

The Role of LCA in Characterizing Sustainability

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Outline

- Why sustainability requirement may be needed?
- Whether LCA is an appropriate tool for quantifying a broad range of sustainability issues?
- Example: Land use change
- Example: LCA water use
- Conclusions

Basic Principles of Sustainability

- Energy feedstock should be produced in a sustainable manner that will promote the long-term welfare the environment, human society, and economic growth;
 1. Achieve sustainable GHG reductions
 2. Avoid large-scale environmental degradation
 3. Do not threaten food supply and food price stability
 4. Lead to continuous technology innovation that improves energy efficiency, reduces energy use, and minimizes environmental footprint.

Key Design Elements of Sustainability Criteria

- Sustainability standard must be robust to future uncertainties such as unexpected research findings of adverse environmental outcome.
- To the extent possible, embed the sustainability criteria in the lifecycle analysis of GHG emissions, including land use changes, land management practices, forest management standard, etc.
 - In many instances GHG emissions and ecological impacts are highly correlated
 - “This will go a long way to address sustainability issues” (Farrell, 08)
- Work with international regulating parties to encourage broad and consistent enforceable rules are (or in the process of being) adopted.
- Treat all bio-based products equally. This can avoid creating incentives for practices such as leakage and shuffling.
- All products, not just bio-based ones, deserve equal treatment.

Why Current Laws and Regulations are Insufficient in Addressing Sustainability Issues?

- Wide range of current laws and regulations already address:
 - Air quality
 - Water quality
 - Multi-media exposure
 - Forest management
 - Local environment impacts
- However, these policies are inadequate in the following sense:
 - Not designed to reduce GHG impacts
 - Inadequate to address indirect, market-mediated effects at macro levels
 - Inadequate to address some issues only associated with large-scale implementation

Currently Proposed Solutions to Address Sustainability Issues associated with LCFS and Renewable Transportation Fuels

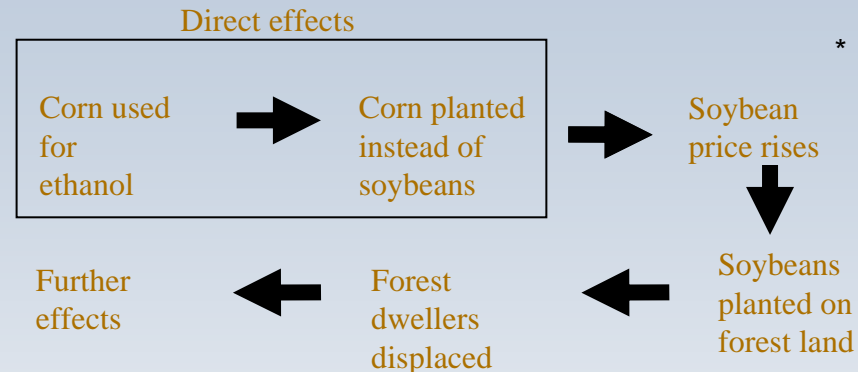
- Mandate
 - e.g. CA SB 210
- Reporting requirement and certification
 - UK RTFO, German Sustainability Decree, EU Biofuels sustainability certification
- Performance-based standard
 - CA: Incorporate direct and indirect land use change GHG values into LCA default values
 - Provide flexibility for the implementation
 - Robust to future uncertainties

Small vs. Large scale?

- Issue: a single farm is in compliance with regulations and meets sustainability criteria, but what about the aggregate effect of 100 farms in the same area?
- Possible Solution:
 - Reporting and careful monitoring will help track the problem over time and provide data needed to analyze policy options to reduce impacts.
 - Identifying opportunities and providing incentives for improvements in best practices and technologies
 - Sector specific sustainability certification/management, each addresses sector-specific environmental, ecological, and social impacts:
 - Forestry
 - Fisheries
 - Agriculture
 - Mining activities

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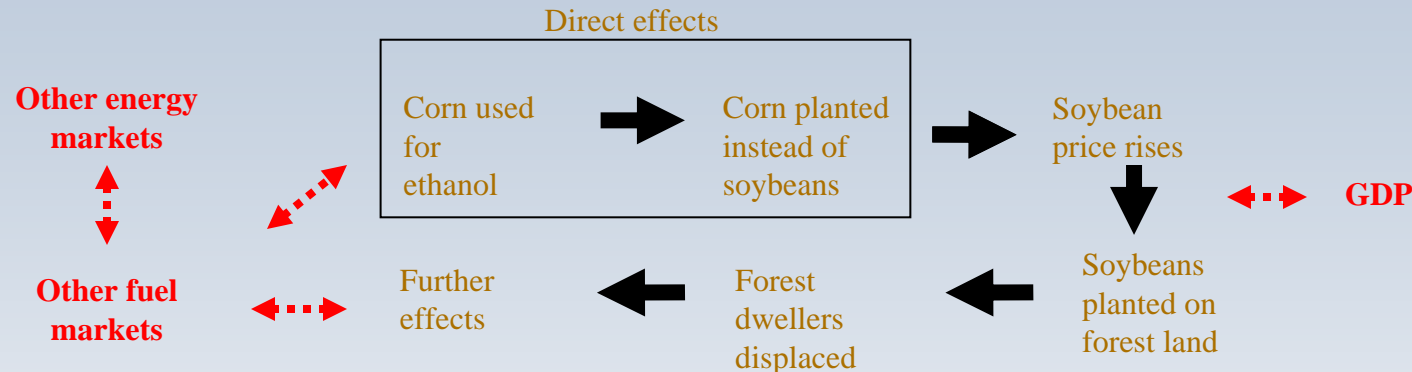
- Current LCA only includes direct effects



- Combining methods for estimating direct and indirect (along the feedstock supply chain and induced market-mediated effects) GHG impacts will make for a complete “life cycle” inventory analysis *
- Is LCA the right tool to integrate sustainability impacts such as ecological and socio-economic impacts?
- Examples:
 - Direct land use change
 - Water impacts

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How to Deal with Direct Land Use within LCA

- A broad definition of “land use” may include impacts to ecosystems as well as to marine ecosystems
- Main types of impact related to changes in land use:
 - Land area disturbed per unit of activity or energy (m^2/MJ or $\text{m}^2/\text{MJ}/\text{yr}$),
 - GHG emissions ($\text{gCO}_2\text{e}/\text{MJ}$ or $\text{gCO}_2\text{e}/\text{MJ}/\text{yr}$),
 - Fertilizer use and water quality,
 - Biodiversity,
 - Biotic production, and
 - Ecological soil quality.
- Under this framework, a broad range of activities (including the extraction of fossil fuels and production of bioenergy) can have LU impacts

Direct Land Use Impact Assessment

Activities

- terracing of croplands, removal of terraces
- restoration of eroded fields
- changes in the groundwater table (in contrast to water extraction)
- ploughing, removal of weed vegetation
- conservation of patches of wild vegetation
- others



Midpoint impacts

- surface area needed for crops
- changes in organic carbon content of soil
- release of greenhouse gases from the soil to the air due to changes in groundwater table
- carbon sequestration
- release nutrients and acidifying substances from the soil to the groundwater
- salinization due to irrigation in combination of evaporation of soil water
- others



Life support impacts

- soil erosion
- soil fertility loss
- disturbance of nutrients cycling
- disturbance of hydrology
- others

Damage impacts

- habitat loss
- impacts on biodiversity (existence value)
- impacts on biodiversity (production value)
- others

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GHG calculations provide a framework for consistent comparison and are somewhat correlated with LUC impacts

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Problematic to measure due to:

- **no flow character with clear input or output characteristics**
- **local focus or a discrete time behavior**
- **need more case studies**

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GHG calculations

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Sustainability Issue: Direct Land Use Impact Assessment

GHG calculations
gCO₂e/MJ/yr

- Activities** **Coal, natural gas, oil extraction, oil shale, oil sand, biofuel...**
- terracing of croplands, removal of terraces
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Total land area disturbed
(m²/MJ or m²/MJ/yr)

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Qualitative characterization

Collect and report quantitative data

Regional specific

Environmental impact assessment

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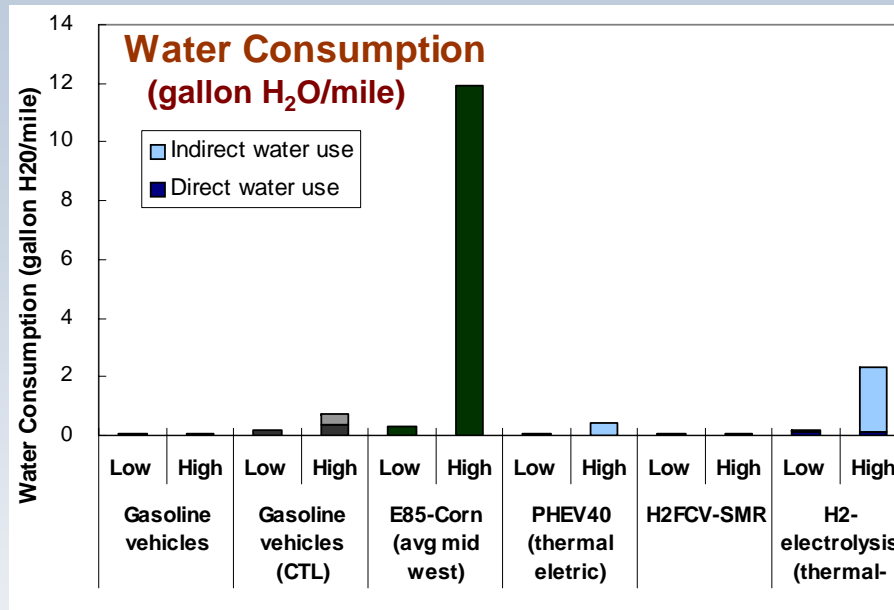
Environmental Impact Analysis vs. LCA

- LCA
 - Needs flow character with clear input or output characteristics
 - Aggregating similar impacts across the product chain
- EIA is better suited to address site specific and time dependent impacts that are hard to be generalized or extrapolated to the entire fuel pathway.
- Sector-specific sustainability certification/management will be better to address problems appear only at one predictable point in the product chain
- How to characterize tradeoffs of different impacts?
 - Multi-objective decision-making analysis
 - Delucchi: social cost-benefit analysis, as a way of “weighing” all the risks associated with a fuel life cycle.

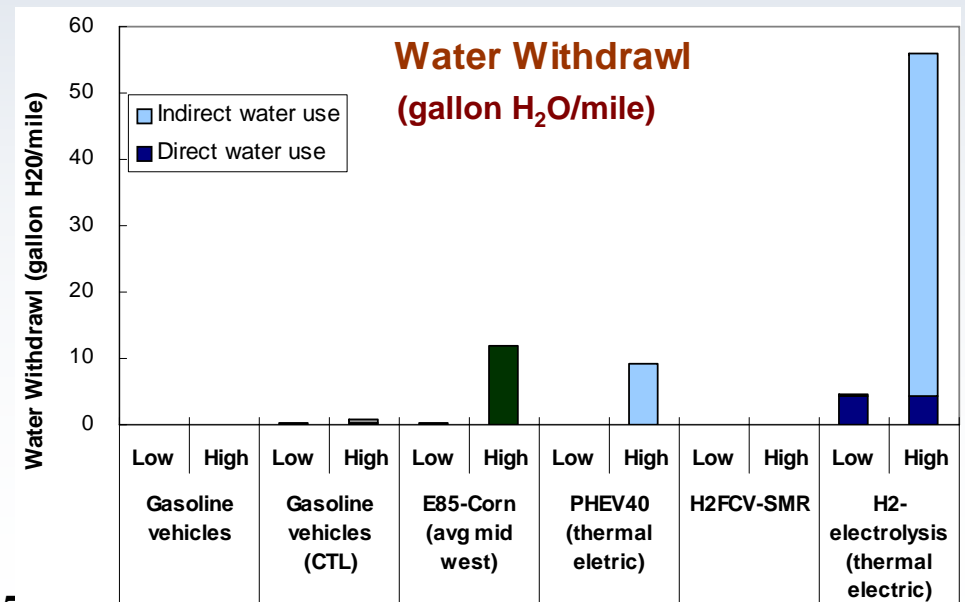
Example: LCA Based Water Use

- LCA-based water use
 - Direct (fuel level): process, refining, steam reforming, syngas production process
 - Indirect (include feedstock and others): bio-feedstock, electricity (feedstock, production, water transport, water treatment, water heating, waste water treatment and disposal) , EOR, oil extraction
 - Systematically compare all transportation fuels
- Water footprint of fuel pathways: using detailed statistics and technical analysis combined with GIS techniques, superimposing the results with the water shortage map to identify regions of concern
- There is no common language in what constitute water use:
 - Different types of water use: fresh water, saline water, ground water, recycled water, reclaimed water. And they have different impact concerns
 - Consumption vs. withdrawals

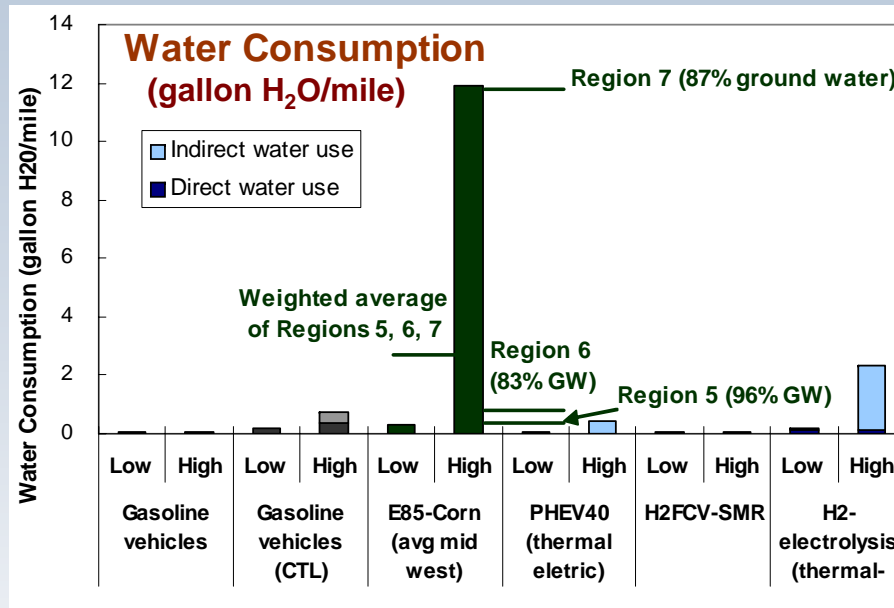
Illustrative Results of Transportation Fuel Water Use



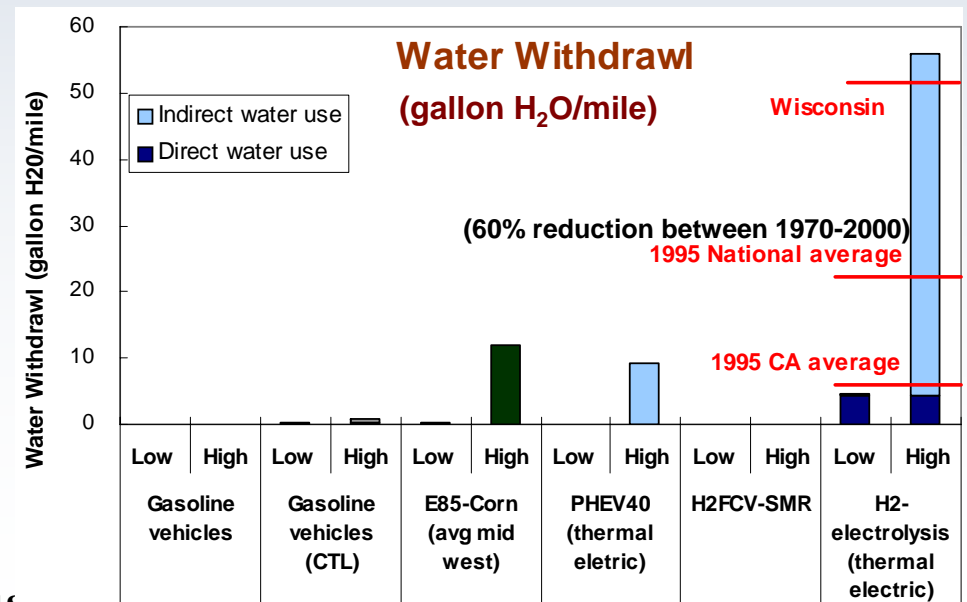
The estimates are crude estimates and not a true lifecycle-based analysis yet, but they are first order correct



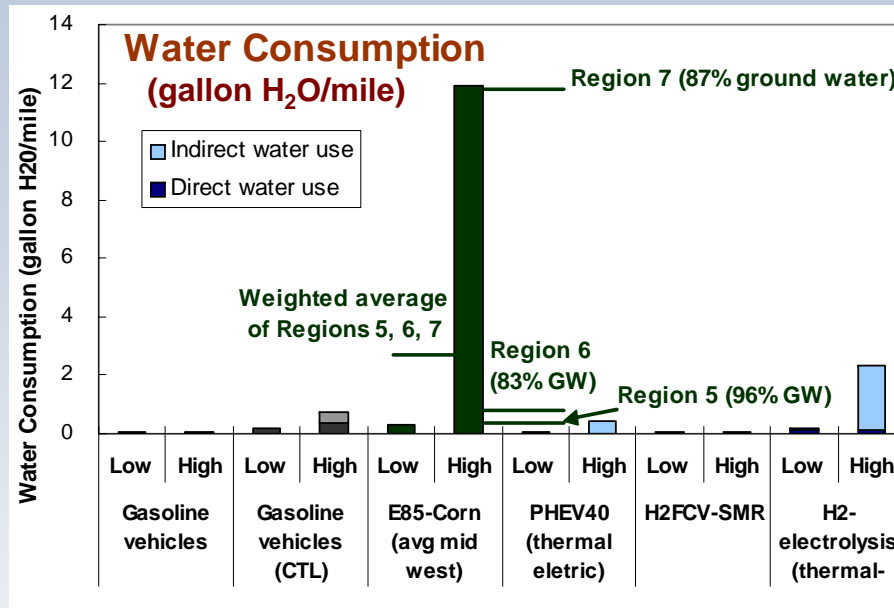
Illustrative Results of Transportation Fuel Water Use



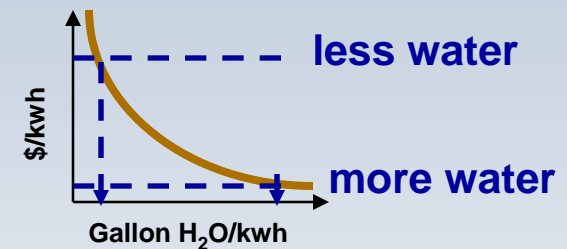
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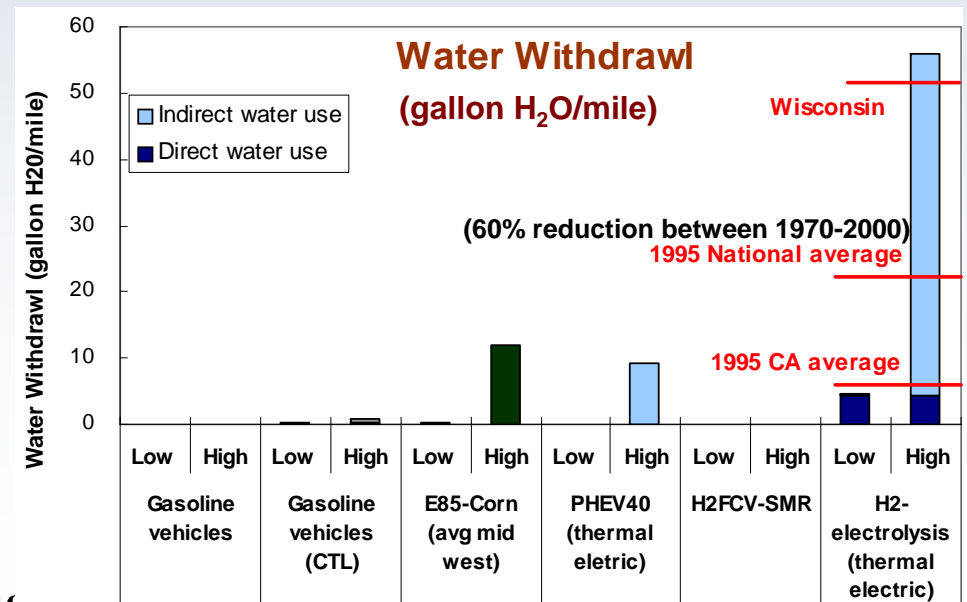
Illustrative Results of Transportation Fuel Water Use



Cost (and efficiency) tradeoffs of technology options to reduce water use



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Focus of Water Impacts of Transportation Fuel

- LCA-based water use
- Regional differences in water consumption
 - Each region has unique technology adaptations with regards to water consumption
 - Water costs
 - Embedded energy in water use
- The roles of technologies in determining water consumption
 - Best practices and technology options to reduce water consumptions/impacts
- Impacts on water quality
 - Water pollution
 - Water runoff and discharge
 - nutrients and acidifying substances from the soil to the groundwater
 - Eutrophication and acidification
 - Toxicity
 - Water impacts associated with excavation, extraction, processing, transportation, and use of fossil resources (e.g. oil spills)
 - Groundwater extraction
 - Salinization of soil

Conclusions

- Sustainability
 - Establishing sustainability reporting criteria is increasingly being adopted in many biofuel importing/exporting countries;
 - Greatly facilitate information gathering and data collection
 - Establishing sustainability standard on a farm-by-farm level is a step toward the right direction to deal with direct impacts;
 - Consistency in Implementation and enforcement of sustainability standards may a concern;
 - More work and policies will be needed to address the impacts caused by large scale implementation and indirect effects at macro levels.
 - LCA may provide a tool that helps to establish consistent robust performance-based sustainability standard.
 - However, more critical analyses are needed to examine the efficacy of using LCA to integrate sustainability issues
 - LCA can't do it all and other strategies will all be needed