Sustainable Transport
Challenges and Opportunities in a Carbon Constrained World

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Petroleum and transport are closely linked

Today...50% of petroleum goes to transport fuels AND 95% of transport energy comes from petroleum

Source: IEA World Energy Outlook 2018
Future demand driven by population and energy access

Energy, climate and health concerns must be addressed to ensure transport sustainability
60% of all GHGs commitments are transport related

<table>
<thead>
<tr>
<th>Sector</th>
<th>End Use/Activity</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>Road</td>
<td>11.9%</td>
</tr>
<tr>
<td></td>
<td>Rail, Air, Ship &amp; Pipeline</td>
<td>4.3%</td>
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<tr>
<td></td>
<td>Residential Buildings</td>
<td>10.3%</td>
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</tbody>
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Global Paris Agreement commitments (as of Dec 2018)*

- **Transportation sector**: 101
- **All Other Sectors**: 59

*160 national policy programs

Transport sector bears a disparate climate change burden - Promotion of alternative energies and powertrains

* Figure from [https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016](https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016)
* Data from IHS Markit ([https://ihsmarkit.com/research-analysis/climate-change-regulations.html](https://ihsmarkit.com/research-analysis/climate-change-regulations.html))
Dominant transport trends - A number of “Silver Bullets”

- ELECTRIFICATION/HYBRIDIZATION
- AUTONOMOUS, SHARED AND CONNECTED
- ICE ABANDONMENT
- E-FUELS AND FCEV

Right technology mix for the right sector, at the right time, and in the right location yields maximum impact.
Technology agnostic approach to address climate concerns

Regulated

Well to tank and/or grid to tank

Oil Production Emissions

Refinery Emissions

Electricity Generation Emissions

Tank to wheels

Production and Recycling

Vehicle Emissions

CO₂ other

Vehicle Production Emissions

Recycling Emissions

Cradle to Grave LCA ensures an impact on CO₂ emissions
Analysis-guided policy will ensure the largest impact on CO₂

**Scenario 1:** CAFE/CAFC met via 50% BEV penetration

**Scenario 2:** CAFE/CAFC met by improving ICEV only

**Global LD Vehicle GHG Emissions**

- **CO₂ Savings with ICE:** (8584 MM-ton)

**Accumulated CO₂ Saving by 2040**

- **8584 Million tons**
  - Or
  - Equivalent to the CO₂ emissions of **1177 million** passenger car (40 mpg) driving around the earth equator
  - = 100 million

**Improving the ICE has greater potential to improve CO₂ if BEVs are not counted as zero emissions**

Source: Preliminary data, Aramco

Saudi Aramco: Company General Use
ICE has abundant potential to improve CO₂

Leverages existing infrastructure and synergistic with hybridization, e-fuels and onboard carbon capture
Continued investment in ICE for a bigger impact on GHGs

- Gasoline Compression Ignition: +40% mpg
- Opposed Piston: +33% mpg
- Mobile Carbon Capture: >42% CO₂ capture
- Zero Impact Emission Vehicle: 0 Impact Pollutants

We're innovating across the vehicle to drive efficiency and lower emissions
Concluding Remarks

- No silver bullet - right technology mix for the right sector, at the right time, and in the right location yields maximum impact on GHGs
- ICE has abundant potential to deliver efficient, low emitting and competitive solutions especially through hybridization
- A holistic approach to reducing emissions is essential for achieving our climate goals
- Cross-sector collaboration will lead to optimized and sustainable transport solutions