HARD-TO-ELECTRIFY SECTORS

- Aviation
- Long-haul trucking / shipping
- Rural
- Industrial
U.S. transport emissions by mode

Million metric tons CO$_2$e

Source: Rhodium Climate Service
LIGHT-DUTY CHALLENGES

Source: Richard Corey, CARB
POTENTIAL SOLUTION: AVIATION

• Sustainable Aviation Fuel
  ❑ Fully fungible fuel made from renewable feedstocks

• Headwinds:
  ❑ LCFS provides important but limited value to SAF
  ❑ Hard to capture the premium value & justify the long-term investment.
  ❑ Global book-and-claim unavailable
SOLUTIONS: LONG-HAUL / SHIPPING

• Renewable Diesel
  - Offered by several companies already; interest from oil majors

• Direct Air Capture to Fuel
  - What will be the demand for pure underground sequestration, and how will that be paid?
  - What are the policies driving DAC?

• Ammonia & Hydrogen
  - Especially suitable for marine & rail

• Headwinds:
  - Infrastructure
  - Up-front expense
POTENTIAL SOLUTION: RURAL

• Low-carbon compatible vehicles
  - For any combustion engine sold in CA, require that the engine be low-carbon fuel compatible
    • E.g., FFVs + PHEV
  • Would offer decarbonization benefits before fleet fully turns over

• Headwind:
  - Infrastructure
POTENTIAL SOLUTION: INDUSTRIAL

Refineries may continue to operate in California past 2050, just focused on exports.

• Renewable natural gas to green hydrogen
• Solar steam
• CCS for process heating, paired with upstream methane abatement
• Ammonia

• Headwinds:
  - No LCFS value for exports
  - NGO advocacy against RNG
CASE STUDY: WORLD ENERGY

- Paramount, CA facility
  - Producing sustainable aviation fuel, renewable diesel, naphtha
  - Scaling facility to meet 10% of California’s diesel demand
  - Approved CIs range from 43 to recently approved score of 24
  - Potential for carbon neutrality through pathway development
CASE STUDY: CARBON ENGINEERING

• Direct Air Capture
  ■ TX partnership with Occidental Petroleum
  ■ Commercial-scale demonstration
  ■ Infinitely scalable; range of uses

• Research into supersonic jet fuel with Aerion
INVESTMENT BARRIERS

• Scale of future market
• Market access
• Feedstock diversification
• Price uncertainty = investor uncertainty
• Government and regulatory policy
INVESTMENT CONSIDERATIONS

Exhibit 31: The biggest impact of the financial downturn was experienced by higher-cost technologies such as biofuels and CCUS, as opposed to the lower-cost renewables
Total global investment in low-carbon energy (US$bn)

Source: FS-UNEP Collaboration Centre, IEA, Goldman Sachs Global Investment Research
INVESTMENT CONSIDERATIONS

Exhibit 48: EU Big Oils are spending c.10-15% of their total capex on low-carbon energy, as capex in the traditional oil & gas business falls by c.20% for the group in 2020-21E and low-carbon initiatives remain intact

Share of renewables as a % of total capex for EU Big Oils

Source: Company data, Goldman Sachs Global Investment Research
THANK YOU.

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