Bracing for Mass EV Adoption

The Ethics behind Autonomous Vehicles

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Bracing for Mass EV Adoption

• Infrastructure Charging
• Electric Vehicles
• Autonomous Vehicles
• Vehicle to Infrastructure communications
• Public Acceptance and Adoption
• Ethics and Liability
## Storage Technology Characteristics

**TABLE 2. TYPICAL PERFORMANCE CHARACTERISTICS OF SELECTED ENERGY STORAGE SYSTEMS**

<table>
<thead>
<tr>
<th></th>
<th>Electrochemical Storage</th>
<th>Mechanical Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LEAD ACID</td>
<td>LITHIUM-ION</td>
</tr>
<tr>
<td>Round-trip efficiency</td>
<td>70-85%</td>
<td>85-95%</td>
</tr>
<tr>
<td>Typical duration</td>
<td>2-6 hr</td>
<td>0.25-4 hr</td>
</tr>
<tr>
<td>Time to build</td>
<td>6-12 mo</td>
<td>6-12 mo</td>
</tr>
<tr>
<td>Operating cost</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Space required</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>Cycle life</td>
<td>500-2,000</td>
<td>2,000-6,000+</td>
</tr>
<tr>
<td>Technology maturity</td>
<td>Mature</td>
<td>Commercial</td>
</tr>
</tbody>
</table>
Battery Cells

Tesla Battery Cell

Tesla Battery Module
Stationary versus Mobile

U.S. utility-scale battery storage power capacity (March 2019)

megawatts (MW)

3,000

2,500

2,000

1,500

1,000

500

0


annual capacity additions

operating capacity

Tesla Model 3 Energy Storage Capacity

18,000

16,000

14,000

12,000

10,000

8,000

6,000

4,000

2,000

0

EV Superchargers

Typically 8 bays, 12kV, 750 KVA – fed from the Electric Utility, it steps it down to 408 V, three phase on site. That pushes 2000 Amps into the switchgear units (one for each pair of pods). Each unit contains 12, 10 kW rectifiers (AC to DC bridge rectifier conversion). This gives a 120 kW DC push per pod.

The transformer can sometimes be 13.2/480 V (Y-Y). There are usually 6 supercharger cabinets that can run up to 150 kW as each module can get 12.5 kW each.

One can get 12.5 kW instead of 10 kW because of the onboard charger gets fed 240 V AC, but the ones in the cabinets get 277 V, as they run 480 V, 3 phase. The rectifiers in the cabinet are the same as the onboard Tesla Model S chargers.
Wireless Power Transfer via Magnetic Resonance

- Insert inductively coupled transformers with UG cables
- Magnetic fields wirelessly charge moving cars
- A hidden blessing for public transportation – zero external charging?
- Economic impact to highways and roadways
- Disadvantage of full power transfer, efficiency
- Cost of building external charging networks reduce
How are Electric Vehicles Built

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery size</td>
<td>100 kWh</td>
</tr>
<tr>
<td>Acceleration</td>
<td>2.5 seconds 0-60 mph</td>
</tr>
<tr>
<td>Range</td>
<td>315 miles</td>
</tr>
<tr>
<td>Battery life</td>
<td>about 8 years</td>
</tr>
<tr>
<td>Recharge</td>
<td>170 miles in 30 minutes</td>
</tr>
<tr>
<td>Supercharger locations</td>
<td>10,000+</td>
</tr>
</tbody>
</table>
How are Autonomous Vehicles Built

- **GPS (global positioning system)**
  - Combined with readings from tachometers, altimeters, and gyroscopes to provide the most accurate positioning
  - Cost: $80-$6,000

- **Lidar (light detection and ranging)**
  - Monitor the vehicle’s surroundings (road, vehicles, pedestrians, etc.)
  - Cost: $90-8,000

- **Ultrasonic sensors**
  - To measure the position of objects very close to the vehicle
  - Cost: $15-$20

- **Odometry sensors**
  - To complement and improve GPS information
  - Cost: $80-$120

- **Video cameras**
  - Monitor the vehicle’s surroundings (road, vehicles, pedestrians, etc.) and read traffic lights
  - Cost (Mono): $125-$150
  - Cost (Stereo): $150-$200

- **Radar sensors**
  - Monitor the vehicle’s surroundings (road, vehicles, pedestrians, etc.)
  - Cost (Long Range): $125-$150
  - Cost (Short Range): $50-$100

- **Central computer**
  - Analyzes all sensor input, applies rules of the road, and operates the steering, accelerator, and brakes
  - Cost: ~50-200% of sensor costs
Vertical and horizontal setup of the system is possible

Image acquisition with fully integrated NIKON DSLR camera

3D mode of the VZ scanner with continuous rotation of the scanning head for highly efficient mobile data acquisition

360-degree static scanning

Mainly used by Google Inc. for detecting the surroundings of the vehicle
The Cruise System

- Cameras and Radars to map out surroundings (including other vehicles)
- Used mainly for highway scenarios
- Steering wheel motor mounted to steering column
- Adaptive speed control
- Collision avoidance
- RP-1 sensors
- Will be made in future for other vehicles
Types of Algorithms

- 3-D imaging with multiple 1064 nm lasers
- Edge-Detection algorithm
- Motion-Detection algorithm
- Tracking algorithm
Correlation as Degrees of Freedom Increase

Vehicle to Vehicle (V2V)

Vehicle to Infrastructure (V2I)

Vehicle to People (V2P)

V2X = V2V + V2I + V2P
Public Acceptance and Adoption

- Vehicle to Vehicle (V2V) technology cannot function ideally without adoption across the board
- Minority vs. majority
- Legal precedents
The Trolley Problem – A classic thought exercise in ethics

• A trolley’s brakes have failed.
• You are controlling the signal switch.
• If you do nothing, five people will be killed.
• If you activate the switch, only one person will be killed.
• What do you choose to do?
• Critical distinction: Allowing death versus causing death?
Problems with Utilitarian Analysis – A classic thought in ethics

- Ineffective when information is omitted.
- A truly accurate analysis may require valuing one human life over another.
- The “least bad” outcome may still result in the loss of life.
Another Problem: Consequentialism

• Without complete information and the gift of hindsight, a decision that results in a net gain of welfare in the short run may turn out to be a very poor decision in the long run.
A new class of Victims

- There will be an inherent shift in the makeup of automobile accident victims.
- Likely a decrease in driver deaths and an increase in pedestrian and cyclist deaths.
- Great news for some people, bad news for others.
- An ethical conundrum: Can we accept an increase in the death rate of certain groups of people if it means a decrease in the overall death rate?
Random Outcome Generator: A Monte Carlo Analysis?

• Generate a list of potential outcomes, then roll the dice:

1. Swerve to the right, potentially killing a cyclist.
2. Swerve to the left, potentially killing two pedestrians.
3. Continue forward into the path of an oncoming vehicle, potentially killing yourself and its occupant(s).
### The Sales Pitch to Millennials: Driving a Car Is Not Fun Anymore

- Dangerous – Death and Injury Rate statistics
- Climate change/dirty – Green house gas emissions
- Most underutilized asset – 96% idle, used 2 hours/day
- Inefficient – 1.5% energy, unsuited to mass urbanization
- Expensive – Second biggest purchase, after a house
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