Laboratory for Aviation
and the Environment
Massachusetts Institute of Technology

Co-product methods for alternative jet fuel LCA in an international context

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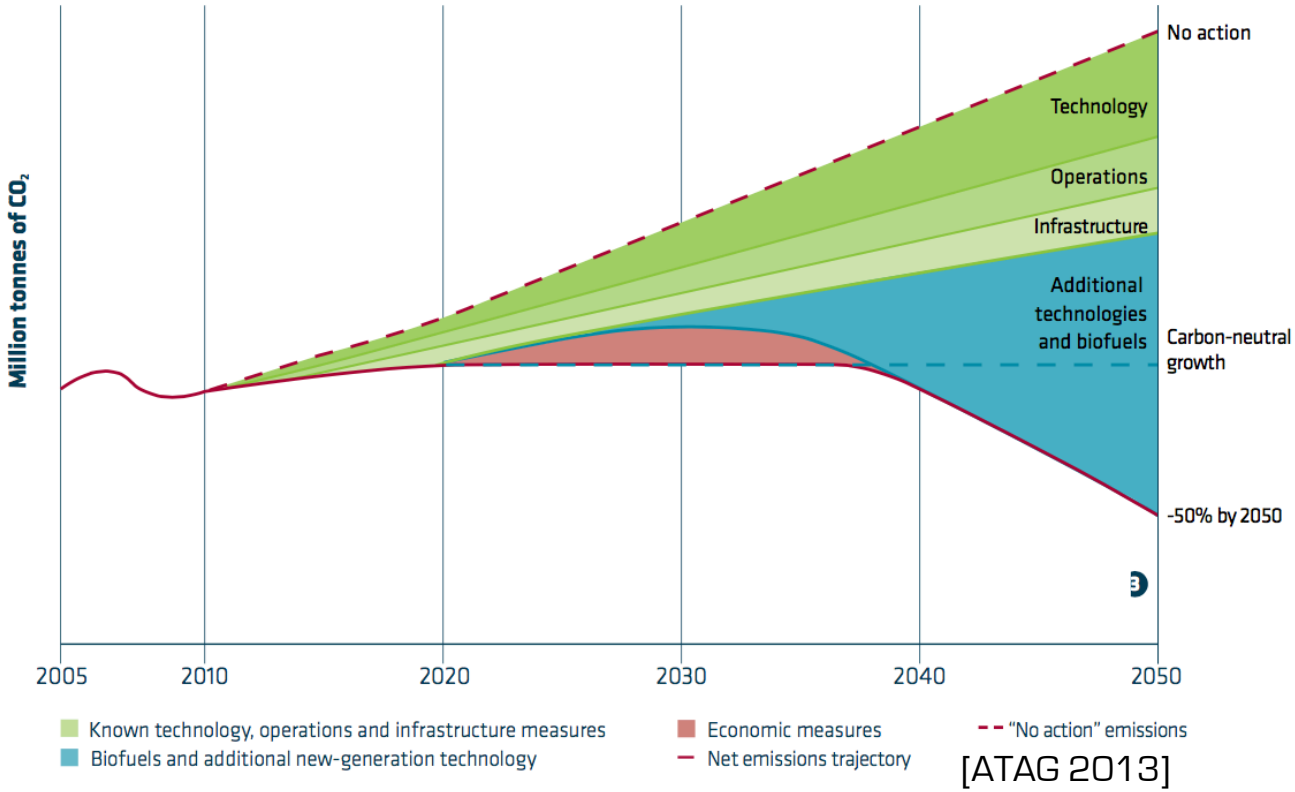
Context: environmental goals of ICAO

International Civil Aviation Organization



[ATAG 2013]

- Goal: carbon neutral growth of international aviation from 2020
- To be achieved through a basket of measures: technology, operations, alternative fuels, and a market-based measure (MBM)

Proposed market-based measure (MBM)

Considering an offsetting approach

- Seeking carbon neutral growth of aviation from 2020
- Applicable to international flights & combustion CO_2

Could involve purchase of emissions units that certify emission reductions in other locations or sectors

- Emissions reduction credits from existing carbon markets

Airlines could potentially reduce their emissions through the use of alternative jet fuels

ICAO CAEP are examining the use of life cycle analysis to account for emissions reductions from alternative jet fuels

MBM methodology for aviation biofuels

Building blocks of MBM LCA methodology

- LCA approach
- System boundary definition
- Choice of allocation rule(s)
- Criteria for data suitability
- Inclusion of variability & uncertainty
- Conventional jet fuel baseline value
- Entities responsible for calculation
- Review mechanism

Attributional co-product allocation options

1. Mass/volume
2. Displacement (system expansion)
3. Revenue-based (market-based)
4. Energy

Selection criteria

- Scientifically justifiable
- Robust to "gaming"
- Implementable

Attributional co-product allocation options

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Attributional co-product allocation options

2. Displacement (system expansion)

Recommended by ISO 14044

Already in use in regulatory systems

- US EPA RFS2

However:

Requires considerable knowledge of product & co-product economics

Issues of spatial & temporal heterogeneity/variability

Displacement of marginal vs. average unit of production

Can lead to unintuitive results

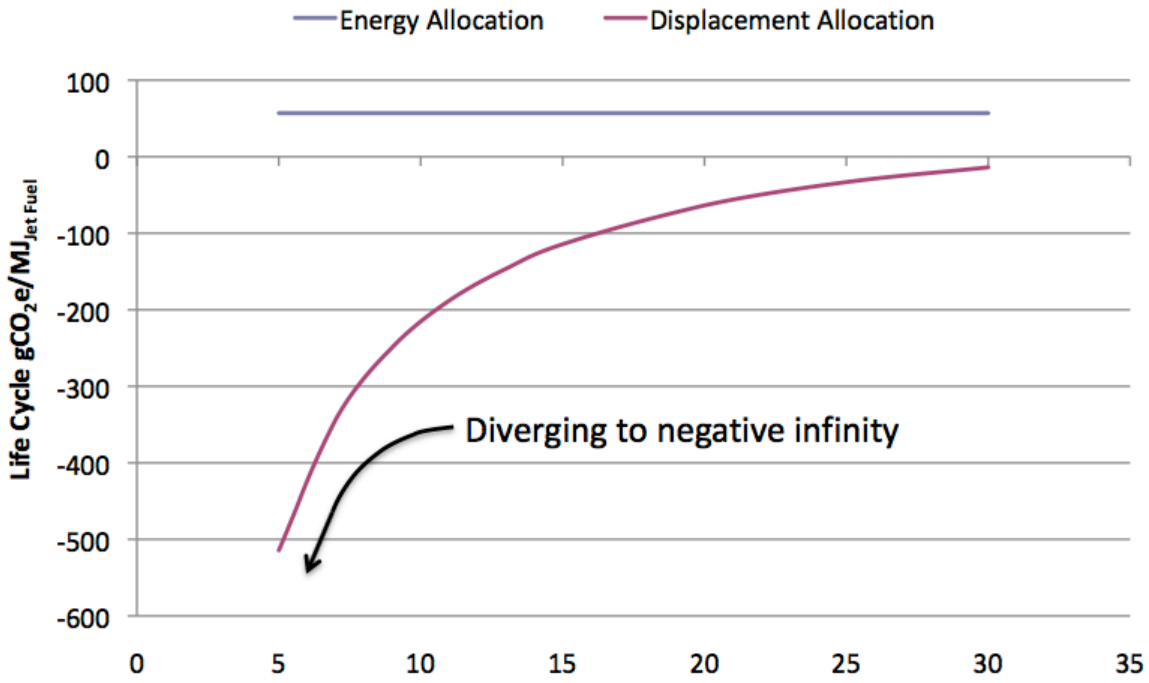
Attributional co-product allocation options

2. Displacement (system expansion)

Example

Disp. of non-jet fuel co-products

- FT_{jet} receives emissions credits for fuel co-product emissions relative to conventional products (in this case, diesel)
- FT middle distillate fuel production, with decreasing share of jet fuel
- As: diesel-to-jet fuel ratio→∞, LCA emissions attributable to jet → - ∞



[Stratton et al. 2010]

Could occur any time:

Jet fuel makes up small share of all products

and/or

Co-prod has significant env. benefit over conventional prod

Attributional co-product allocation options

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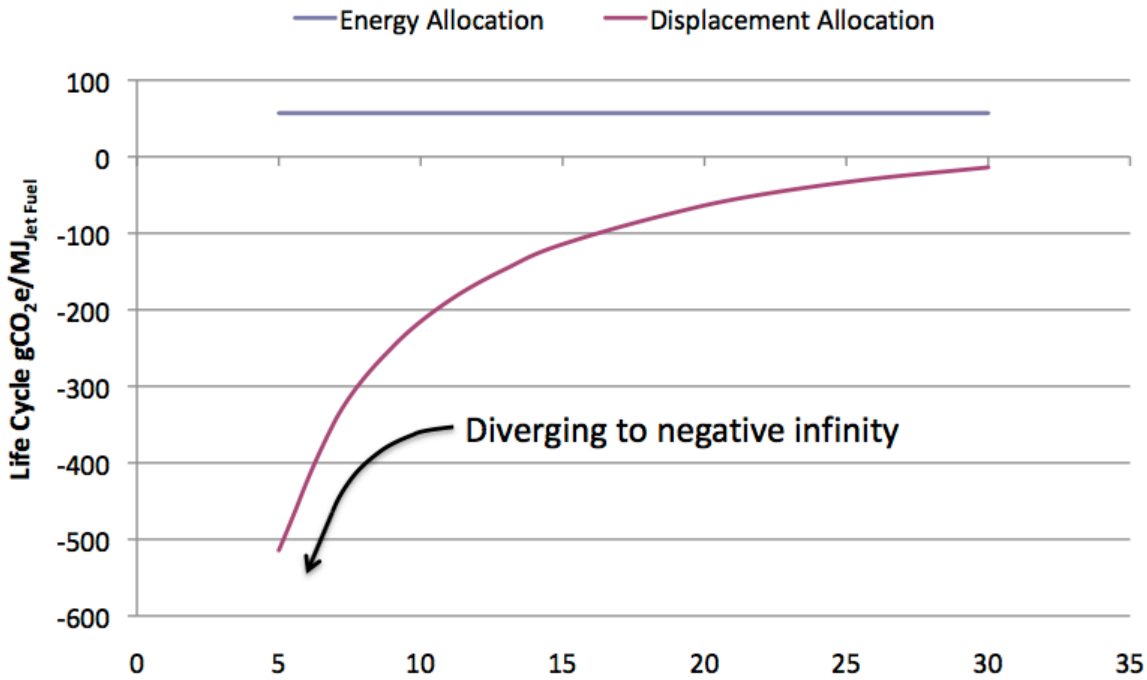

[Stratton et al. 2010]

Fuel producers could potentially receive double credit for emissions reductions:

Once for jet fuel under MBM…and again for diesel, under a separate reg scheme.

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Attributional co-product allocation options

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3. **Revenue-based (market-based)**
4. **Energy**

Attributional co-product allocation options

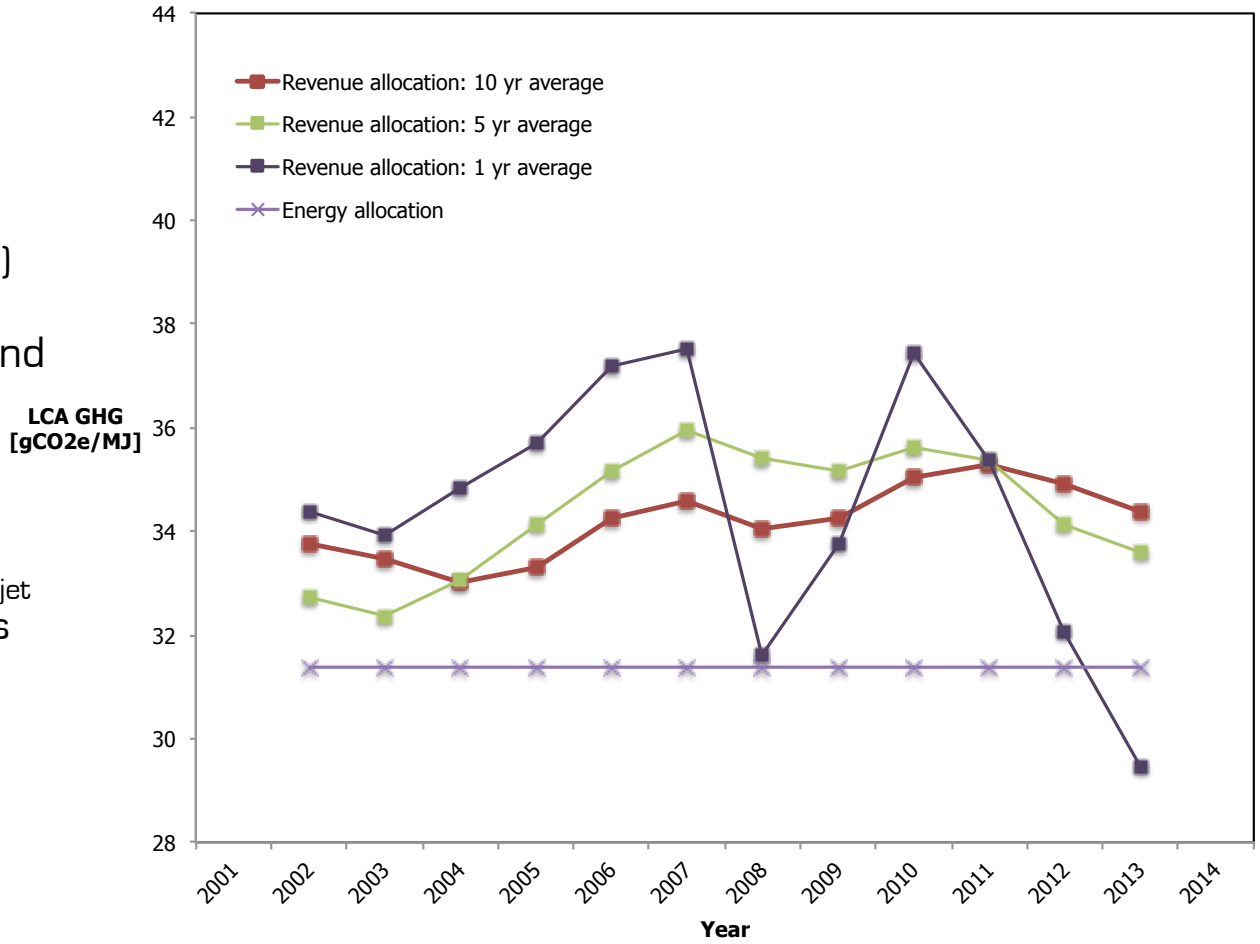
3 & 4. Revenue-based vs. energy

Example 1

Soybean HEFA jet fuel

(Hydroprocessed Esters & Fatty Acids)

- Co-product split between fuel and animal feed
- Time variation in LCA GHG emissions attributable to $HEFA_{jet}$
  - Historical commodity prices
  - Soy HEFA jet pathway in GREET



Attributional co-product allocation options

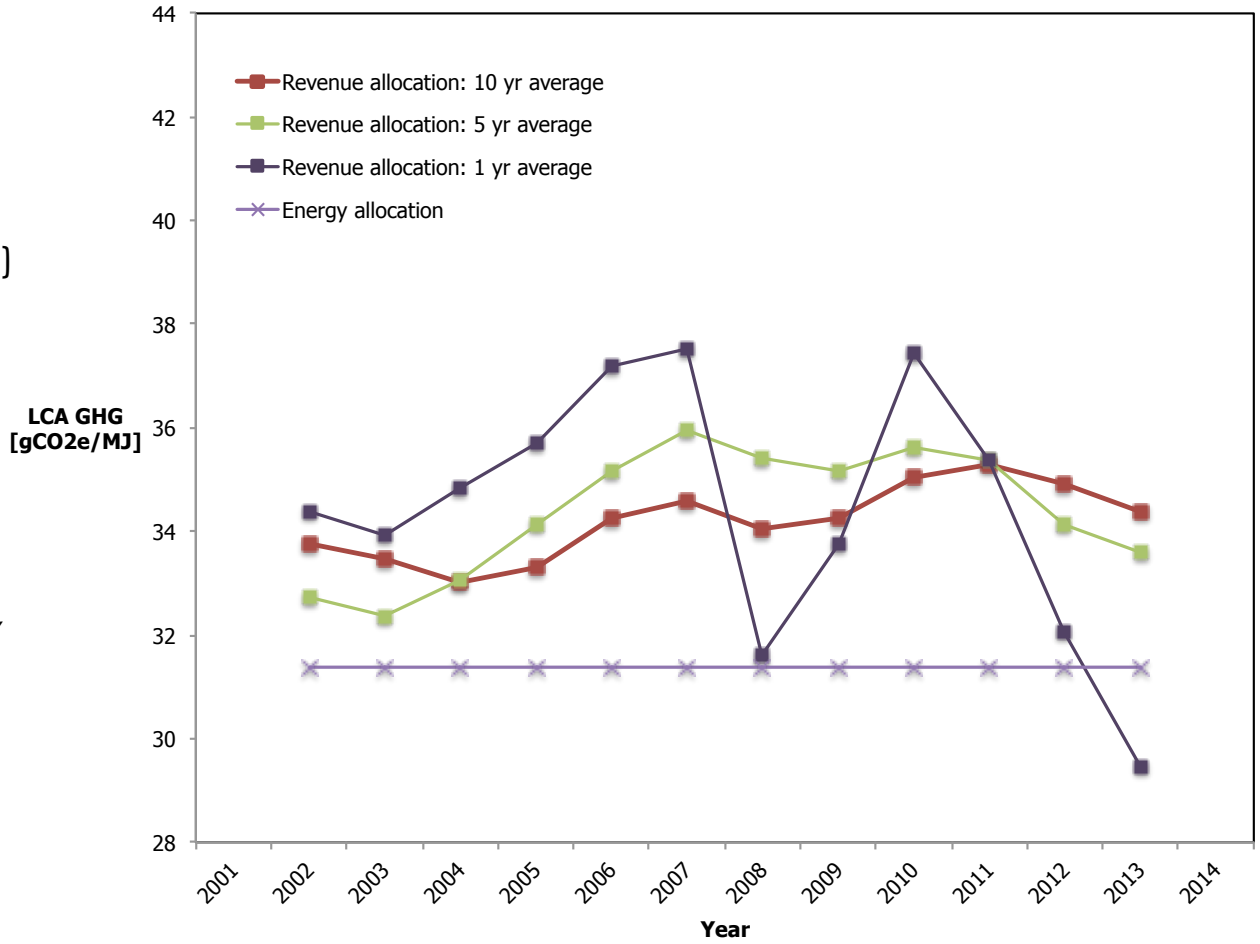
3 & 4. Revenue-based vs. energy

Example 1

Soybean HEFA jet fuel

(Hydroprocessed Esters & Fatty Acids)

- 1-yr average prices result in variable results of 29.5-37.5 gCO_2e/MJ (±13%)
- 10-yr averaging can reduce variability to 32.8-35.2 gCO_2e/MJ (±4%)



Attributional co-product allocation options

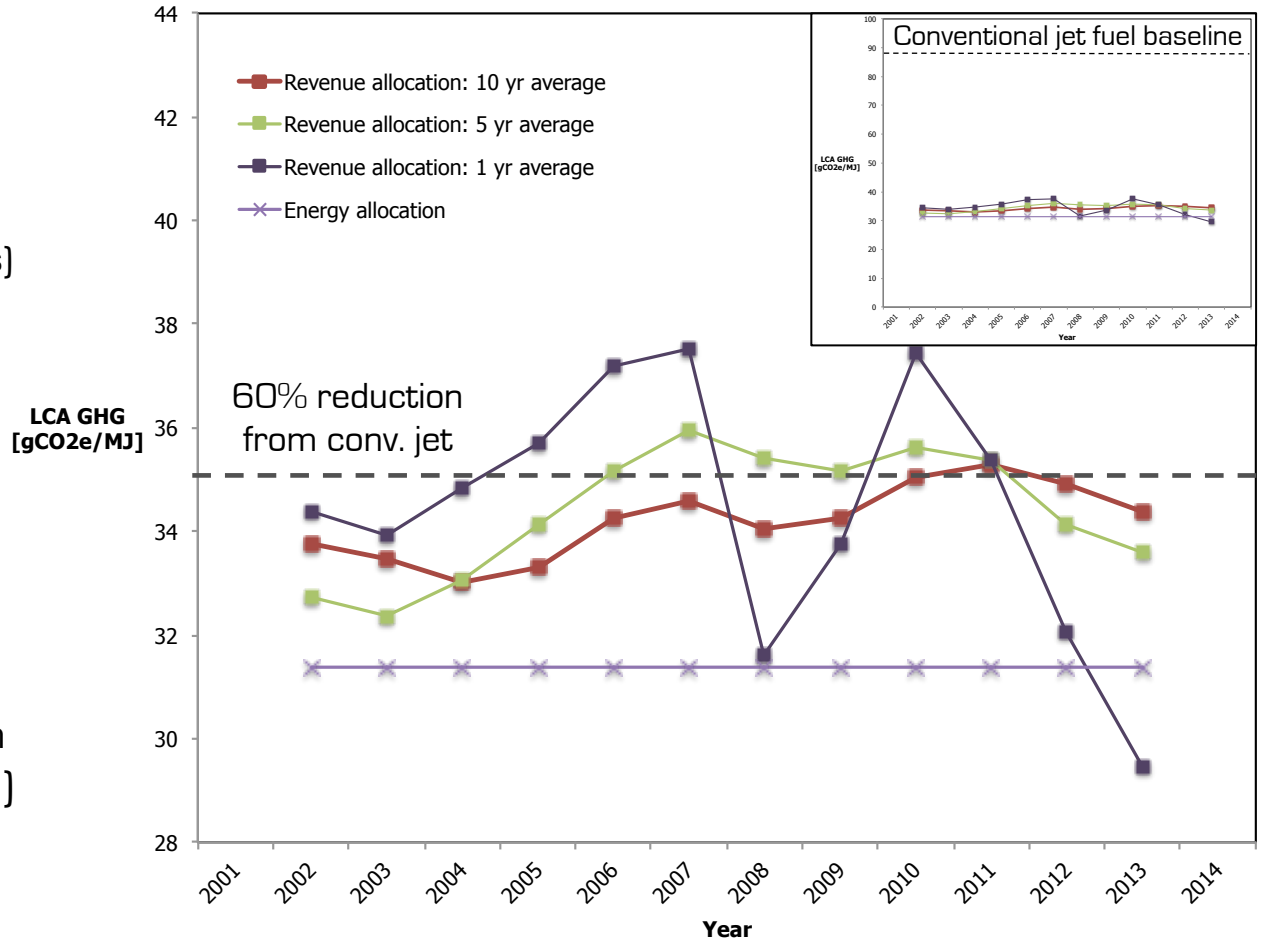
3 & 4. Revenue-based vs. energy

Example 1

Soybean HEFA jet fuel

(Hydroprocessed Esters & Fatty Acids)

- Variability is relatively small compared to conv. jet
- However:
  - Could put a fuel over a threshold (and back again)
  - More pronounced if system (rather than process-based) allocation were considered



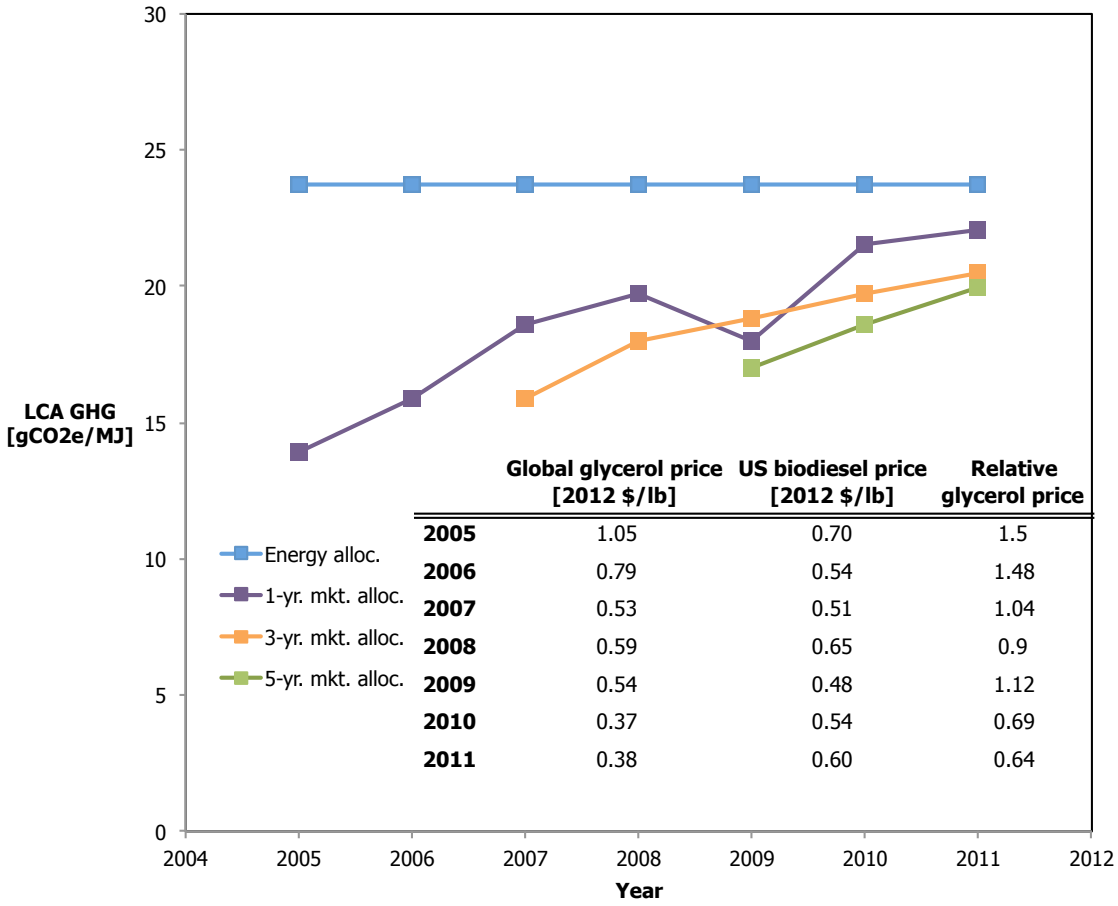
Attributional co-product allocation options

3 & 4. Revenue-based vs. energy

Example 2

Stylized soy biodiesel example

- Co-prod split btw BD and glycerol
- Example of fuel production w/ chemical byproduct
- Time variation in LCA GHG emissions attributable to $HEFA_{jet}$
  - Historical commodity prices
  - Soy BD pathway in GREET



	Global glycerol price [2012 $/lb]	US biodiesel price [2012 $/lb]	Relative glycerol price
2005	1.05	0.70	1.5
2006	0.79	0.54	1.48
2007	0.53	0.51	1.04
2008	0.59	0.65	0.9
2009	0.54	0.48	1.12
2010	0.37	0.54	0.69
2011	0.38	0.60	0.64

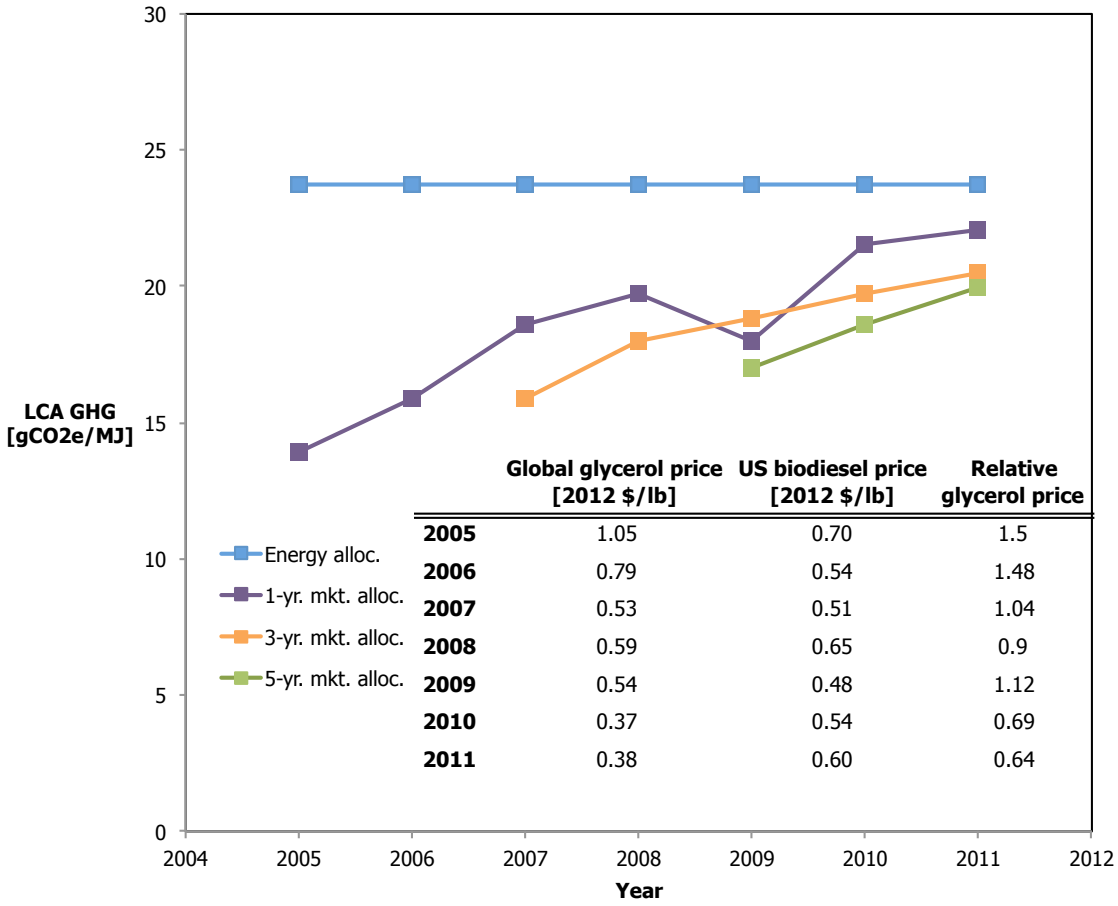
Attributional co-product allocation options

3 & 4. Revenue-based vs. energy

Example 2

Stylized soy biodiesel example

- US glycerol production more than doubled from 2001-2011
- Glycerol prices dropped while BD prices remained about the same
- Relative share of emissions to BD went up



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Attributional co-product allocation options

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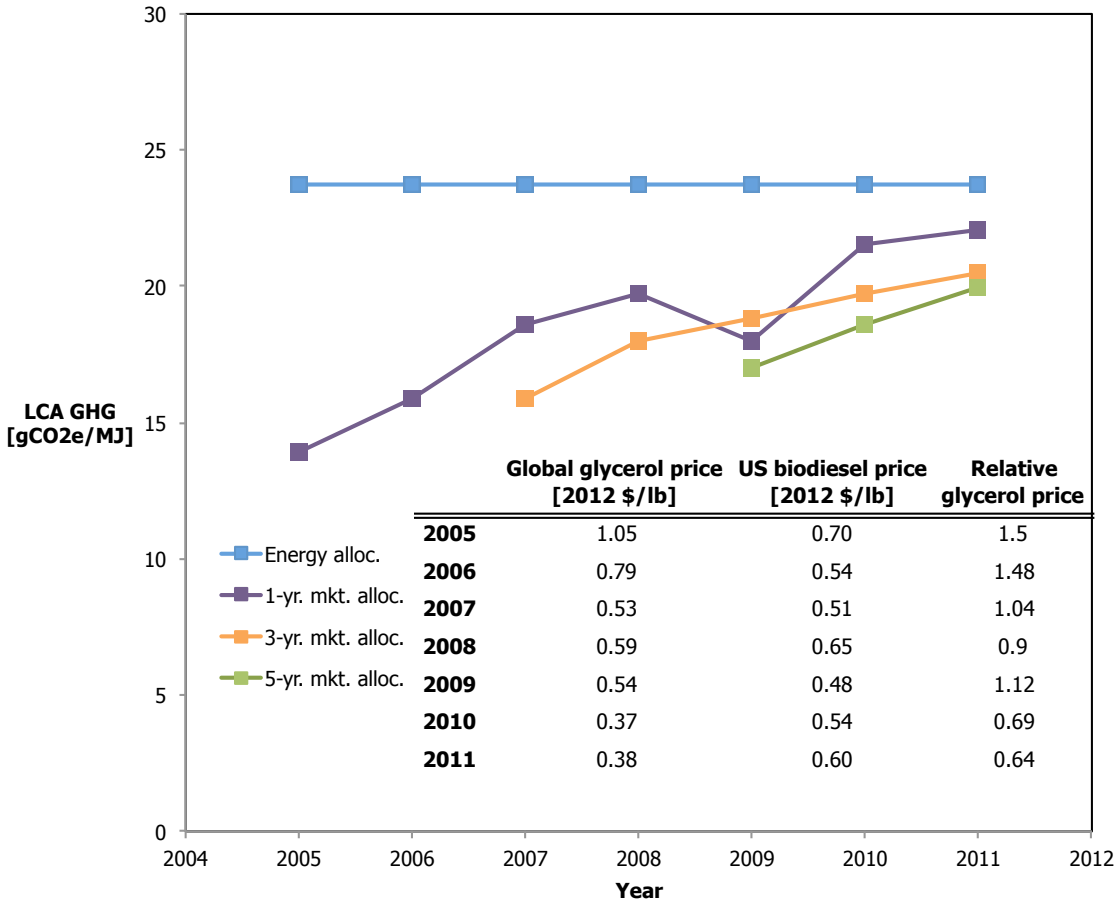
Example 2

Stylized soy biodiesel example

- In this case, biofuel production changed market conditions and, ultimately, LCA GHGs



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3 & 4. Revenue-based vs. energy

Revenue-based allocation

- Reflective of relative social utility placed on co-products
- Subject to temporal & spatial variability
- Small markets (eg. chemicals) could be flooded by co-prod of biofuels

Energy allocation

- (Relatively) reflective of utility of co-products
  - especially since we are interested in fuels
- Time/location invariant (except if process changes)
- Tied to physical, measurable characteristics of co-products
- Already implemented in existing regulatory systems

Selection criteria

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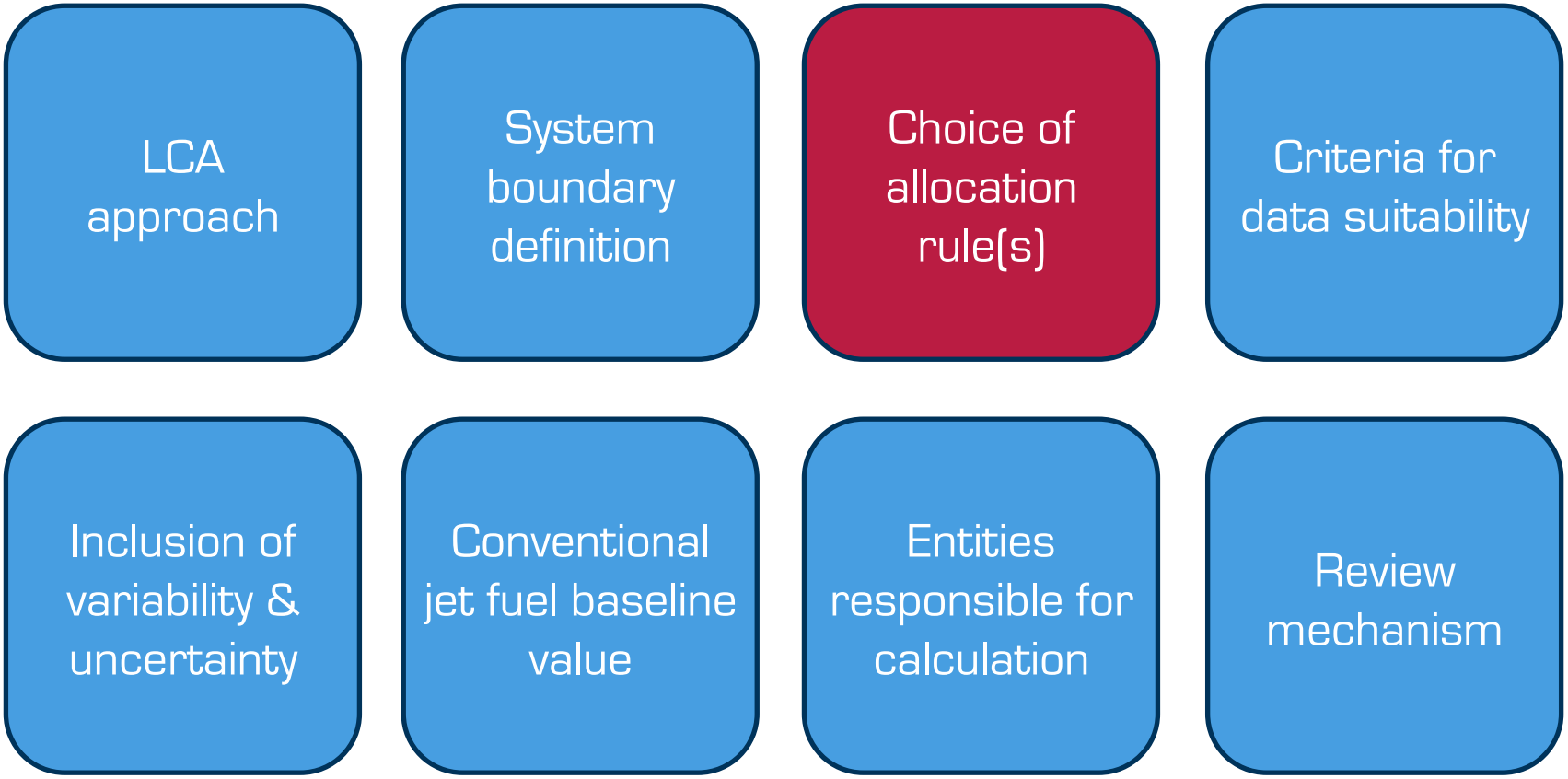
MBM methodology for aviation biofuels



Overall goal is to develop a mechanism for that is **scientifically rigorous** and **implementable.**

Acknowledgements

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