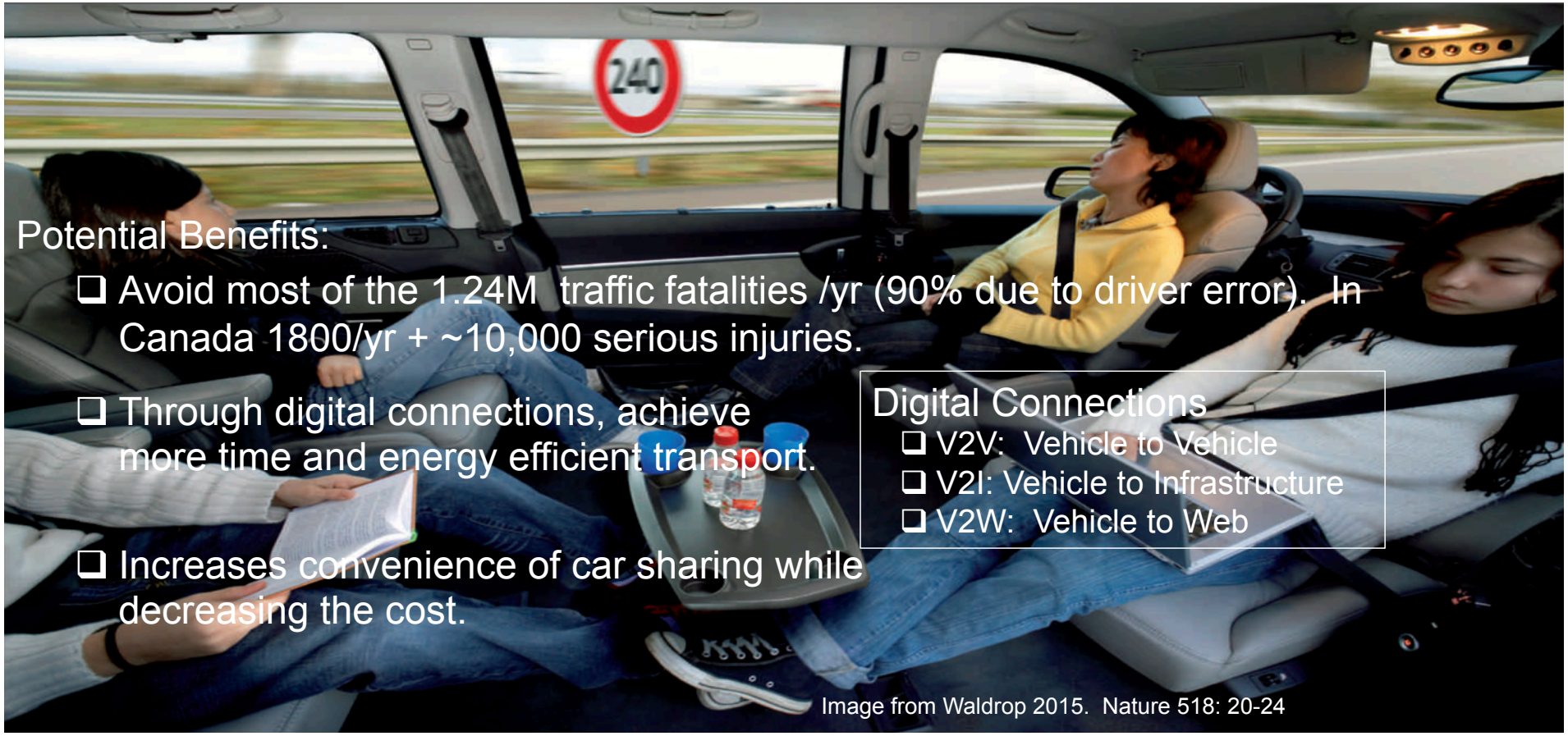
# Personal Transportation: On the Cusp of Transformation




*"If the rate of change on the outside exceeds the rate of change on the inside, the end is near."*

**Jack Welch**,
Former CEO, General Electric

# Autonomous Vehicle




Potential Benefits:

- ❑ Avoid most of the 1.24M traffic fatalities /yr (90% due to driver error). In Canada 1800/yr + ~10,000 serious injuries.
- ❑ Through digital connections, achieve more time and energy efficient transport.
- ❑ Increases convenience of car sharing while decreasing the cost.

Digital Connections

- ❑ V2V: Vehicle to Vehicle
- ❑ V2I: Vehicle to Infrastructure
- ❑ V2W: Vehicle to Web

Image from Waldrop 2015. Nature 518: 20-24

# Levels of Autonomous Vehicle Deployment

**Levels**

**1** Vehicles marketed with some autonomous features.

**2** Vehicles driving themselves with human standby:
A: on highways
B: on highways + urban and rural roads

**3** Level 2, but no human backup needed for most traffic & environmental conditions.

What I am talking about

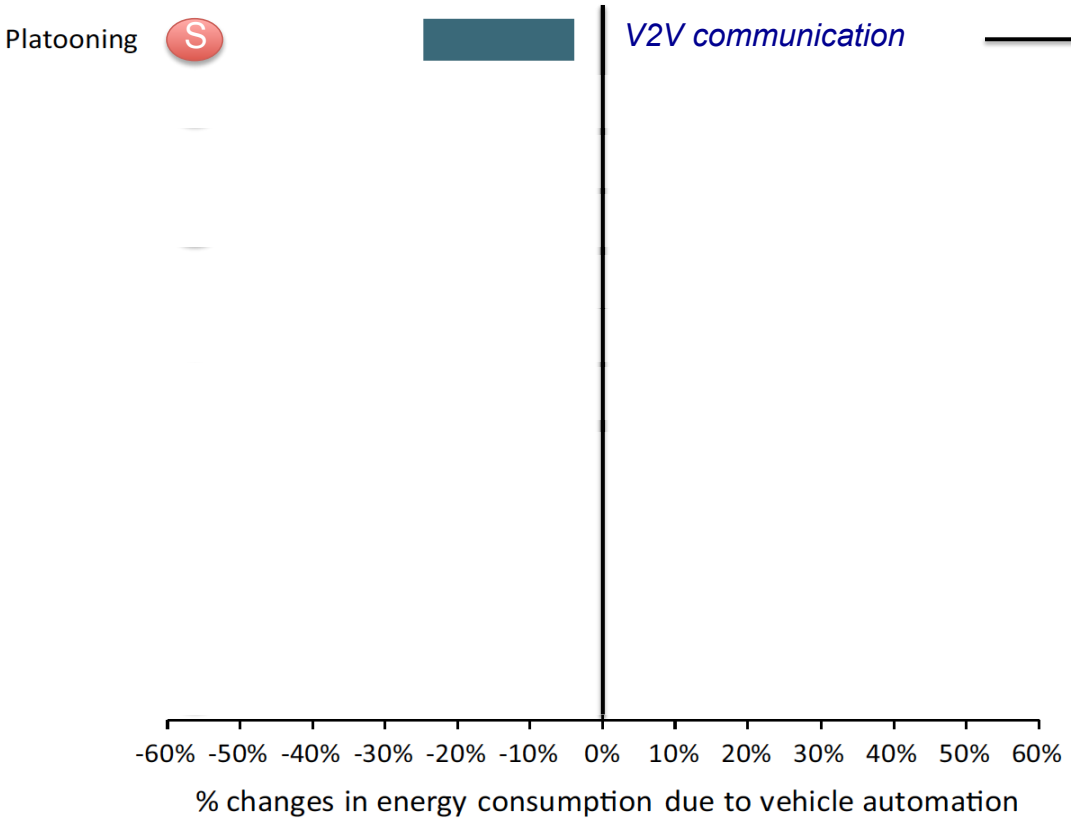
**4** Full automation, in an occupied or unoccupied state.

*Underwood, 2014. Automated Vehicles Symposium, Cal.; Also: Dvorak 2016
http://www.pcmag.com/commentary/343666/the-autonomous-car-by-2020-no-way

# Autonomous Vehicles & Energy Use [ ]

From: Wadud et al. 2016. Transp. Res. A 86:1-18

S =Sharing enhanced





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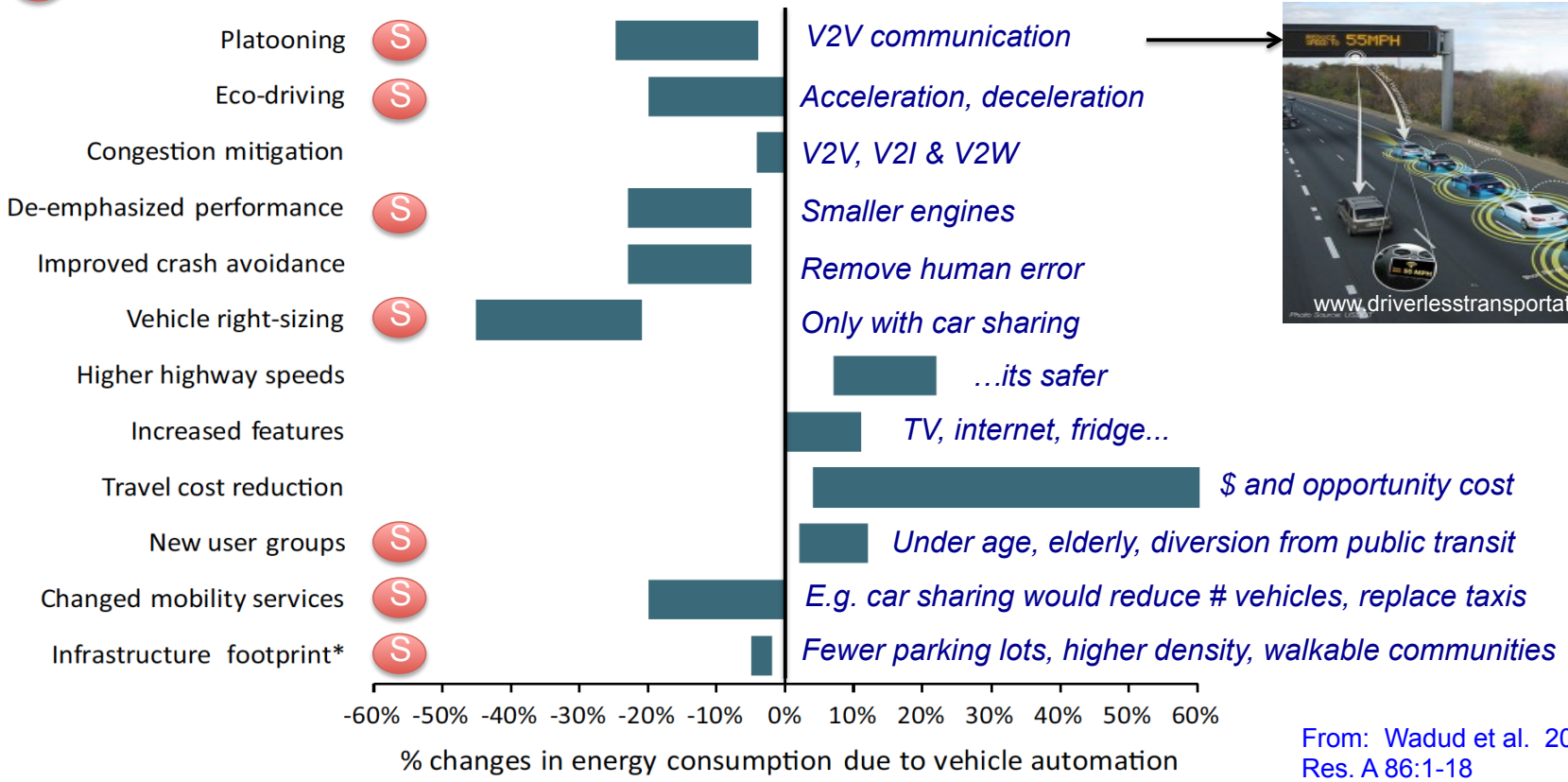





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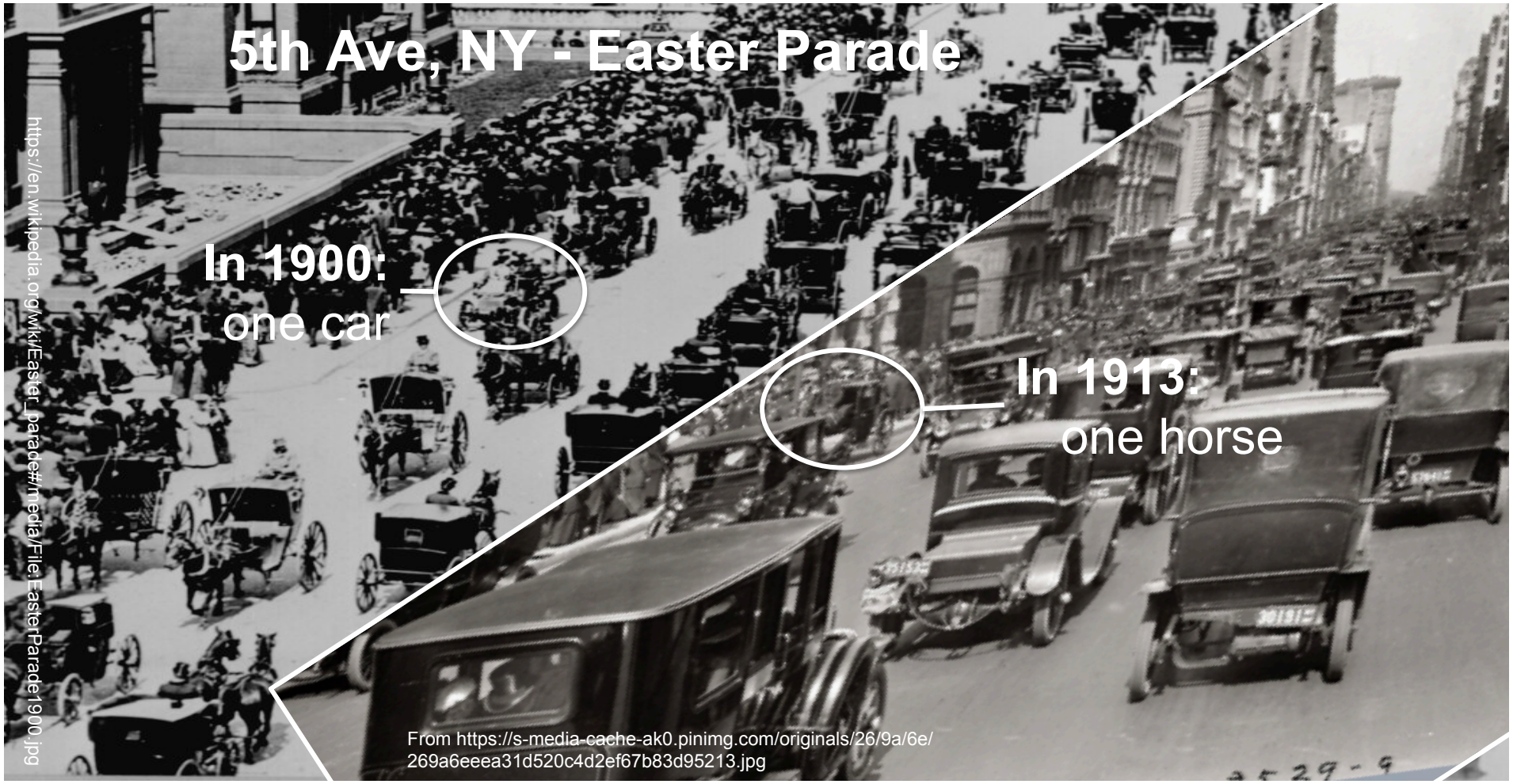
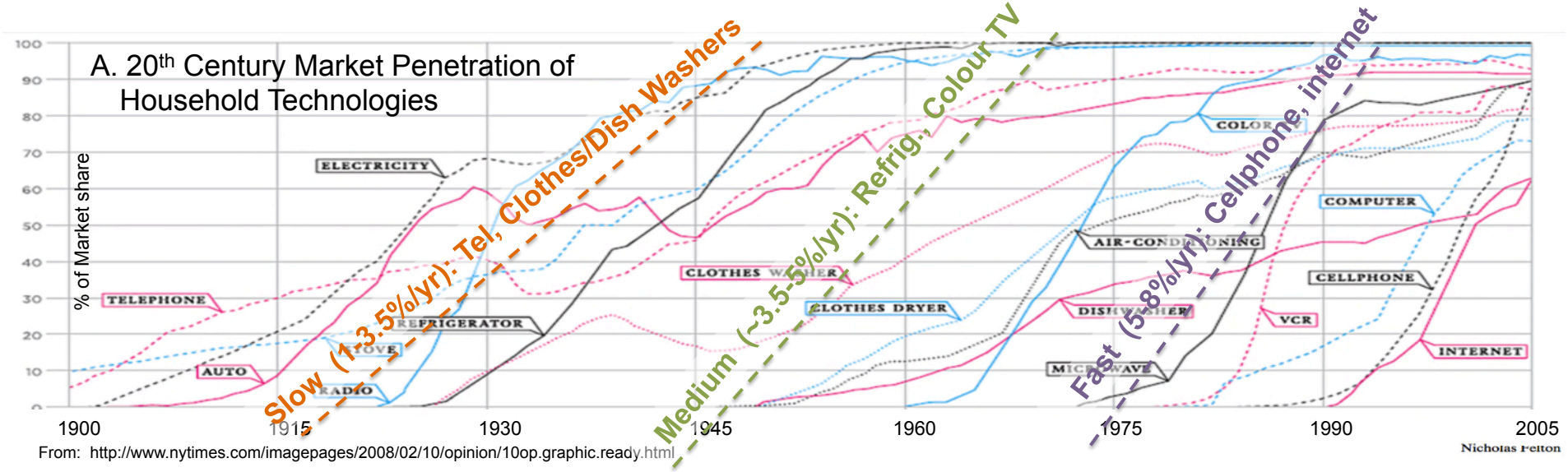
# Autonomous Vehicle Deployment

| | Personally Owned | Shared |
|---|---|---|
| Use (% of day) | ~4% | ~30-40% |
| km travelled | 15,000 km/yr X 15 yr = 225,000 | 160,000 km/yr X 5 yrs = 800,000 |
| Fueled by | Gasoline or Electric | Electric |
| Car accidents | ++ | +++ |
| Traffic Jams | Possibly worse | ++ (public transit?) |
| Value for money | Similar or worse | +++ (1/2-1/10$^{th}$ cost) |
| Parking and Roads | + (still some parking) | +++ |
| Air Pollution | Possibly worse | +++ |
| GHG Emissions | Possibly worse | +++ |

# How Rapidly Could Such a Disruption Occur?



# Rate of Market Penetration of Household Technologies




From: http://www.nytimes.com/imagepages/2008/02/10/opinion/10op.graphic.ready.html

Note that the over the last century, transition times have accelerated

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# Rethinking Transportation 2020-2030

A RethinkX Sector Disruption Report
May 2017
James Arbib & Tony Seba

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*"By 2030,…95% of US passenger miles traveled will be served by on demand autonomous, electric vehicles owned by fleets, not individuals."*
*(**https://www.rethinkx.com/transportation**)*

- Highlights (for USA by 2030)
  - eSAVs 2-10X lower cost than PAVs
  - eSAV will drive 800K km over 5 yrs vs. today's car (220K km in 13+ yr)
  - Save ~$5,600/family/yr
  - Disposable income boost ($1T/yr)
  - Productivity gain (GDP up $1T/yr)
  - GHG emissions (80-90% decrease)
  - Job losses (~5M jobs), but also gains
  - Electricity Demand (+18%)
  - Global Oil Demand (peak 2021 @100M bpd; in 2030 @70M bpd)
  - Oil Price (~$25/bbl)
  - New pipelines (stranded assets?)
  - Mass stranding of autos after 2021
- Scenario modeling: powerful tool to explore energy futures