Climate Benefits of US Produced Corn Ethanol
美国玉米乙醇的气候效益

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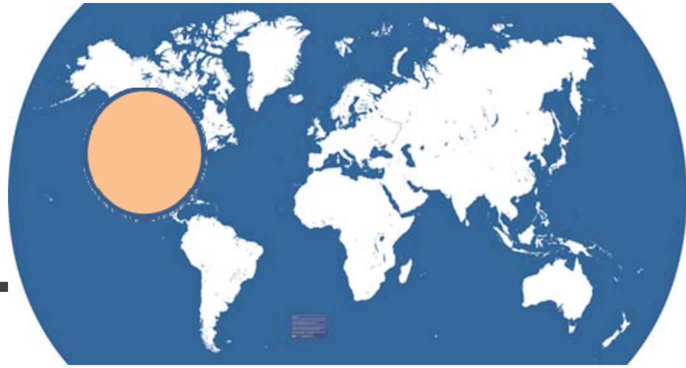
Biofuels and Climate: United States Efforts
生物燃料和气候：美国的举措



- Many policy and regulatory structures around the globe recognize biofuels' potential to reduce global warming.
  世界各国多项政策和监管架构认可生物燃料具有减轻全球变暖的潜能。
- In the US the Low Carbon Fuel Standards (LCFS) in California and Oregon as well as the expanded Renewable Fuels Standard (RFS2) have successfully reduced carbon emissions from transportation fuels.
  在美国，加利福尼亚和俄勒冈州的低碳燃料标准（LCFS）及相关的可再生燃料标准（RFS2）已成功地减少了交通燃料的碳排放。
- While both programs replace gasoline with lower carbon fuels, the RFS2 specifically provides volumetric blending requirements for biofuels whereas fuel suppliers under the LCFS need to meet performance based GHG reduction targets from a fuel mix of their choice.
  两个项目都用低碳燃料代替汽油，RFS2特别提出了生物燃料混合配比量的要求，而按照LCFS的要求燃料供应商自行选择燃料成分配比但需要满足基于实际结果的减少温室气体排放的目标。
  - The RFS2 creates GHG reduction categories for four types of fuels: biomass-based diesel, cellulosic biofuel, advanced biofuel, and renewable/conventional fuel. For example, corn ethanol must meet a 20% lifecycle GHG reduction threshold, while advanced biofuels produced from qualifying biomass must meet a 50% reduction in GHG emissions.
    RFS2为四种类型的燃料创建了温室气体排放类别：生物质柴油，纤维素生物燃料，先进生物燃料和可再生/传统燃料。例如，玉米乙醇必须满足20%全周期温室气体减排的门槛，而用符合要求的生物质生产的先进生物燃料必须实现温室气体减排50%。
  - The LCFS in California requires a 10% reduction in the carbon intensity of transportation fuels by 2020.
    加利福尼亚州的LCFS要求2020年之前交通燃料的碳浓度减少10%。
  - Both RFS2 and LCFS consider emissions from land use change
    RFS2和LCFS均考量了土地利用变更的排放。

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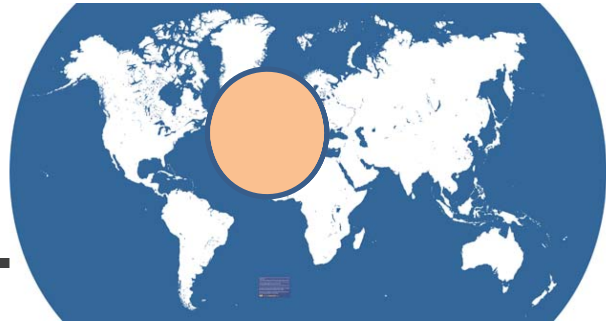
Biofuels and Climate: European Union Efforts
生物燃料和气候：欧盟的举措

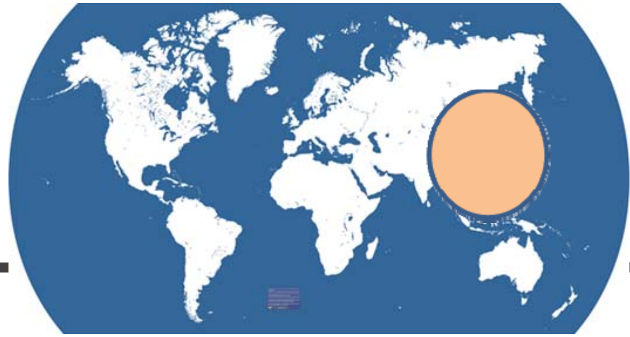
- European efforts under the "Fuel Quality Directive" are similar to the LCFS approach albeit with different GHG reduction targets, whereas Japanese efforts under the "Act on the Promotion of the Use of Nonfossil Energy Sources" are more in line with the RFS2 approach of volumetric blending requirements.
  欧盟在“燃料质量指令”框架下的举措与LCFS的方案类似，但温室气体减排目标不同，而日本的“促进使用非化石能源法案”与RFS2相一致，提出了混合配比量化要求。
- Significant differences exist between these international efforts in the treatment of emissions related to land use change (LUC) prompted by biofuels production.
  各国对生物燃料生产引起的土地利用变更相关排放的处理上有着显著的区别。
- In Europe, due to the evolving science and uncertainties associated with quantifying emissions from LUC, the Fuel Quality Directive does track but **does not include** emission from LUC in a fuel's GHG assessment.
  在欧洲，由于科学的发展和土地利用变更导致的排放难以具体量化，燃料质量指令对一种燃料进行温室气体评估时仅追踪但并不包含土地利用变更导致的排放。
- Corn ethanol must achieve a GHG reduction **of 35% over gasoline (with an increasing threshold to 50% starting in 2018).** However, biofuels must be certified for sustainable production based on an EU-approved certification protocol.
  玉米乙醇必须达到相对汽油燃料减排温室气体35%（从2018年开始门槛进一步提高，达到50%）。然而，生物燃料还必须在欧盟批准的认证协议基础上被认定为可持续发展产品。

Biofuels and Climate: European Union Efforts
生物燃料和气候：欧盟举措



- During the 2010-2011 time frame many US-based ethanol plants exported ethanol to the EU which also required a third party certification (e.g by International Sustainability and Carbon Certification – ISCC or RSB) of the greenhouse gas reductions and additional sustainability criteria such as feedstock sourcing from non-deforested land.
  在2010-2011的时间框架内，多家基于美国的乙醇生产者将乙醇出口到欧盟，欧盟要求具有温室气体减排和其他可持续性标准如从非滥砍滥伐地区采购原料等第三方认证（如国际可持续发展和碳认证—ISCC或RSB）。
- 23 plants in the US were ISCC certified. The certified plants span a wide range of technologies, owner entities, and geographic locations.
  23家美国企业得到了ISCC认证。这些认证企业广泛分布于各技术领域、实体形式和地理位置。
- Note that several other US-based plants would have possibly met the EU GHG reduction threshold but may have chosen not to participate in the export markets to Europe
  要注意有些基于美国的厂家可能符合欧盟温室气体减排的门槛，但选择不进入向欧洲出口的市场。

Biofuels and Climate: Asia Region
生物燃料和气候：亚洲地区



- Japan is increasing its biofuels blending volumes for gasoline over the next years.
  日本此后会逐年增加生物燃料在汽油中的混合比例。
- Imported ethanol and ETBE additives **must meet a 50% reduction threshold of biofuels over gasoline** set by the "Act on special accounts and the measures for the enhancement of the energy supply-demand structure."
  进口的乙醇和ETBE添加剂必须满足"能源供求结构改善措施和特别会计法"规定的生物燃料比汽油减排50%的门槛。
- Emissions from LUC are considered but only those associated with direct LUC have to be included in the life cycle modeling effort.
  土地利用变更的排放给予考量，但只有与直接的土地利用变更相关的排放才包括在全周期建模中。

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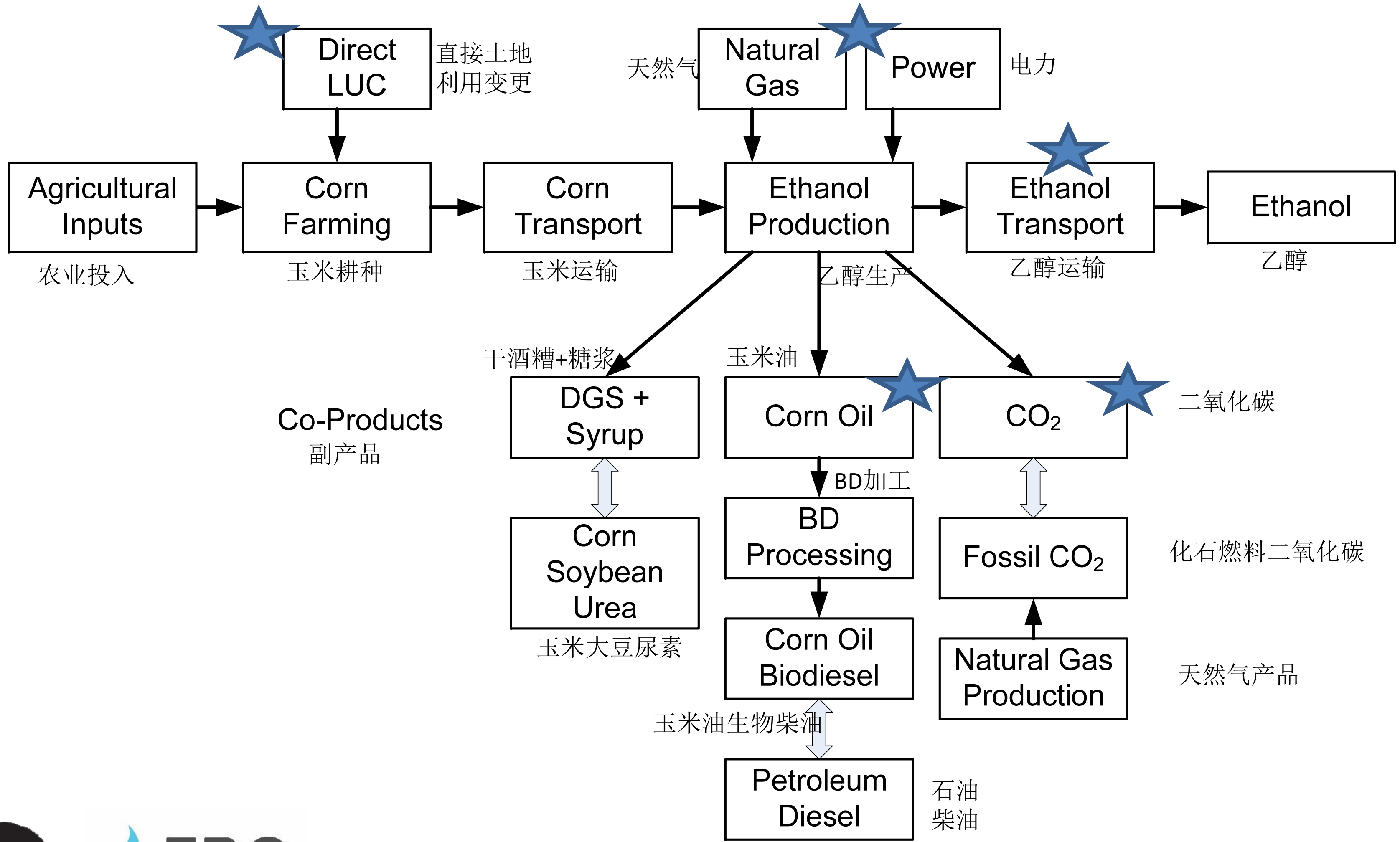
US Ethanol Volume Meeting 50% GHG Reduction
美国乙醇量产满足50%温室气体减排的要求

- We showcase the volume of US produced ethanol that, for example, can also meet the stringent 50% GHG reduction requirements set by Japan
  我们证明了美产乙醇的量产能够满足以日本为例严苛的50%温室气体减排的要求。
- The "Judgment Criteria for Oil Refiners on the Use of Non-Fossil Energy Sources (Ministry of Economy, Trade and Industry Public Notice No. 242 of 2010) regulations" detail the life cycle modeling (LCA) requirements including the ultimate **emissions reduction threshold for ethanol of 50%** (41 gCO2eq/MJ) compared with LCA-based GHG emissions from gasoline (81.7 gCO2eq/MJ)."
  "炼油厂使用非化石能源的判定标准"（经济、贸易和工业部2010年第242号公告）详细规定了全周期建模（LCA）的要求，包括乙醇比石油基于全周期模型的温室气体排放最终减少达50%的门槛。(41 gCO2eq/MJ)
- Many of the LCA guidelines from that document are closely in line with the European Union's Renewable Energy Directive (RED)
  该文件中多项全周期模型指导原则与欧盟的可再生能源指令（RED）相似性很高。
- For past exports of US ethanol to the EU the achieved greenhouse gas reductions were often assessed using the Argonne GREET life cycle model funded by the US Department of Energy.
  过去美国对欧盟出口的乙醇通常运用美国能源部资助的阿贡实验室GREET全周期模型对起温室气体减排效益进行评估。
- Therefore, GREET is used in this analysis
  因此，GREET被用于此分析。

Employed Life Cycle Model
使用的全周期模型

- The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model by Argonne National Laboratory (a US Department of Energy laboratory) is the gold standard for life cycle analysis in the US and it contains the most up to date databases on US production methods and the efficiency of the US agriculture and energy sectors.
  阿贡国家实验室（美国能源部实验室）创建的交通领域温室气体、排放控制和能源利用模型是美国全周期分析的金标准，包含了美国生产方法和美国农业和能源领域效益的最新数据库。
- GREET is a flexible LCA model that can be and has been adapted to fit regulation-specific guidelines including those set by the California Low Carbon Fuel Standard, the EPA RFS2 and the RED.
  GREET是有灵活性的全周期评估模型，能够适应有具体规定的指导方针，包括加利福尼亚低碳燃料标准、EPA RFS2和RED。
- In light of the Japanese alignment with the RED we assumed that GREET based modeling would be accepted by Japanese regulators.
  考虑到日本相关法规与RED的一致性，我们推定基于GREET的模型也会被日本监管机构所接受。
- As with modifications for LCFS, RFS2, and RED type pathway modeling GREET can be adjusted to fit the Japanese "Judgement Criteria."
  而通过对LCFS、RFS2和RED类型的路径模型的调整，GREET经过调整亦可适应日本的"判定标准"。

Introduction to Life Cycle Modeling:
System Boundary for Selected Corn Ethanol Pathway
全周期模型介绍：
部分玉米乙醇路径系统边界



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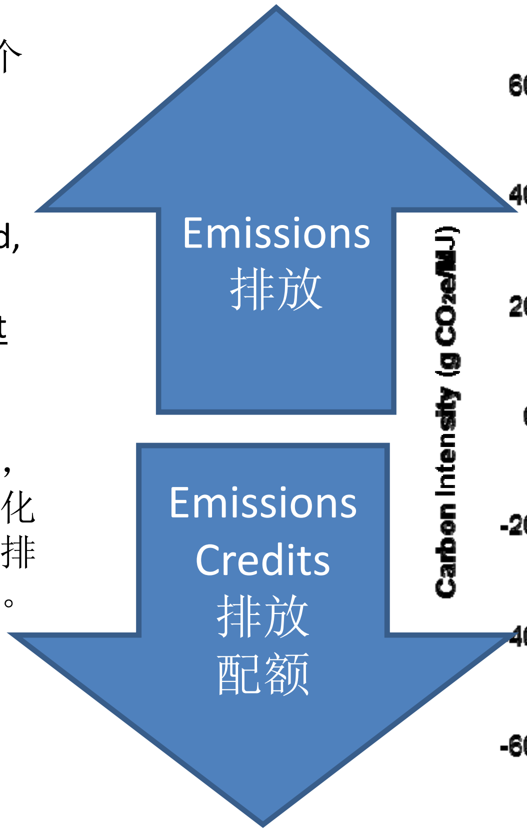
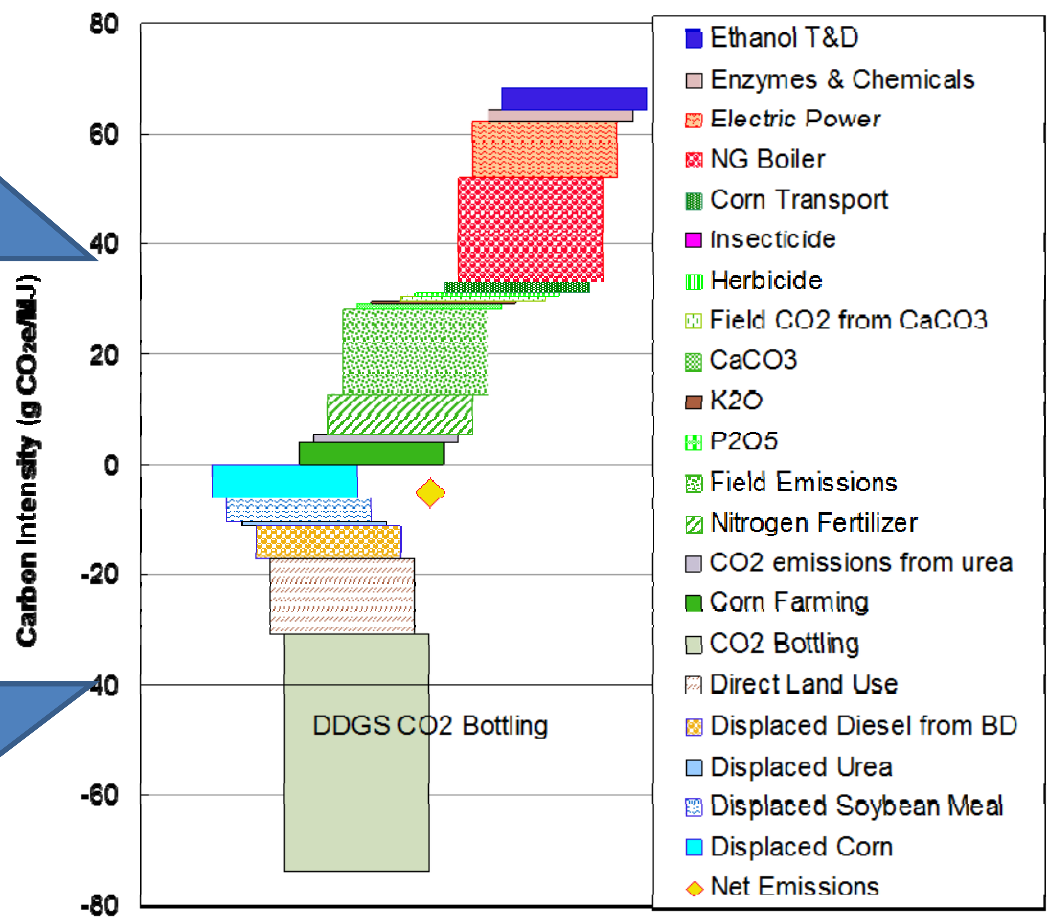
Illustrative Example:
GREET LCA Emission Steps and Life Cycle Stages
图示：GREET LCA排放步骤和全周期阶段

GREET has detailed emission profiles for each production input along a fuel pathway
GREET详述了燃料路径每个生产输入环节的排放量

Products co-produced with ethanol such as animal feed, beverage CO_2, soil carbon sequestration provide a net emissions credit to the life cycle emissions
乙醇生产过程中的副产品，如动物饲料、饮料用二氧化碳、土壤碳固定在全周期排放量中提供了净排放配额。





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Leading-Edge US Ethanol Plant Technologies that Provide CO_2 Reductions

美国乙醇生产商用前沿技术实现了二氧化碳减排

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Qualifying Technologies that Provide CO_2 Reductions
实现二氧化碳减排的合格技术

- Corn Oil Separation at Ethanol Plant going into Biodiesel Production
  乙醇厂家对玉米油脂进行分离，投入生物柴油生产
- Enogen and Energy Efficiency Improvements
  伊诺根品种和能源效率的提高
- CO_2 Recovery for Food Industry or Enhanced Oil Recovery
  二氧化碳回收用于食品业或提高油脂提取率
- Wet DDG 湿酒糟
- Anaerobic Digesters 厌氧消化器
- Direct Land Use Change 直接土地利用变更

Technologies will be detailed in the following slides
下面的幻灯片将进行技术方面的详述

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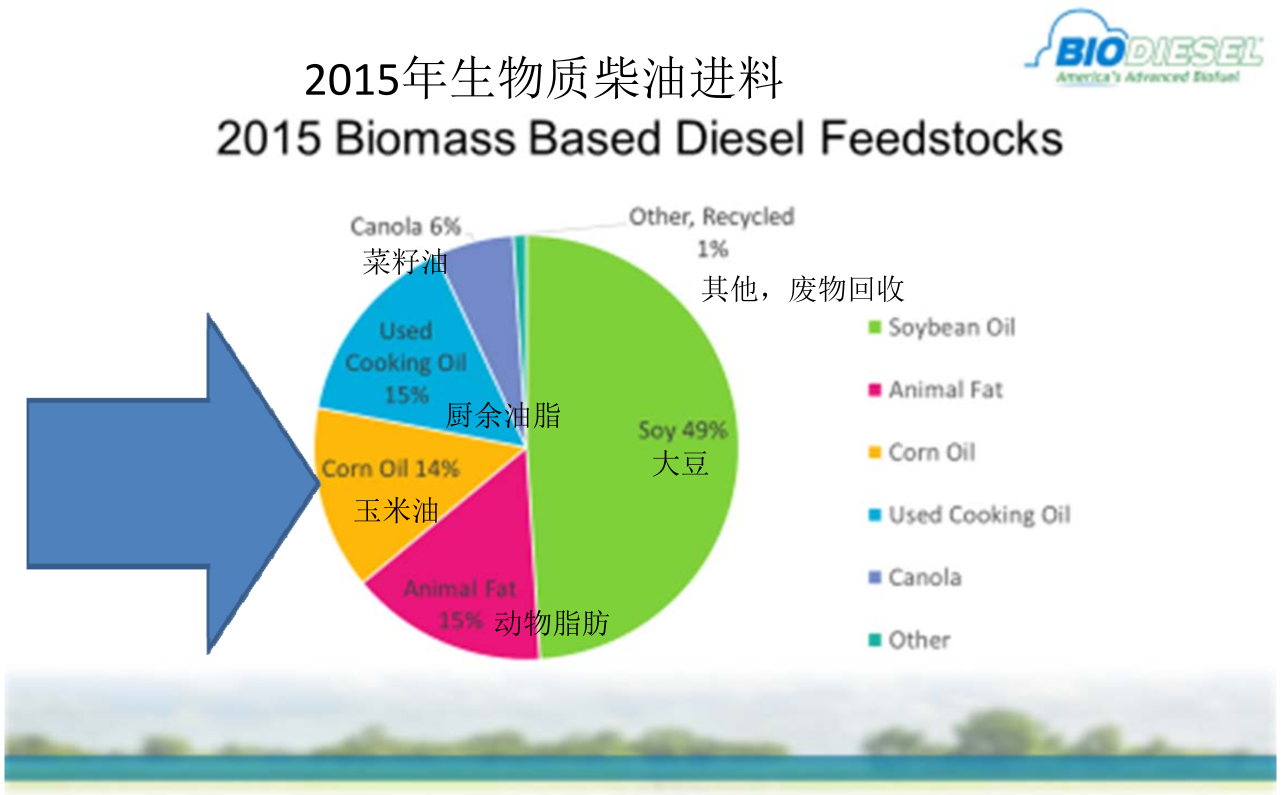
Corn Oil to Biodiesel
玉米油到生物柴油

- Corn oil separated at ethanol plants provides feedstock for biodiesel production
  乙醇厂家对玉米油进行分离，成为生物柴油进料
- Two Uses:
  两种用途：
  - Sale into Animal Feed Markets
    销往动物饲料市场
  - Substitution for petroleum based diesel fuel
    成为石油基柴油的替代物



Enogen伊诺根品种

- Syngenta’s Enogen product has directly incorporated enzymes into its corn traits.
  先正达公司的伊诺根产品直接将酶添加到玉米性状中。
- The technology is now used by 18 plants producing 1.3 billion gallon of corn ethanol (EPM 12/2015).
  此项技术如今在18家厂家应用，生产了13亿加仑玉米乙醇。（EPM 12/2015）。
- According to Syngenta Enogen raises ethanol yield per bushel by up to 3%, reduces electricity use up to 3%, and lowers natural gas use up to 10%.
  根据先正达公司的说法，伊诺根将每蒲式耳玉米的乙醇产量提高了3%，节省了3%的电力，减少天然气使用达10%。
- Example: Western Plains Energy
  实例：西部平原能源公司

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CO_2 Recovery at Ethanol Plants for Food Industry Use and Enhanced Oil Recovery
乙醇生产厂二氧化碳回收用于食品产业和油采收率提升

- About 40 percent of the North American merchant market for CO_2 is sourced from ethanol plants.
  北美商品二氧化碳市场约40%的份额从乙醇生产厂采购。
- Each bushel of corn produces 17 lbs of CO_2 during fermentation
  每蒲式耳玉米在发酵过程中产出17磅二氧化碳。
- Ethanol plants produce CO_2 for both:
  乙醇生产厂出产的二氧化碳用于以下目的：
  - Food/Beverage Industry as well as for
    食品/饮料产业以及
  - Enhanced Oil Recovery
    油采收率提升
- If not recovered as a by-product CO_2 must be produced in conventional CO_2 and Dry Ice Production Plants:
  如果没有作为副产品回收，二氧化碳必需在传统二氧化碳和干冰厂家生产：
  - Fuel source: low Sulphur content diesel, kerosene or natural gas.
    燃料来源：低硫柴油，煤油和天然气。

Conventional CO2 plant fired by fossil fuels
传统二氧化碳工厂用化石燃料作为动力

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Wet DDG and Anaerobic Digesters
湿酒糟和厌氧分解

Wet DDG 湿酒糟

- Nebraska Plants collocated with feed lots
  内布拉斯加工厂和饲养场设在一处
- Skip the drying step of Distillers Dried Grains and ship feed wet to feedlots
  省略了干酒糟的干燥步骤直接将湿酒糟运送到饲养场
- Significant energy savings
  大幅节省了能源

Anaerobic Digesters 厌氧分解

- Anaerobic digestion of syrup, DGS, and manure
  用于糖浆、干酒糟和肥料的厌氧分解
- Digester produces biogas for energy production offsetting onsite energy use
  分解池出产能源产品沼气，抵消了现场能源消耗
- Example: Western Plains Energy LLC in Kansas (also uses Enogen)
  实例：堪萨斯西部平原能源有限公司（也使用伊诺根品种）

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Direct Land Use Change
直接土地利用变更

- Direct land use change to high corn on corn rotations around plants provide annual carbon sequestration
  直接土地利用变更是在工厂周边进行高效玉米连种从而每年进行碳固化
- Derive state-specific carbon sequestration factors based on the GREET CCLUB database
  基于GREET CCLUB数据库提取特定州的碳固化因子
- Soil carbon changes for mixed cropland going into corn on corn rotations under convectional tillage; 100 cm soil depth; CCLUB Version 2015; C-Database Tab Column “CH”)
  在传统耕作方式下混合农田进行玉米连种引起的土壤碳变化；100cm土壤深度；CCLUB2015版；C-数据库“CH”列选项）
- Recommendation: Credit under Japanese Direct Land Use Provisions could be applied if transitions to high corn on corn transitions around the plant are verified
  建议：如工厂周边土地向高效玉米连种农田的转换经过验证，则适用于日本直接土地利用变更条例项下的配额。

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Transport from United States
美国对外运输

Rail Shipment of Ethanol to US Port (1750 miles) followed by Vessel to Korea
乙醇通过铁路运往美国港口（1750英里），然后船运到韩国

Model Inputs and Results
模型输入和结果

Technology Combinations
技术组合

- Base Case: Corn Ethanol Dry Mill 基础案例：玉米乙醇干磨加工
  - Dry DGS production 干酒糟生产
  - Corn oil extracted for biodiesel and biodiesel displaces diesel
    提取玉米油用于生物柴油,生物柴油替代柴油
- Wet DGS with Efficiency Improvements 效率提升的湿酒糟
  - Corn Ethanol Dry Mill with Primary wet DGS production, Located near cattle feeding (Nebraska)
    湿酒糟的主要出产者玉米乙醇干磨厂，位于牛饲养场附近（内布拉斯加州）
  - Corn oil extracted for biodiesel (1 lb/bu corn) and Biodiesel displaces diesel
    用于生物柴油的玉米油（每蒲式耳玉米出产一磅）和生物柴油替代柴油
  - Enogen and efficiency improvements (+3% yield, -10% NG, -3% power)
    伊诺根和效率提升（单产+3%， 天然气-10%， 电力-3%）
- Corn Ethanol Dry Mill with CO_2 collected for dry ice and beverage
  在玉米乙醇干磨厂，收集二氧化碳用于干冰和饮料生产
- Wet DGS with Enhanced Oil Recovery 湿酒糟和油脂回收效率提升
  - Corn Ethanol Dry Mill with Primary wet DGS production 湿酒糟的主要出产者玉米乙醇干磨厂
  - Located near oil production (Kansas) 位于产油厂家附近（堪萨斯）
  - Corn oil extracted for biodiesel and Biodiesel displaces diesel提取玉米油用于生物柴油或生物柴油替代柴油
- Wet DGS with Anaerobic Digestion 湿酒糟和厌氧消化池
  - Corn Ethanol Dry Mill with Primary wet DGS production 玉米乙醇干磨厂
  - Located near cattle feeding (Nebraska) 位于养牛场附近 （内布拉斯加）
  - Corn oil extracted for biodiesel and Biodiesel displaces diesel提取玉米油用于生物柴油或生物柴油替代柴油
  - Anaerobic digestion of syrup, DGS, and manure 使用糖浆、酒糟和肥料的厌氧消化池

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Energy Inputs (SI Units)
能源输入（SI 单位）

Case Name 案例名称		Base Case 基础案例	High Efficiency Case 高效能案例	CO_2 Bottling Case 二氧化碳罐装案例	CO_2 EOR Case 二氧化碳气驱强化采油案例	Digester Case 消化池案例
Scenario 场景		Dry DGS 干酒糟	Wet DGS 湿酒糟	Mixed DGS 混合酒糟	Wet DGS 湿酒糟	Less DGS 酒糟较少
		Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油
			Enogen 伊诺根	CO_2 Bottle 二氧化碳灌装	CO_2 EOR 二氧化碳气驱强化采油	Anaerobic 厌氧
			Membrane薄膜			Digester消化池
Natural Gas 天然气	MJ/L	6.83	4.55	5.85	4.55	0.84
Electric Power 电力	kWh/L	0.20	0.15	0.36	0.53	0.26
DGS 酒糟	kg/L	0.65	0.58	0.60	0.60	0.30
Corn Oil BD 玉米油生物柴油	kg/L	0.34	0.36	0.34	0.34	0.34
CO_2 二氧化碳	kg/L	0	0	-0.61	-0.61	0
Yield 单产	L/kg	0.029	0.031	0.029	0.029	0.029

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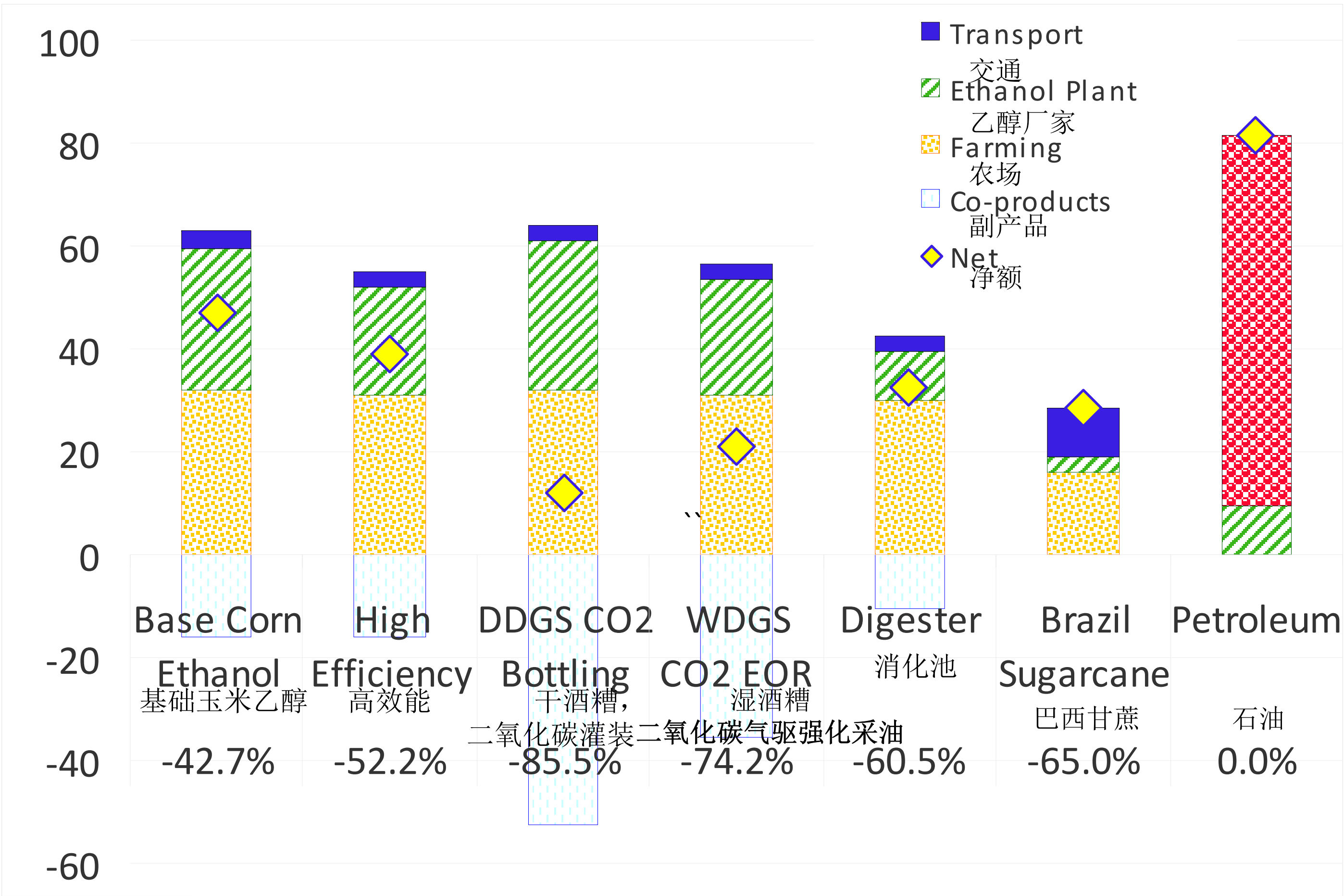
81.7 g/MJ Petroleum Basecase
Without Land Use Credit
81.7 g/MJ石油基础案例
无土地利用配额



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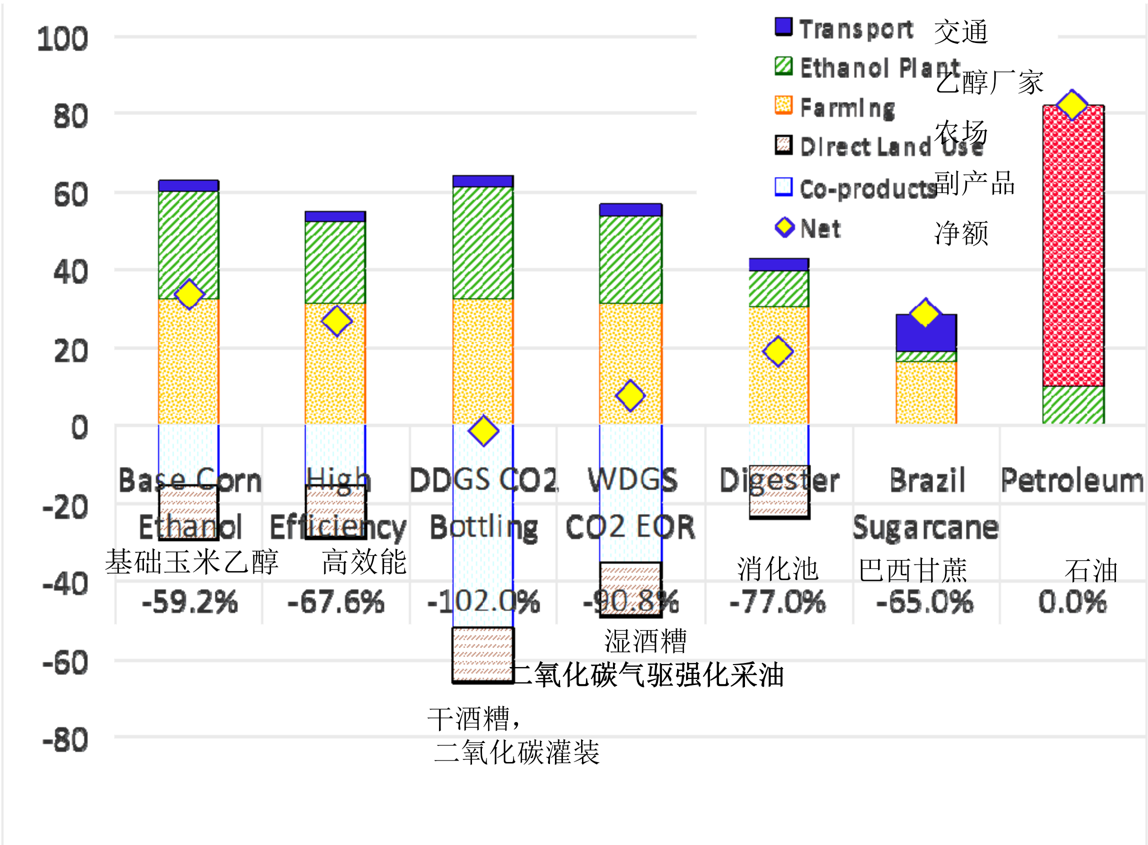
81.7 g/MJ Petroleum Basecase
With Land Use Credit
81.7 g/MJ石油基础案例
有土地利用配额



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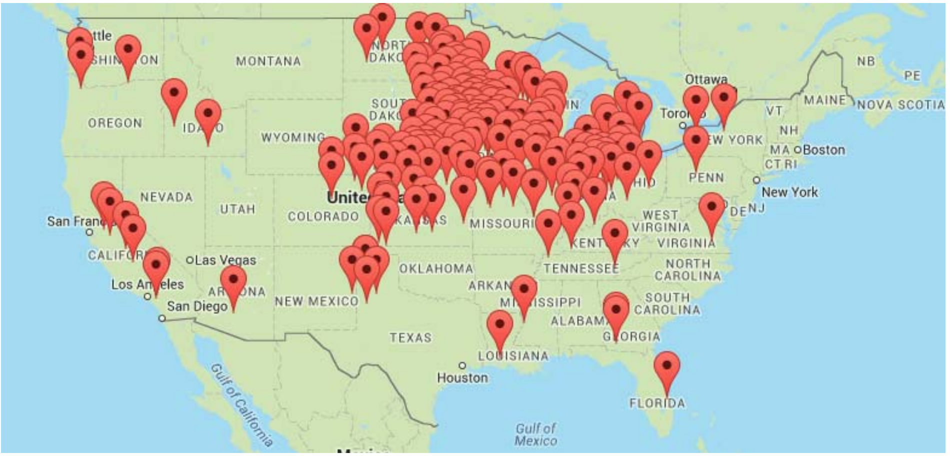
Total Ethanol Volume that Meets Japanese Criteria
符合日本标准的乙醇总量

Ethanol Production in the US
美国乙醇产量



Renewable Fuels Association: Ethanol Biorefinery Locations
可再生能源协会；乙醇生物炼厂分布
http://www.ethanolrfa.org/resources/biorefinery-locations/

Simple Average of Plant Capacity: 74 million gallons per year
*Excludes multiple feedstock plants
工厂产能的简单平均数：每年7400万加仑
*不包括使用多种原料的工厂

State	产量总额 Sum of PRODUCTION (MGY)	工厂数量 Number of Plants
IA	3937	42
NE	2081	26
MN	1169	21
IL	1597	15
SD	1032	15
IN	1163	14
KS	447	11
WI	537	9
OH	528	7
MO	256	6
MI	273	5
ND	465	5
CA	215	4
TX	390	4
CO	122	3
NY	169	2
OR	40	2
TN	225	2
AZ	50	1
GA	120	1
ID	60	1
KY	33	1
MS	54	1
NC	0	1
NM	0	1
PA	110	1
VA	0	1
WY	10	1
Grand Total 共计	15083	203

Renewable Fuels Association Data (reanalyzed)

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Volume that Meets Japanese GHG Reduction Criteria
符合日本温室气体减排标准的总量

			Plants Meeting 50% GHG Reduction With Direct Land Use Credit 符合５０%温室气体减排并具有直接土地利用配额的工厂	Plants Meeting 50% GHG Reduction Without Direct Land Use Credit 符合５０%温室气体减排并不具有直接土地利用配额的工厂
Base Plant: Dry DGS 基本工厂：干酒糟	Corn Oil to Biodiesel 玉米油到生物柴油		30	0
湿酒糟 Wet DGS	Corn Oil to Biodiesel 玉米油到生物柴油	Enogen / Efficiency Improvements 伊诺根 / 效益提升	10	10
混合酒糟 Mixed DGS	Corn Oil to Biodiesel 玉米油到生物柴油	二氧化碳食品市场 CO_2 Food Markets	35	35
湿酒糟 Wet DGS	Corn Oil to Biodiesel 玉米油到生物柴油	二氧化碳气驱强化采油 CO_2 EOR	5	5
酒糟较少 Less DGS	Corn Oil to Biodiesel 玉米油到生物柴油	Anaerobic Digester 厌氧消化池	2	2
		Total # of Plants 工厂总数	**82**	**52**
		Volume (gallons) 产量（加仑）	**6,068,000,000**	**3,848,000,000**

=22.8 Billion Liters

= 14.4 Billion Liters

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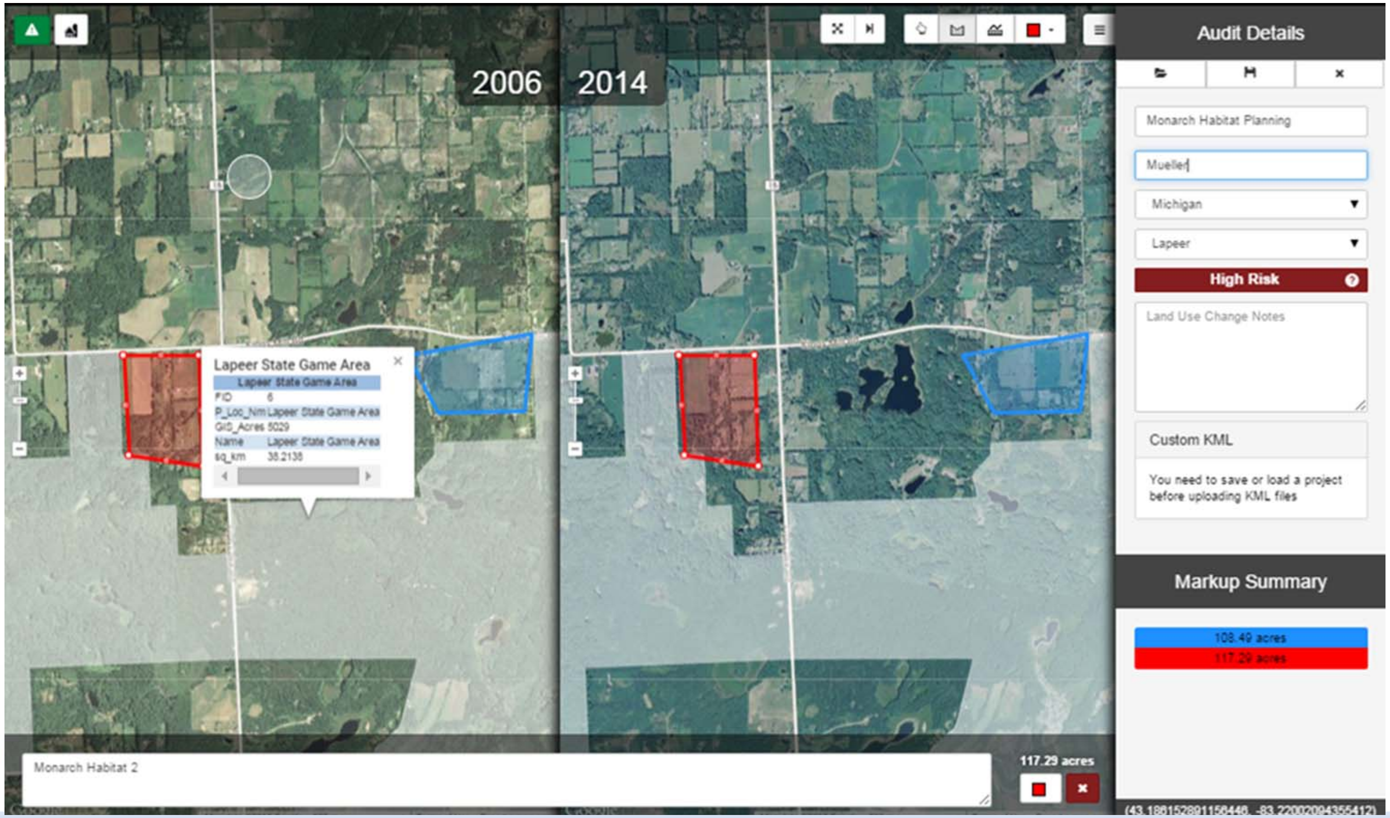
Sustainability
可持续性

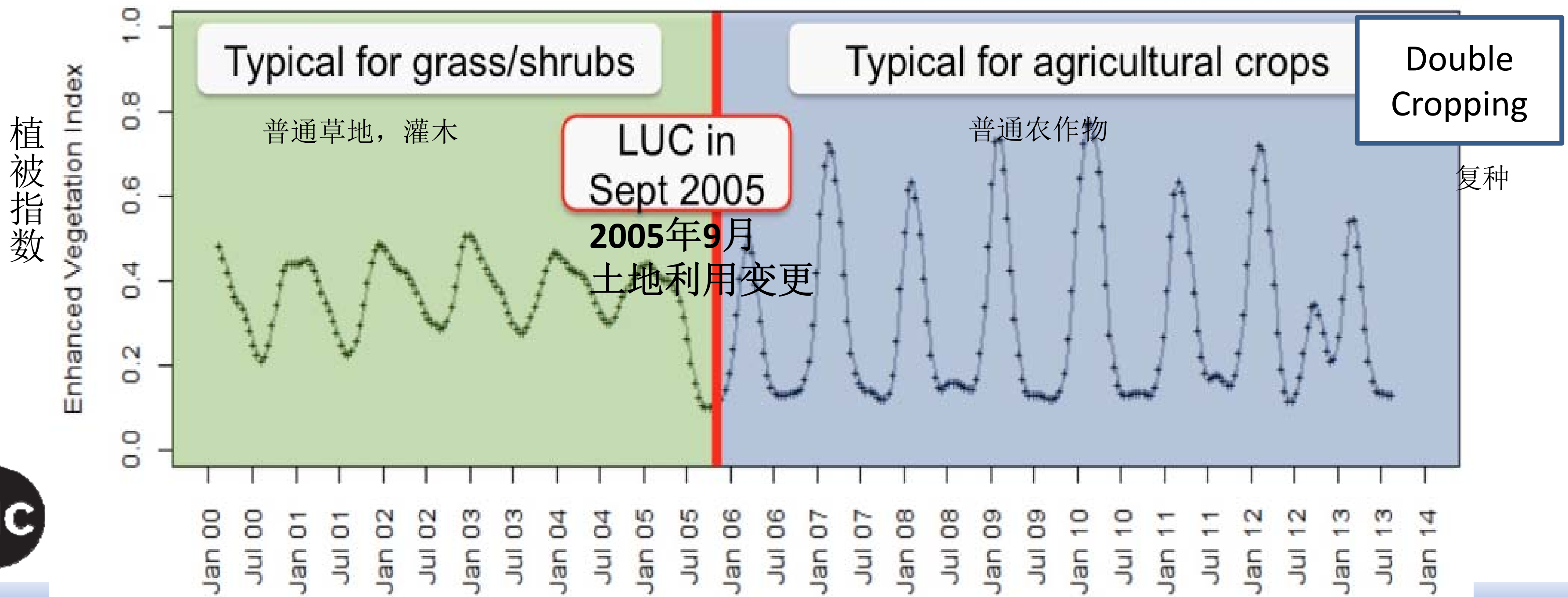
New Software for Sustainability Assessment:
Global Risk Assessment Services Tool (GRAS) for United States Domestic LUC Analysis
可持续性评估的新软件：
用于美国国内土地利用变更的全球风险评估服务工具(GRAS)

- Feedstocks are not grown on deforested lands; Verify use of large, mature crop areas
  原料并非采自滥砍滥伐地区，确认利用大面积的成熟的农耕土地
- Applicable for US corn/soy feedstocks　适用于美国玉米 / 大豆原料
- Use of NAIP Imagery (1-2 m resolution)　利用NAIP图像（1-2 m分辨率）
- Side by side viewer of pre 2008 and current image for direct comparison
  2008年之前和当前图像逐张对比
- Overlay protected areas, carbon masks, LUC risk masks
  覆盖了保护地区，碳掩护和土地利用变更风险掩护地区。



New Software: GRAS Tool for Global Land Use Analysis – Ensure Biofuels Feedstocks Do not come from Deforested Lands
新软件：全球土地利用分析GRAS工具-确保生物燃料原料来自非乱砍乱伐地区

- Particularly applicable for South American Feedstocks (sugarcane, corn soy) and S/E Asia (Palm, etc.)
  尤其适用于南美原料（甘蔗，玉米，大豆）和东南亚（棕榈树等）
- Use of MODIS Enhanced Vegetation Index (300 Images) going back to 2000.
  利用MODIS植被指数（300张图片），回溯到2000年。
- Differentiate among the types of green cover, see the history of the land, assess double cropping and detect LUC.
  区分出植被的各种类型，了解土地历史，评估复种，发现土地利用变更。
- Grassland has EVI value of 0.3-0.4. The same would apply for perennial trees such as rain forests but on a higher EVI value of about 0.6. Conversion would appear as a clear change in those with a drop of EVI to a value below 0.2.
  草地的植被指数值为0.3-0.4。同样适用于多年生树木如雨林，但植被指数值较高，约为0.6。如数值变化较明显，植被指数降至0.2以下，将会显示为转换。



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Combustion Emissions

燃烧排放

University of Illinois Chicago utilizes US Environmental Protection Agency MOVES Model

- EPA's MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics. 环保署的机动车排放模拟系统（MOVES）是极为先进的模型系统，用于估算国家、县、和具体项目的指标空气污染物、温室气体和有毒物质的排放水平。
- MOVEs is used for State Implementation Plan (SIP) development and transportation conformity analyses – Meaning the model is used to document, for example, how states who do not meet air quality standards can come back into compliance.

  MOVES用于制定国家执行计划（SIP）和交通合规分析 — 模型用于记录，比如，某一空气质量未达标的州如何达标。
- MOVES takes into account parameters like regional fuel formulation, vehicle types and ages, market shares, etc.
- MOVES使用如地区燃料构成、机动车类别和新旧程度，以及市场份额等综合参数。

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Particulate Matter Emissions Reductions with Ethanol

- Generally speaking, high blending (E85) and pure ethanol (E100) are almost always found to produce less PM emissions than E0 fuels

  高配比汽油（E85）和纯乙醇产生的颗粒物排放量低于E0无调配燃料。
- Many studies have reported reduced PM emissions with increasing ethanol blends [15, 16, 17, 18, 19]. This may be explained by ethanol's double bond equivalent (DBE) value of zero [18], relatively high vapor pressure and low boiling point (78 0C) [20], and ethanol's oxygenates [21].
- Citations: 许多研究显示乙醇配比越高，PM排放量就越少（15、16、17、18、19）。原因可能是：乙醇的双键当量值（DBE）为零（18）；蒸发压力相对高；沸点相对低（78°C）（20）以及乙醇的增氧性（21）。

援引文献如下：

15.Storey, J., Barone, T., Thomas, J., and Huff: S., 2012, Exhaust Particle Characterization for Lean and Stoichiometric Dl Vehicles Operating on Ethanol-Gasoline Blends, SAE Technical Paper 2012-01-0437,doi: 10.4271/2012-01-0437

16.Marrion, C.D., Wiles, M.A., Gwidt, J.M., and Parrish, S.E., 2009. Development of a Naturally Aspirated Spark Ignition Direct-Injection Flex-Fuel Engine. SAE Int. J. Engines 1(1):267-295.

17.Maricq, M.M., Szente, J.J., and Jahr. K., 2012. The Impact of Ethanol Fuel Blends on PM Emissions from a Light-Duty GDI Vehicle. Aerosol Science and Technology 46(5):576-583.

18.Aikawa, K., Sakurai, T., and Jetter, J., 2010. Development of a Predictive Model for Gasoline Vehicle Particulate Matter Emissions. SAE International Journal of Fuels and Lubricants 3(2): 610-622.

19.Storey, J., Barone. T., Norman, K., and Lewis, S., 2010. Ethanol Blend Effects On Direct Injection Spark-Ignition Gasoline Vehicle Particulate Matter Emissions. SAE Int. J. Fuels Lubr. 3(2):650-659.

20.ASTM International, 2010. ASTM D4814-10b, Standard Specification for Automotive Spark-Ignition Engine Fuel. West Conshohocken, PA.

21.Wu, J., Song, K.H., Litzinger, T., Lee, S.Y. et al., 2006. Reduction of PAH and Soot in Premixed Ethylene-Air Flames by Addition of Ethanol. Combustion and Flame 144(4): 675-687

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Knock Resistance and Octane

- Increased ethanol content can provide substantial increase in knock resistance due to ethanol's high Research Octane Number由于其较的高研究法辛烷值，乙醇成分的增加可以提高燃料的抗爆性。
  - Enables improved fuel efficiency through downsizing and increased compression ratios通过缩小并提高压缩率实现燃料效率的改善
- PM emissions and toxic compounds are also decreasing with higher ethanol contents.乙醇成分的增加可以降低颗粒物和有毒化合物的排放
- Some emissions behavior needs further research某些排放行为仍需进一步研究。

Citations援引: Stein, R.A., Anderson, J.E., Wallington, T.J., 2013. An Overview of the Effects of Ethanol-Gasoline Blends on SI Engine Performance, Fuel Efficiency, and Emissions. SAE International Journal of Engines 6(1): 470-487.

Summary小结

- Significant volumes of US produced corn ethanol can meet diverse international sustainability standards
  美国出产的玉米乙醇中很可观的一部分能够达到各种国际可持续发展标准。
- However, detailed pathway analysis is required and thorough understanding of international sustainability modeling approaches
  然而，仍需详尽的路径分析和更深入理解国际可持续发展模型方法
- New remote sensing tools are now available to verify and confirm land use and agricultural production practices
  现在已有可用的新的远程监测工具，用以验证和确认土地利用和农业生产实践。
- Ethanol not only reduces greenhouse gas emissions but also combustion emissions
  乙醇不仅可以减少温室气体排放也可以减少废气排放

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Appendix 附件
Modeling Inputs in SI Units
SI单元的模型输入

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Energy Inputs (in US Units)
能源输入（美国单位）

Case Name 案例名称		Base Case 基础案例	High Efficiency Case 高效能案例	CO_2 Bottling Case 二氧化碳灌装案例	CO_2 EOR Case 二氧化碳驱强化采油案例	Digester Case 消化池案例
Scenario场景		Dry DGS 干酒糟	Wet DGS 湿酒糟	Mixed DGS 混合酒糟	Wet DGS 湿酒糟	Less DGS 酒糟较少
		Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油	Corn Oil BD 玉米油生物柴油
			Enogen 伊诺根	CO_2 Bottle 二氧化碳灌装	CO_2 EOR 二氧化碳气驱强化采油	Anaerobic 厌氧
			Membrane 薄膜			Digester 消化池
Natural Gas 天然气	Btu/gal	24,500	16,328	21,000	16,328	3,000
Electric Power 电力	kWh/gal	0.742	0.6	1.35	2	1
DGS 酒糟	lb/gal	4.98	4.76	4.98	4.98	2.49
Corn Oil BD 玉米油生物柴油	lb/bu	1.0	1.0	1.0	1.0	1.0
CO_2 二氧化碳	kg/gal	0	0	-2.3	-2.3	0
Yield 单产		2.8	3	2.8	2.8	2.8

Appendix B: 附件B：
Selected Team Publications
部分团队出版物

University of Illinois at Chicago Selected publications
芝加哥的伊利诺伊大学部分出版物

- Qin, Z., Dunn, J. B., Kwon, H., Mueller, S. and Wander, M. M. (2016), Influence of spatially-dependent, modeled soil carbon emission factors on life-cycle greenhouse gas emissions of corn and cellulosic ethanol. GCB Bioenergy. Accepted Author Manuscript. doi:10.1111/gcbb.12333
- Qin, Z., Dunn, J. B., Kwon, H., Mueller, S. and Wander, M. M. (2015), Soil carbon sequestration and land use change associated with biofuel production: empirical evidence. GCB Bioenergy. doi: 10.1111/gcbb.12237
- Elliott, J., Sharma, B., Best N., Glotter., M., Dunn, J., Foster, I., Miguez, F., Mueller, S., Wang, M., A Spatial Modeling Framework to Evaluate Domestic Biofuel-Induced Potential Land Use Changes and Emissions, Environ. Sci. Technol., 2014, 48 (4), pp 2488–2496 DOI: 10.1021/es404546r
- J. B. Dunn, S. Mueller, H. Kwon Land-use change and greenhouse gas emissions from corn and cellulosic, M. Wander, M. Wang. Carbon Calculator for Land Use Change from Biofuels Production (CCLUB) Manual, ANL/ESD/12-5, Rev. 2, May 2014.
- Ho-Young Kwon, Steffen Mueller, Jennifer B. Dunn, Michelle M. Wander; Modeling state-level soil carbon emission factors under various scenarios for direct land use change associated with United States biofuel feedstock production; Biomass and Bioenergy (2013), http://dx.doi.org/10.1016/j.biombioe.2013.02.021
- Jennifer B Dunn, Steffen Mueller, Ho-young Kwon and Michael Q Wang; Land-use change and greenhouse gas emissions from corn and cellulosic ethanol; Biotechnology for Biofuels 2013, 6:51 doi:10.1186/1754-6834-6-51; Published: 10 April 2013
- Dunn, Jennifer and Steffen Mueller, Michael Wang, Jeongwoo Han. Energy consumption and greenhouse gas emissions from enzyme and yeast manufacture for corn and cellulosic ethanol production; Biotechnol Lett DOI 10.1007/s10529-012-1057-6, October 2012.
- Mueller, S. 2008 National dry mill corn ethanol survey; Biotechnol Lett DOI 10.1007/s10529-010-0296-7, May 15, 2010.
- Mueller, S. Research investigation for the potential use of combined heat and power at natural gas and coal fired ethanol plants; US Department of Energy; 2006.

Life Cycle Associates: Selected Publications
全周期伙伴：部分出版物

Forman, G.S. and S. Unnasch (2015) Integration of Non-Fuel Coproducts into the GREET Model. Environ. Sci. Technol. DOI: 10.1021/es505994w.

Unnasch, S., T. Darlington, J. Dumortier, W. Tyner, J. Pont and A. Broch (2014) CRC Report No. E-88-3. Study of Transportation Fuel Life Cycle Analysis: Review of Economic Models Used to Assess Land Use Effects. Prepared for Coordinating Research Council Project E-88-3.

Boland, S. and S. Unnasch (2014) Carbon Intensity of Marginal Petroleum and Corn Ethanol Fuels. Life Cycle Associates Report LCA.6075.83.2014, prepared for Renewable Fuels Association.

Unnasch, S. et al. (2013) Review of Fuel Programs, Sustainability

Keesom, W. H., J. Blieszner, and S. Unnasch (2012) EU Pathway Study: Life Cycle Assessment of Crude Oils in a European Context. Prepared by Jacobs Engineering and Life Cycle Associates for Alberta Petroleum Marketing Commission (APMC).

Unnasch, S. et al. (2011) CRC Report No. E-88. Review of Transportation Fuel Life Cycle Analysis. Prepared for Coordinating Research Council Project E-88.

McCormick, J. and S. Unnasch (2011) Inventory of Fugitive Emissions from LPG Transfers in California. Life Cycle Associates Report LCA.8026.42S.2011, prepared for Western Propane Gas Association.

Brandt, A.R. and S. Unnasch (2010) Energy Intensity and Greenhouse Gas Emissions from Thermal Enhanced Oil Recovery. Energy Fuels, 2010, 24(8), pp 4581–4589.

Unnasch, S. et al. (2009) Assessment of Life Cycle GHG Emissions Associated with Petroleum Fuels. Life Cycle Associates Report LCA-6004-3P, prepared for New Fuels Alliance.

Unnasch, S. (1990) Greenhouse Gas Emissions from Corn-Based Ethanol Production and Vehicle Use. Prepared for National Corn Growers Association.

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