INCREASING OCTANE

- Increasing octane facilitates increasing compression ratio (CR)
  - Higher CR leads to higher engine efficiencies with higher octane fuel
  - Higher CR leads to lower engine efficiencies and power with lower octane fuel
    - Mis-fueling with low octane (today’s “regular unleaded”) will lead to customer dissatisfaction
- On a piece cost basis, increasing CR can be virtually free
  - Development work is needed, particularly to manage mis-fueling with low octane fuels
- Adding increased ethanol capability will have a cost
  - Maximum cost is known, the cost of an FFV
WELL TO TANK TO WHEELS CO2 EMISSIONS

Per 100 kBBL/day refinery
From Speth et al, ES&T 2014, MIT
OCTANE TODAY

- Premium gasoline has poor customer value
- Additional cost of premium is more than efficiency gain
- An automaker could market their vehicle as “premium required” and capture the efficiency and power gain
  - However their competitors would take advantage of this and tout their regular gasoline capability
  - Some customers may ignore the “Premium Required” admonishment
- Premium in the US is a performance fuel
PRICE OF OCTANE

- The difference between retail regular and premium gasoline has risen steadily
- Wholesale prices have fluctuated in line with trends in the fuel market

Premium Gasoline Market Share and Incremental Cost

EIA data
OCTANE VALUE

- Fuel needs to be a good value for the average customer
- Percentage price increase for premium typically exceeds the fuel economy benefit
  - Yesterday’s and today’s premiums are performance fuels
  - As declining usage shows, customers are valuing performance less

**Premium Gasoline Incremental Price and Market Share**

- Blue line: Bulk
- Red line: Retail
- Green line: Premium Market Share

EIA data
GASOLINE

- Looking back at the gasoline market, several things are evident
  - Recent declines in volume
  - Declining hydrocarbon octane
  - Declining premium market share
  - Increasing ethanol market share
Declining hydrocarbon octane is primarily related to increased ethanol usage.

Hydrocarbon Octane \((R+M)/2\)

- 1985
- 1995
- 2005
- 2015
HOW TO INCREASE OCTANE?

- Options
  - Increase production of traditional higher octane components
  - Reduce use of low octane components
  - Increase ethanol usage
  - Introduce new high octane molecules
HOW TO INCREASE OCTANE?


"WHERE WILL THE OCTANE COME FROM?"
Joseph M. Colucci,
SAE 2013 INTERNATIONAL HIGH OCTANE FUELS SYMPOSIUM
HOW TO INCREASE OCTANE?

- The market is large
- Regional solutions are likely
  - Raw material cost
  - Conversion availability
  - Transportation costs
- All states and provinces need a solution
HOW TO IMPLEMENT A NEW FUEL?
CHALLENGES

1. Regulating market fuel changes
2. Providing good value to the customer
3. Managing the transition to a new market
4. Matching certification and field fuel so that the “actual use” of certification fuel is high
MISFUELING

- If ethanol blends above 10% ethanol appear in the market, mis-fueling become a significant concern
  - Legacy E10 vehicles need to be protected
- If the ethanol level is above 15%, newer vehicles also need protection
- “Premium Required” vehicles can also be mis-fueled with low octane fuel
  - Full optimization to high octane fuel makes this a more serious concern

- The Lead experience in the 70s shows that many consumers ignore requirements
  - A significant portion of vehicles were mis-fueled despite the nozzle mis-match
- API commissioned a study of mis-fueling prevention pathways
  - There was no painless, highly effective pathway
CONCLUSIONS

- Higher octane gasoline offers fuel economy and GHG benefits on both a tank to wheels and well to wheels basis.
- Higher octane gasoline is not and has not been a good value for consumers except for those seeking improved performance.
- The pathway to higher octane market fuels is unclear.
- Mis-fueling control remains an important issue that limits optimization to higher octane.
- All stakeholders will have to work together to capitalize on the advantages and address the challenges of moving to higher octane fuels.
DOE High-Octane Fuels Study: How much fuel economy can be gained by increasing octane ratings, and how does this answer change for different high-octane blends?

**Approach:** Generate engine-based data for a range of fuel octane ratings, comparing blend streams at approximately equivalent RON. Downselect fuels for complete engine maps and vehicle modelling to estimate fuel economy impacts.

**Include in study**

- Multiple paths to higher octane.
  - Ethanol, isobutanol, high-octane hydrocarbons
- Multiple octane levels.
  - ~100 RON, ~ 98 RON, ~ 95 RON
- Fundamental fuels, such as isooctane.
- Identify technical challenges that limit improvements.