

Indirect Effects of Petroleum

CRC Workshop on Life Cycle Analysis of Biofuels

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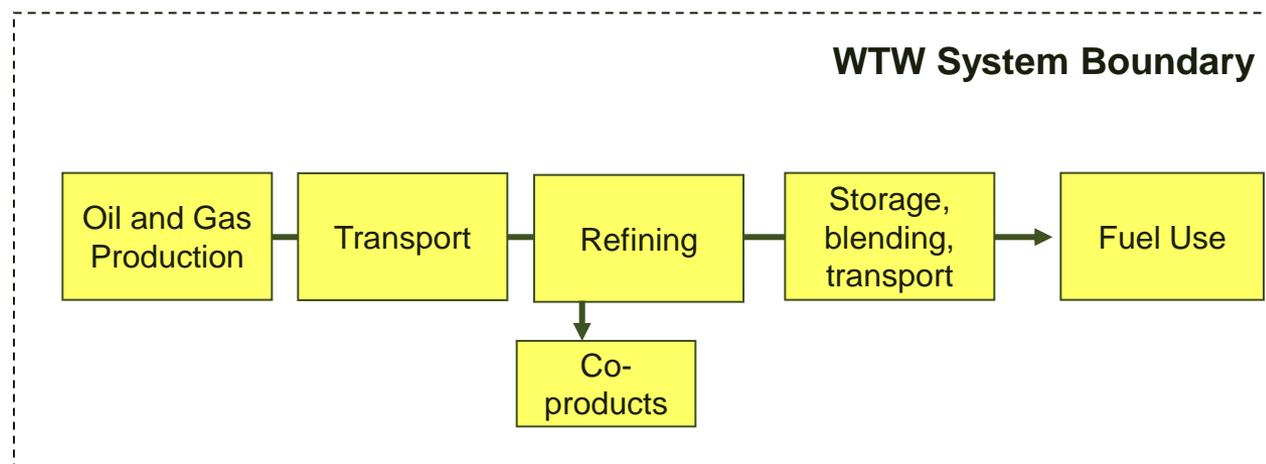


19 October 2011

Objectives

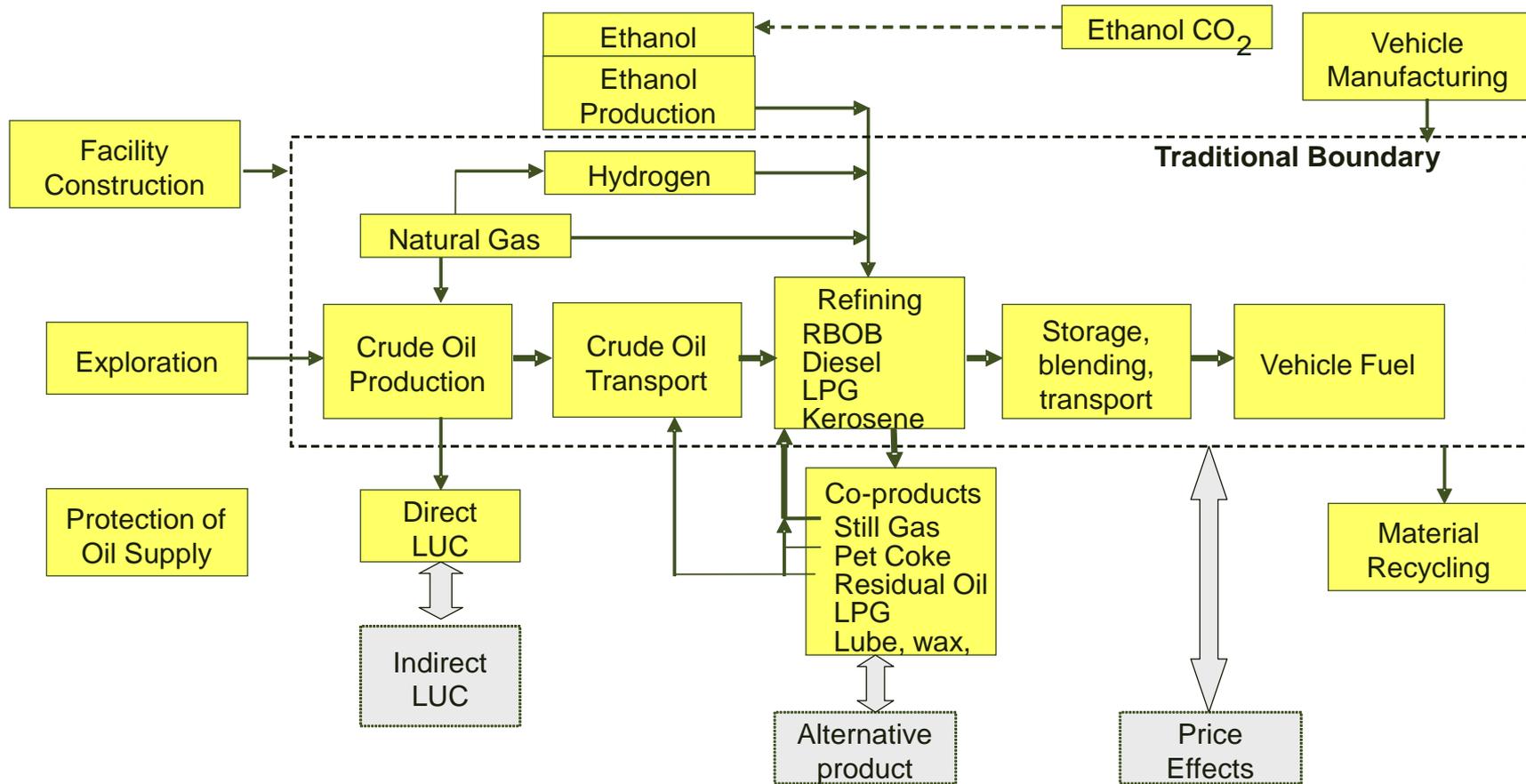
- Categorize direct and indirect emissions
 - What is an indirect effect?
 - Induced, other, anything but direct?
- Identify emissions not include in traditional fuel LCA
- Calculate direct and indirect emissions from petroleum and other fuels
 - Direct effects
 - First order induced effects

Traditional Petroleum System Boundary



- Follow WTW energy inputs
- Treat co-products by process based allocation (JRC and Jacobs are exceptions)
- Limited analysis of indirect effects (Delucchi exception)

Expanded System Boundary



Studies of Indirect and Induced Effects

| Study | Topic |
|--------------------------|--|
| Delucchi (2008) | Price effects, military expenditures |
| Yonzon and Hunter (1991) | Cheese production, cattle, red pandas |
| Unnasch (2009) | Heavy co-products, military expenditures |
| EPA RFS2 (2010) | Price effect via NEMS model |
| NAS (2010) | Difficult to attribute military effects to fuels |
| Liska (2010) | Military expenditures |

Indirect Impacts

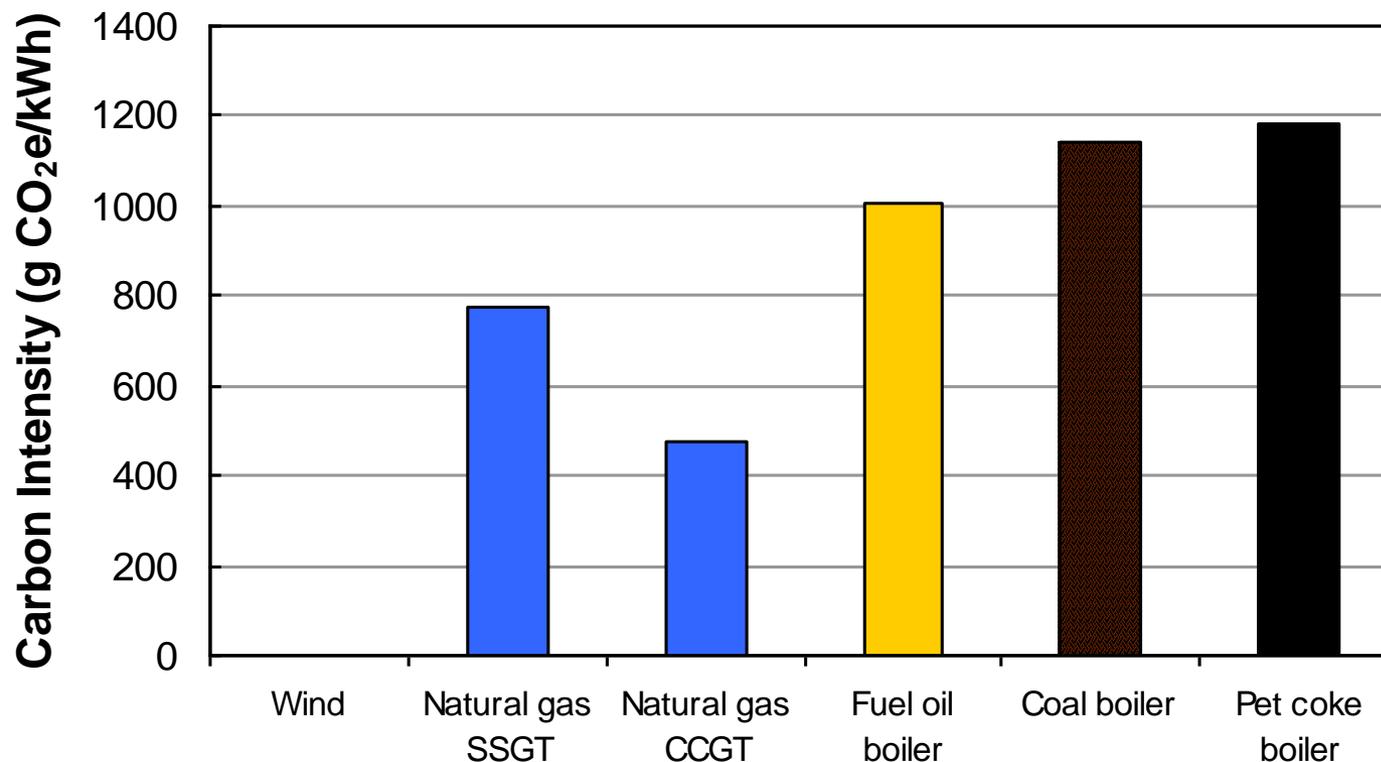
| Category | Effect |
|-----------------------------------|----------------------------|
| Marginal Resources | Marginal Petroleum |
| | Petroleum Coke |
| | Residual Oil |
| | Marginal Natural Gas |
| | Marginal Fertilizer |
| Protection of Petroleum Supply | Military Fuel |
| | Other Military Materials |
| | Oil Field Fires |
| Marginal Electricity | RPS growth |
| | Coal based power |
| Land Use Change | Forest Road Building |
| Transport Logistics | Change in Marine Transport |
| | Displaced Ag Transport |

Supply/Demand Effects

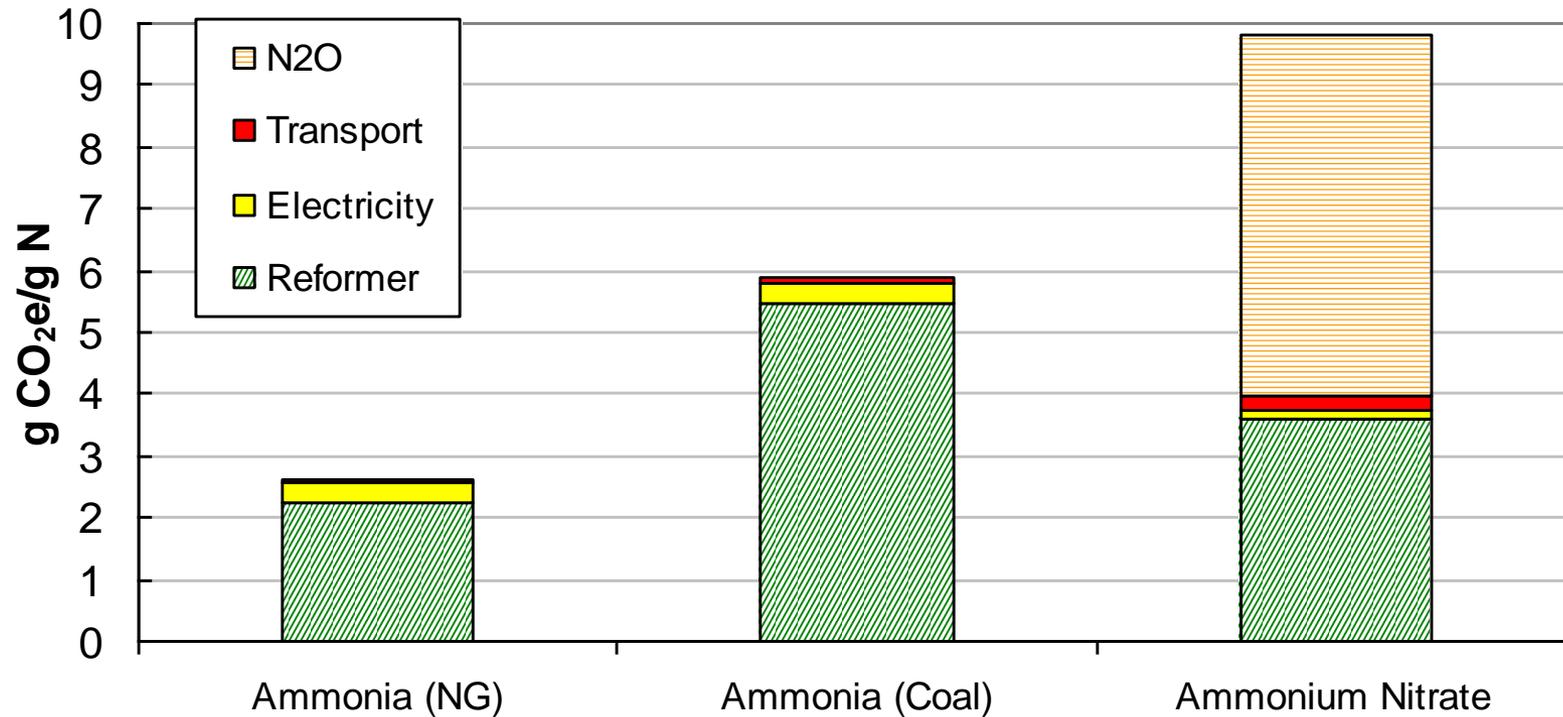
- Induced effects – market mediated
 - Consumer price effect
 - Rebound effect, curtail demand
 - Co-products
 - Residual oil
 - Petroleum coke
 - LPG
 - Process energy inputs
 - Electricity
 - Natural gas
 - Fertilizers (for biofuels)
- Approaches
 - NEMS, GTAP, energy model, EIO-LCA, UCLCA, Dead reckoning
 - How to model resource constraints?

Resources that substitute for fuel oil, coke, and natural gas

Power Generation



Fertilizer Resources

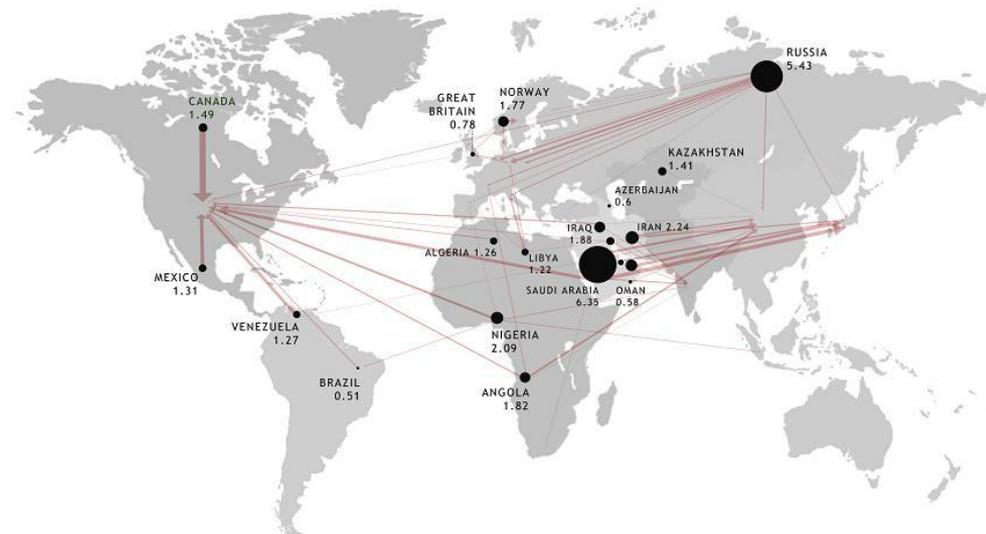


Transportation Logistics

- Fuels and Co-products affect goods transport
 - Residual oil
 - Petroleum coke
- Movement to small product carriers
- Floating storage

TOP CRUDE OIL EXPORTERS

Circles show top exporters in 2009. Line width is proportional to the amount exported from each country, in million barrels per day. Only exports over one hundred thousand barrels per day are shown.



**The Middle East exported 17.46 million barrels crude oil per day. Saudi Arabia was the top Middle Eastern exporter with 6.35 million barrels a day

SOURCE: Energy Information Admini



Transportation Logistics

- Fuels and Co-products affect goods transport
 - Residual oil
 - Petroleum coke
 - Corn DGS
 - Soybean meal
 - Corn ethanol
 - Sugar cane ethanol

TOP SOYBEAN EXPORTERS

Circles show top exporters in 2009. Line width is proportional to the amount exported from each country, in million metric tons.



SOURCE: Soy Stats

Protection of Petroleum Supply

- Connection between US Military Activity and Petroleum Supply
 - Marginal response
 - Attribution
- Military fuel use
- Iraq reconstruction
- Kuwait oil field fires
- Supplies



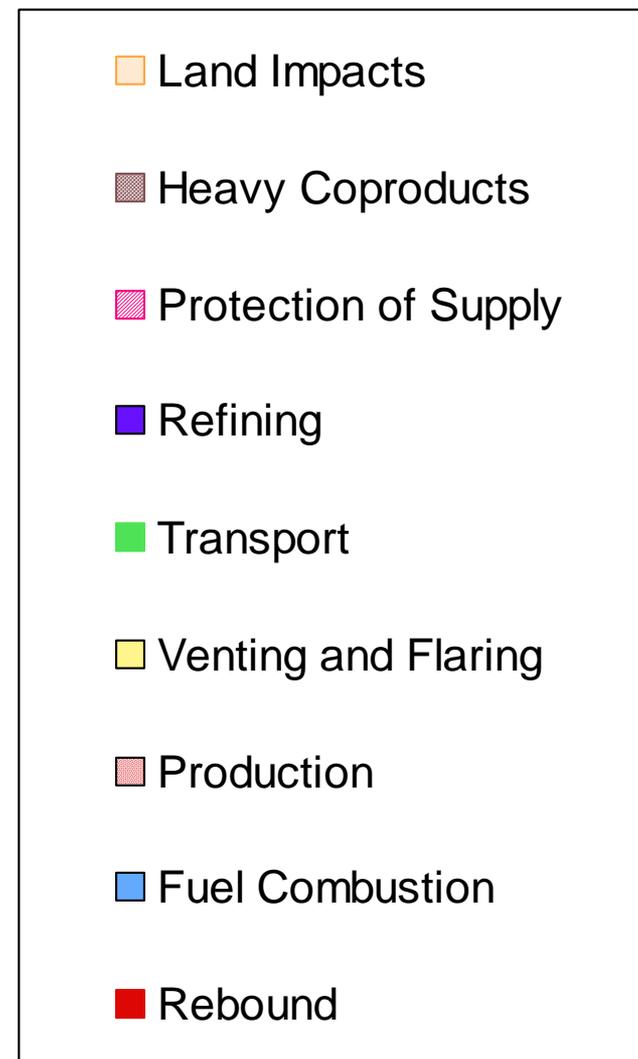
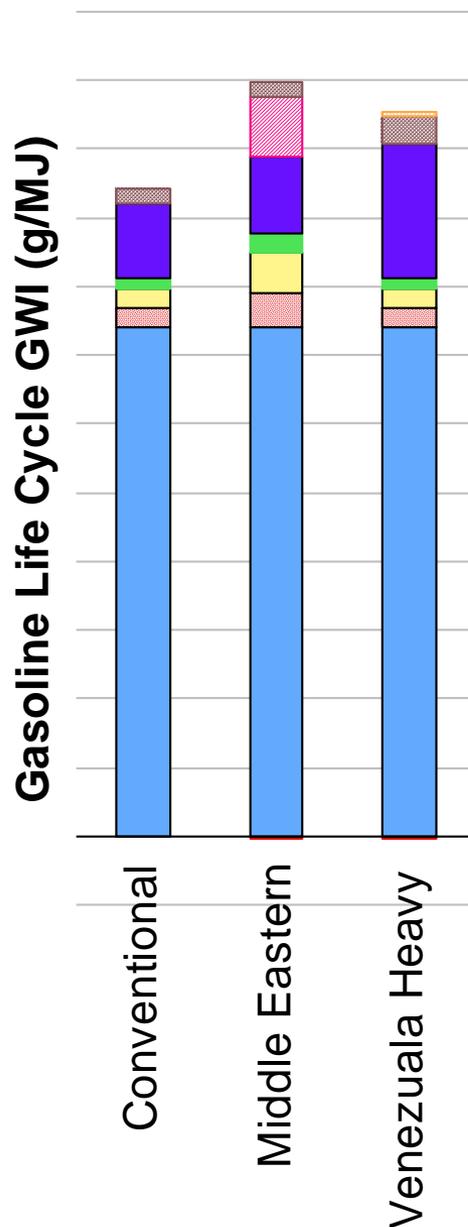
Land Conversion - Forest Roads

| Extent of Deforestation | Colombia | | Ecuador | |
|---|----------|---------|---------|---------|
| | 1973–85 | 1986–96 | 1973–85 | 1986–96 |
| Total area deforested (ha) | 22,519 | 24,326 | 21,167 | 14,911 |
| Annual rate of deforestation (%) | 1.92% | 2.97% | 1.17% | 1.02% |
| Area deforested within 1 km of roads (%) | 4.61% | 4.14% | 55.68% | 42.87% |
| Area deforested within 2 km of roads (%) | 10.58% | 9.11% | 71.84% | 61.83% |
| Area deforested within 5 km of roads (%) | 30.35% | 26.72% | 92.61% | 87.90% |
| Area deforested within 5 km of roads (ha) | 6,835 | 6,500 | 19,603 | 13,107 |

Life Cycle GHG Emissions for Gasoline

Direct +
Indirect

Vehicle +
Fuel Cycle



What's Missing

- Induced Effects
 - Supply demand effects
 - Disaggregate petroleum and power sectors
 - Not in NEMS, EIO LCA, GTAP
- Resource and conversion capacity
 - Fuel oil vs power generation
 - Marginal oil refinery
 - NG vs coal vs wind
- Attribution
 - Oil use .. Military activity
 - Interest rate policy .. Housing bubble

Additional Research

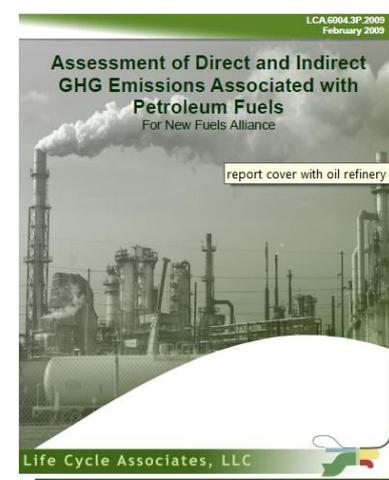
- Categorize LCA Effects
 - Develop consistent set of system boundaries for fuel LCA models and policies
- Modeling Induced Effects
 - Report induced effects used in economic models
 - Supply/demand
 - Food v fuel
 - Disaggregate NG, coal, electric
 - UCLCA – Ultimate Consequential LCA
 - Simple assumptions of displacement effects
 - *“No endeavor that is worthwhile is simple in prospect; if it is right, it will be simple in retrospect”*
Edward Teller , creator of “the super” H bomb

Thank You!

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http://www.newfuelsalliance.org/NFA_PImpacts_v35.pdf