Indirect Land Use
Technical Considerations

Land Use Change Modeling

GTAP (**G**lobal **T**rade **A**nalysis **P**roject from Purdue University)

Step 1: Perform GTAP run to predict types of land converted in each region

Step 2: Estimate increase in GHG emissions for each land type using Woods Hole data

Step 3: Convert total GHG emissions to an equivalent carbon intensity value using an appropriate time accounting method

Stakeholder Comments

1. ARB's measure of the productivity of marginal land is too low.
2. The value chosen for the baseline coarse grain yield is too low.
3. ARB's DDGS co-product credit value is low
4. Emissions attributable to grassland conversion in U.S are too high.

Stakeholder Comments (cont.)

- ARB's measure of the productivity of marginal land (elasticity of crop yields with respect to area expansion) is too low.

- **In determining the final LUC carbon intensity value, staff included scenarios in which the elasticity value ranged from 0.5 to 0.75.**
- **Resulted in a 6% decrease in LUC emissions attributable to corn ethanol**

Stakeholder Comments (cont.)

- The value chosen for the baseline coarse grain yield is too low. Actual yields have risen significantly since the 2001 baseline value used in the model.

- **Increased the corn yield to the 2006-2008 average and proportionally adjusted the GTAP land conversion rates external to the model**
- **Resulted in a 8.7% decrease in LUC emissions attributable to corn ethanol**

Stakeholder Comments (cont.)

- ARB's DDGS co-product credit value is low
- **It is appropriate to credit 1 lb of DGS with 1 lb of feed corn. Will analyze actual market data in the future to determine if needs to be modified**
- Emissions attributable to grassland conversion in U.S are too high.
- **Staff is in the process of evaluating information**

Additional Stakeholder Comments

- Model does not include idle or CRP land
- **We are evaluating other land types**

- Model does not include projected declines in wheat and cotton in U.S.
- **We are evaluating this issue**

Additional Stakeholder Comments (cont.)

- Model may not take into account costs of converting forest and native grasslands
- **We are evaluating under other land types**

- Model estimates that exports will decline and, so far, they have not
- **We are evaluating this issue**

Final Inputs Selected for GTAP for Corn Ethanol

Input Factor	Value
Baseline Year	2001
Target Year	2015
Initial Volume	1.75 Billion Gallons
Final Volume	15 Billion Gallons
Adjustment for Corn Yield (external to model) (used average of 2006-2008 yields)	9.5% increase in yield
Crop Yield Elasticity	0.2 to 0.4
Elasticity of Harvested Acreage Response	0.5
Elasticity of Land Transformation across Cropland, Pasture and Forestry	0.1 to 0.3
Elasticity of Crop Yields with Respect to Area Expansion	0.5 to 0.75
Trade Elasticity	Central case

GTAP Results for Corn Ethanol

Model Results	Current
Total land converted (million ha)	3.9
• Forest land (million ha)	0.9
• Pasture land (million ha)	3.0
U.S. land converted (million ha)	1.6
• U.S. forest land (million ha)	0.6
• U.S. pasture land (million ha)	1.0
LUC carbon intensity (gCO_{2e}/MJ)	30

Final Inputs Selected for GTAP for Sugarcane Ethanol

Input Factor	Value
Baseline Year	2001
Target Year	2015
Initial Volume	3.61 Billion Gallons
Final Volume	5.61 Billion Gallons
Adjustment for Crop Yield (external to model) (used average of 2006-2008 yields)	8.2% increase in yield
Crop Yield Elasticity	0.2 to 0.4
Elasticity of Harvested Acreage Response	0.5
Elasticity of Land Transformation across Cropland, Pasture and Forestry	0.1 to 0.3
Elasticity of Crop Yields with Respect to Area Expansion	0.5 to 0.8
Trade Elasticity	Central case

GTAP Results for Sugarcane Ethanol

Model Results	Current
Total land converted (million ha)	1.09
• Forest land (million ha)	0.33
• Pasture land (million ha)	0.76
Brazil land converted (million ha)	0.74
• Brazil forest land (million ha)	0.22
• Brazil pasture land (million ha)	0.52
LUC carbon intensity (gCO_{2e}/MJ)	46

LUC Analysis for Soy-Biodiesel

- A similar analysis was performed for an increase in production of biodiesel from 5 to 700 million gallons
- Preliminary results will be published upon completing review

LUC Analysis for Cellulosic Feedstocks

- Stover, switchgrass as feedstocks
- Results will be published upon completing analysis

Future Work

- Update all fuel pathway documents
- Continue work on stakeholder comments
- Provide updated CA-GREET model
- Provide details on LUC analysis

Time Treatment of LUC Emissions

Why Time Accounting is Necessary

- Direct emissions from fuel production and use do not vary from year to year over life of project.
- Indirect land use change emissions vary over time.
- Goal is to determine a single, non-varying, value for the carbon intensity of a biofuel.

Time Accounting of iLUC Emissions

Staff have evaluated three accounting methods

- Annualization
- Discounting using Net Present Value (NPV)
- Fuel Warming Potential (FWP) developed at UC Berkeley

Annualization Method

- Add the emissions resulting from indirect land use changes
- Divide this value by a chosen production period and convert to a carbon intensity.
- Add the resulting value to the direct emissions carbon intensity.

NPV Method

- Convert the yearly emissions flows for each fuel (gasoline and biofuel) to a net present value using an assumed discount rate.
- Multiply the carbon intensity of reference fuel (gasoline) by the ratio of NPVs

$$CI_{NPV} = \frac{NPV_{EtOH}}{NPV_{Gas}} \times CI_{Gas}$$

FWP Method

- Calculate the cumulative radiative forcing (CRF) for each fuel from the yearly emissions flows. CRF is a proxy for physical damage caused by emissions.
- Multiply the carbon intensity of the reference fuel (gasoline) by the ratio of the CRF values.

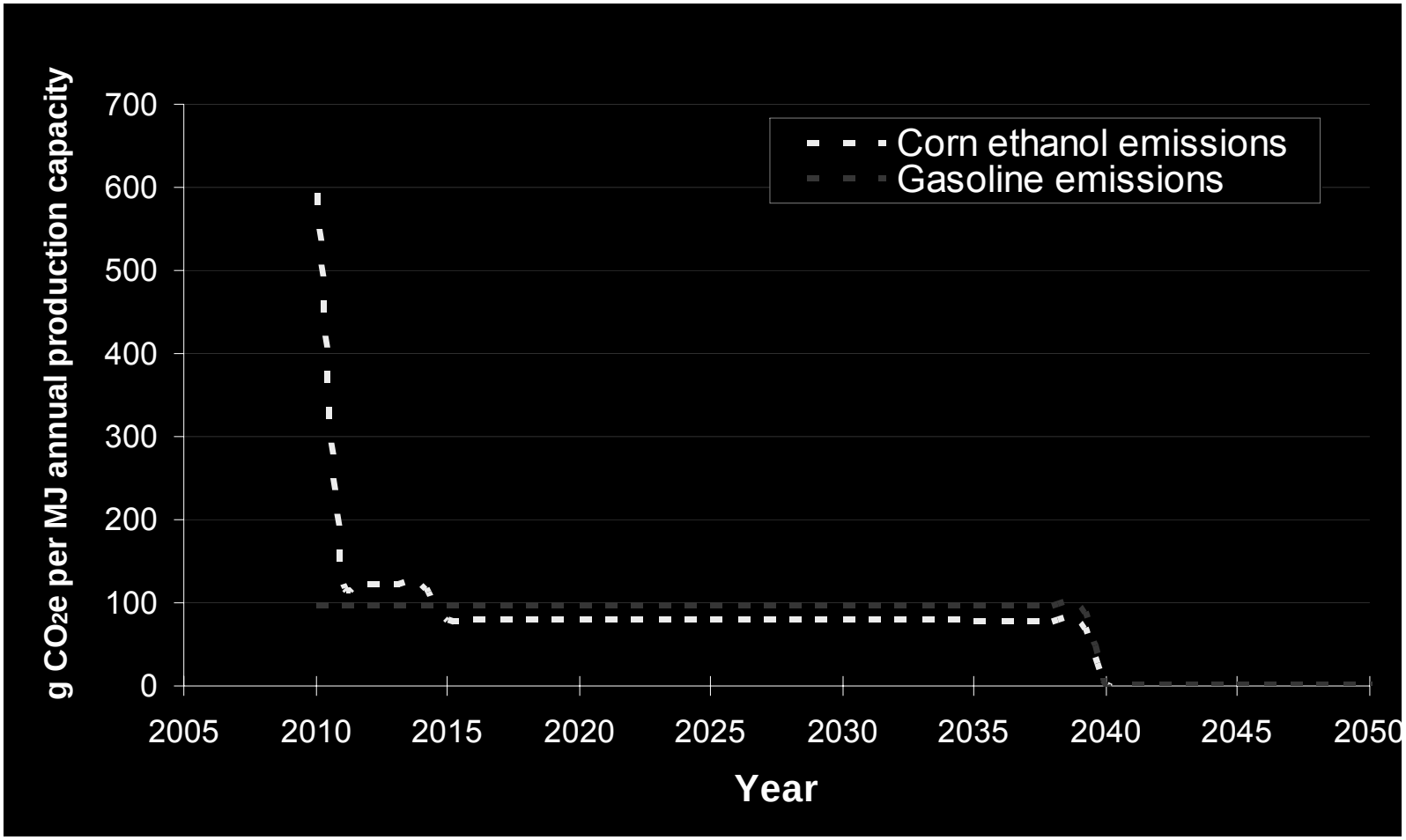
$$CI_{FWP} = \frac{CRF_{EtOH}}{CRF_{Gas}} \times CI_{Gas}$$

Comparison Scenario*

- Compare corn ethanol against gasoline
- Include direct and indirect emissions
- 30 year production period
- Assume a 2% discount rate for NPV calculation

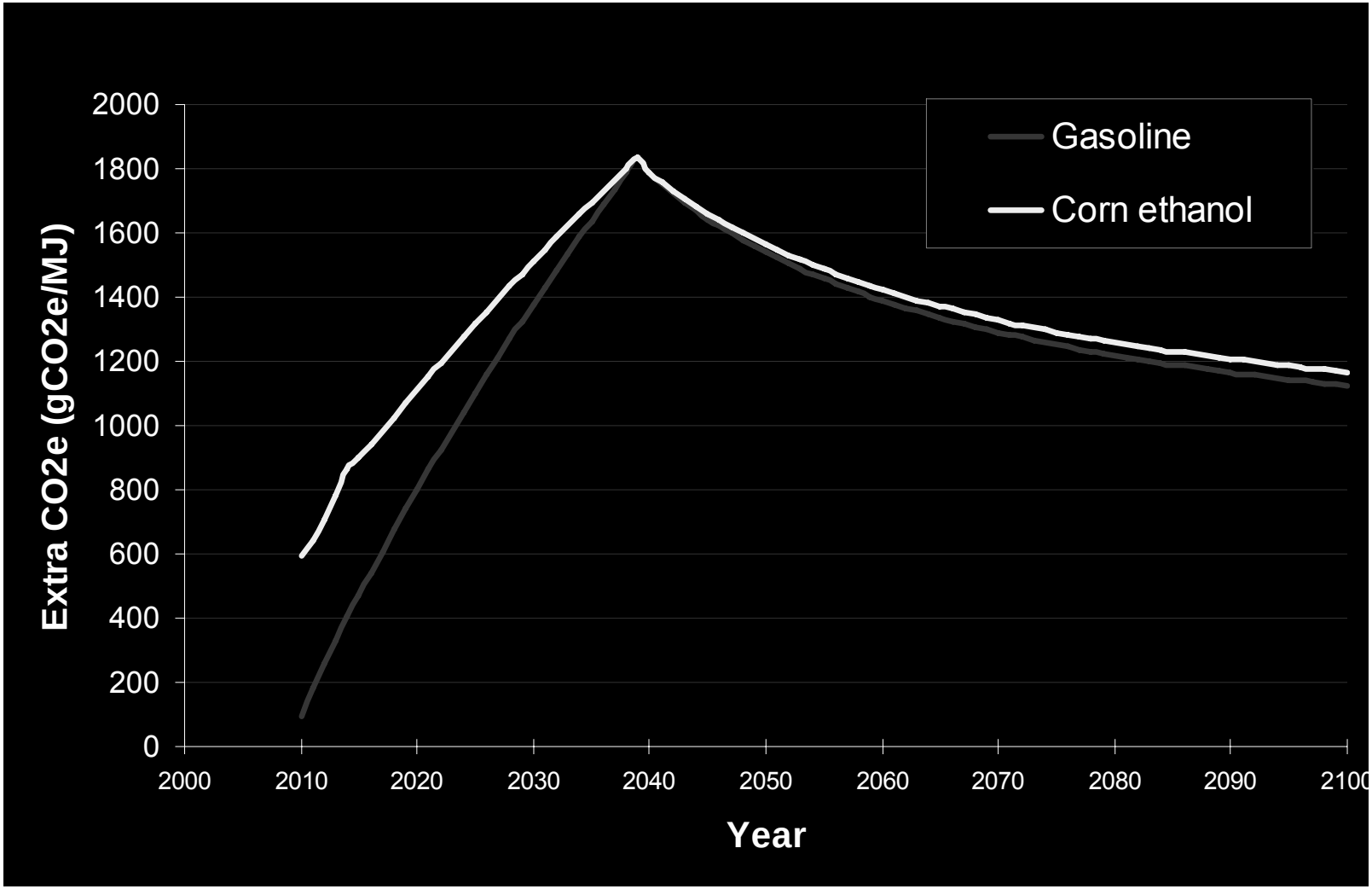
*Note: The data used in this scenario are for comparison purposes only and are not identical to latest GTAP/CA-GREET modeling results.

Time Profile for Total Emissions



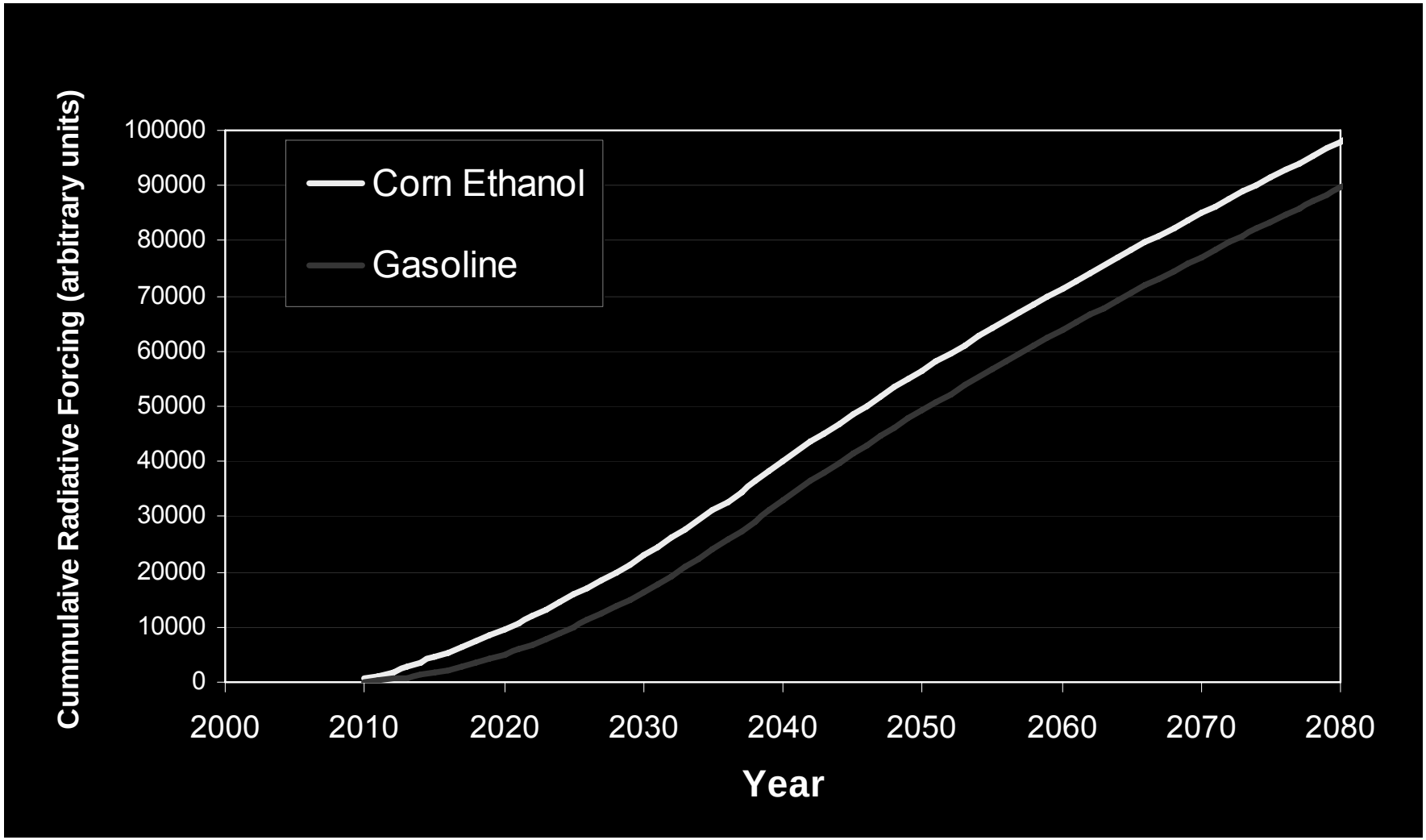
Corn ethanol direct emissions = 69 gCO_{2e}/MJ
Gasoline emissions = 96 gCO_{2e}/MJ

FWP Method
Additional Atmospheric Abundance of CO_{2e}



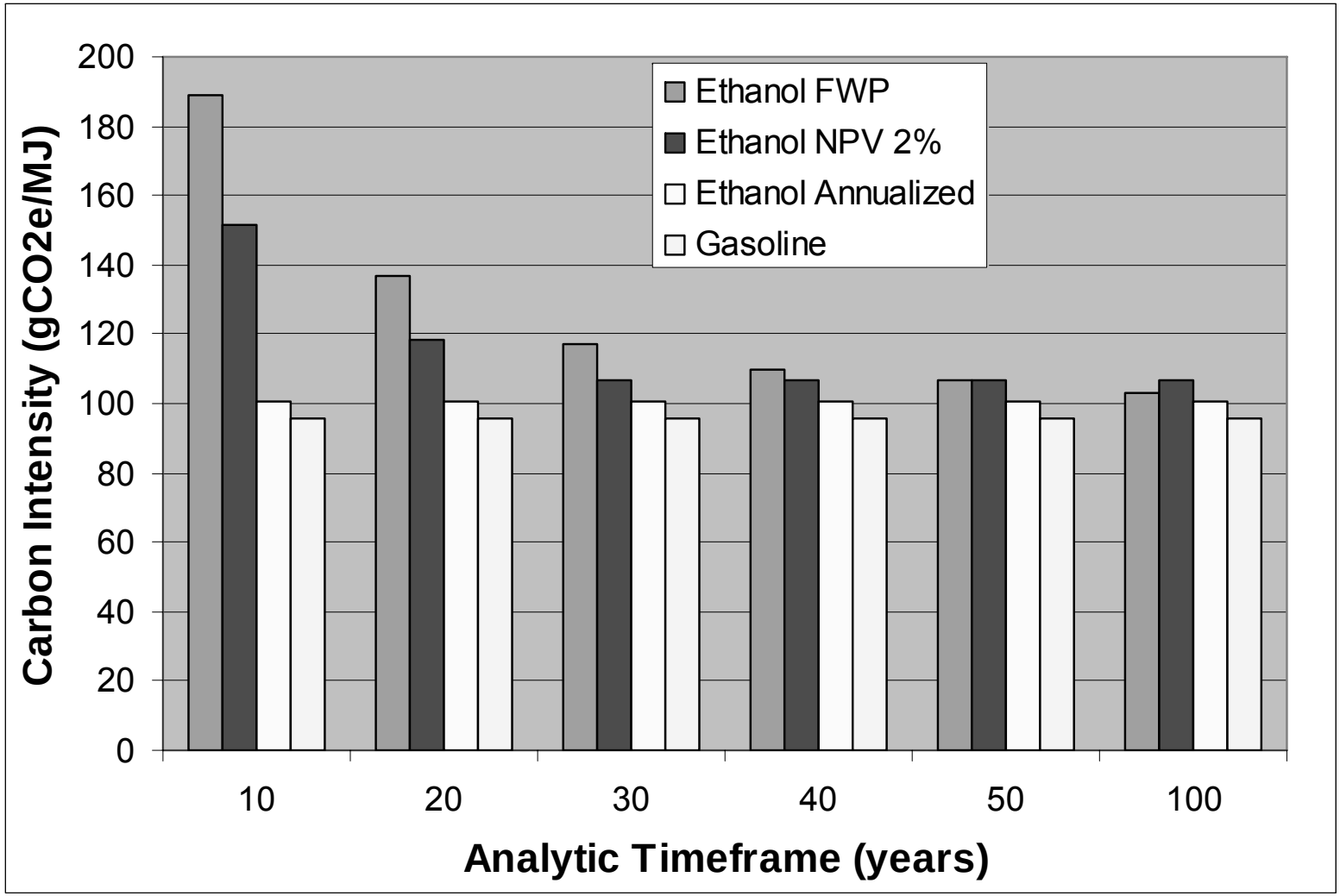
Predicted using the BERN Carbon Cycle Model

FWP Method
Cumulative Radiative Forcing



Proxy for damage of GHG emissions

Comparison of Time Accounting Methods



Impact of Time Treatment Approaches on Indirect LUC Carbon Intensity

Accounting Method	iLUC Carbon Intensity (gCO_{2e}/MJ)
Annualized	31
NPV (2%)	38
FWP	48

30 year production period and analytic time

Considerations – Accounting Method

- FWP method
  - Scientific basis
  - Methodology has not been rigorously peer reviewed
- NPV method
  - Choice of a discount rate is arbitrary
  - Correlation between a discount rate and damage?
- Annualized method
  - Simple
  - Does not differentiate between emissions now or later

Staff Recommendation

30-year Annualization Method

- Simple accounting method.
- Promotes early reductions in emissions and the shift to very low emission fuels.

Questions

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Comments

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Indirect Land Use Policy Considerations

Indirect Land Use Policy Considerations

- **ARB Staff Committed to Hold Policy Discussion**
- **Policy Perspective**
  - **LCFS Requires Low-Carbon Fuels**
  - **Life Cycle Analysis (LCA) Required**
  - **LCA Includes Indirect Land Use Change (ILUC)/Indirect Emissions (IE)**
  - **EISA Requires LCA with iLUC**
- **Methodology Available to Quantify iLUC**
- **Staff Committed to Consider /Assess Significant Other Indirect Effects**