EXPLORING THE VARIABILITY OF BIOFUELS WATER INTENSITY

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Joint International Workshop: Spotlight on Bioenergy and Water

July 5th – 6th, 2010, Paris

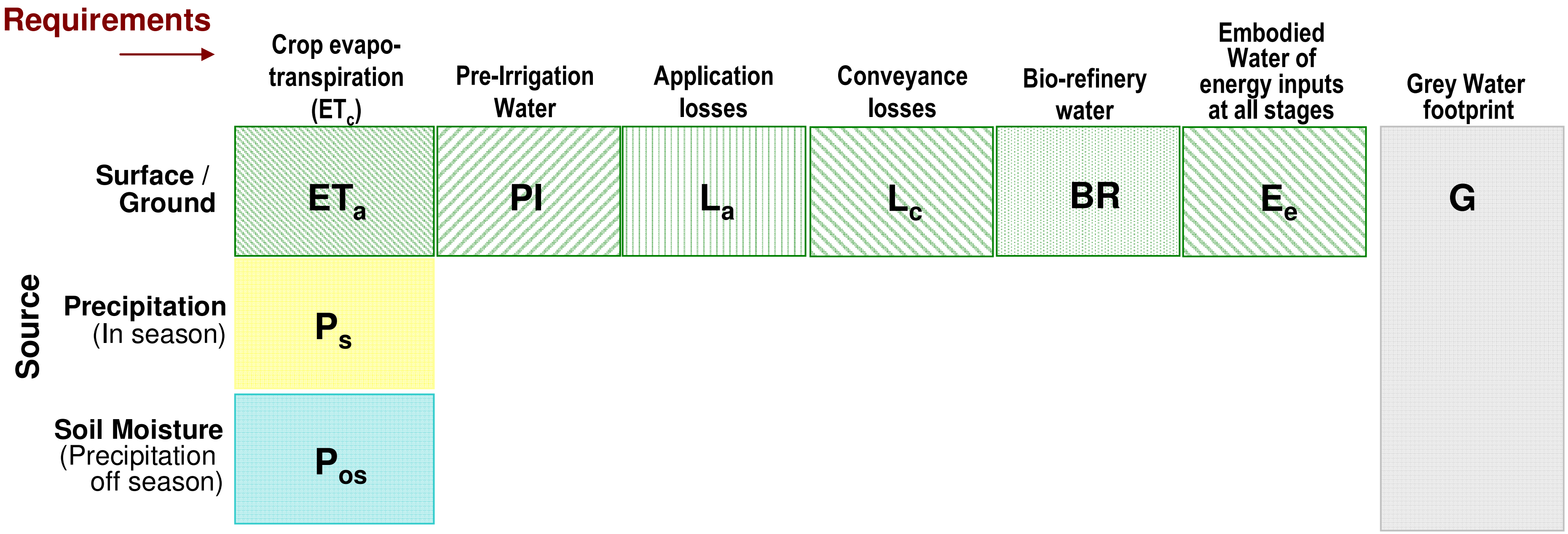
Variability in water use intensity

- Case Study of lifecycle water use: lifecycle water use intensity of ethanol from corn and corn cob (cellulosic agricultural wastes) in the US
  - surface/ground (non-precipitation) water constitute 16 - 117% of lifecycle water need, of which 31-87% is from ground water
  - the total non-evapotranspiration water use range from 5 - 44% of the lifecycle
  - water displaced by co-products ranges from 1.25 - 2.6 times the water credited to ethanol
- A comprehensive accounting of water use/intensity is the first step toward good estimates of water impacts and management.

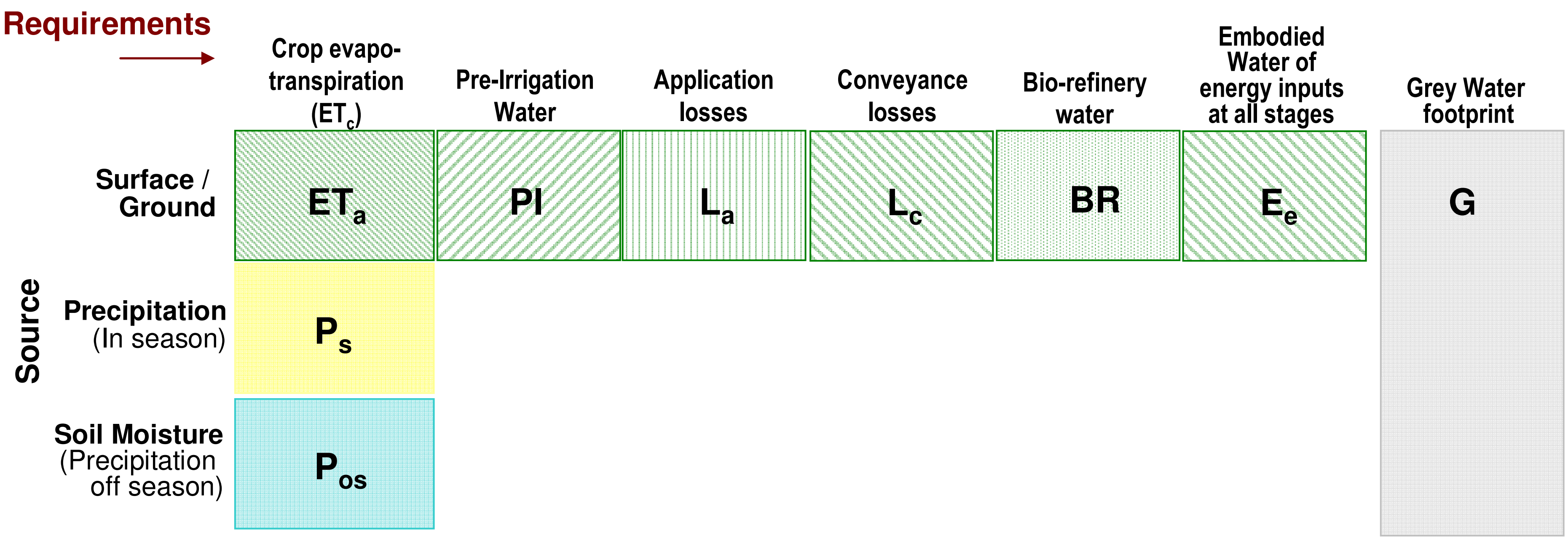
Variability in water use intensity

- Highlight the variability in
  - "*system boundary"* (what is being measured)
  - "*estimation*" of water use
  - "*actual*" water use by crops
  - procedure for co-product allocation
  - economic values of water resource and the role of technological change

Defining system boundaries on an LCA basis



Defining system boundaries on an LCA basis



Reported water use differs by orders of magnitude, due to…
differences in estimates due to system boundary – water requirements considered (or not considered)

	Ps	Pos	ETc	SL	La	Lc	BR	Ee	G	Storage Losses	Allocation Basis(a)
Wu et al	-	-	Yes	Yes	Yes, but..	-	Yes	-	-	-	No allocation
Chiu et al	-	-	Yes	Yes	-	-	Yes	-	-	-	As above
Gerbens-Leenes	Yes	Yes, but..	Yes	-	-	-	Yes	-	-	-	As above
Mubaoko & Lant	Yes	Yes, but..	Yes	-	Yes	-	Yes	-	-	-	As above

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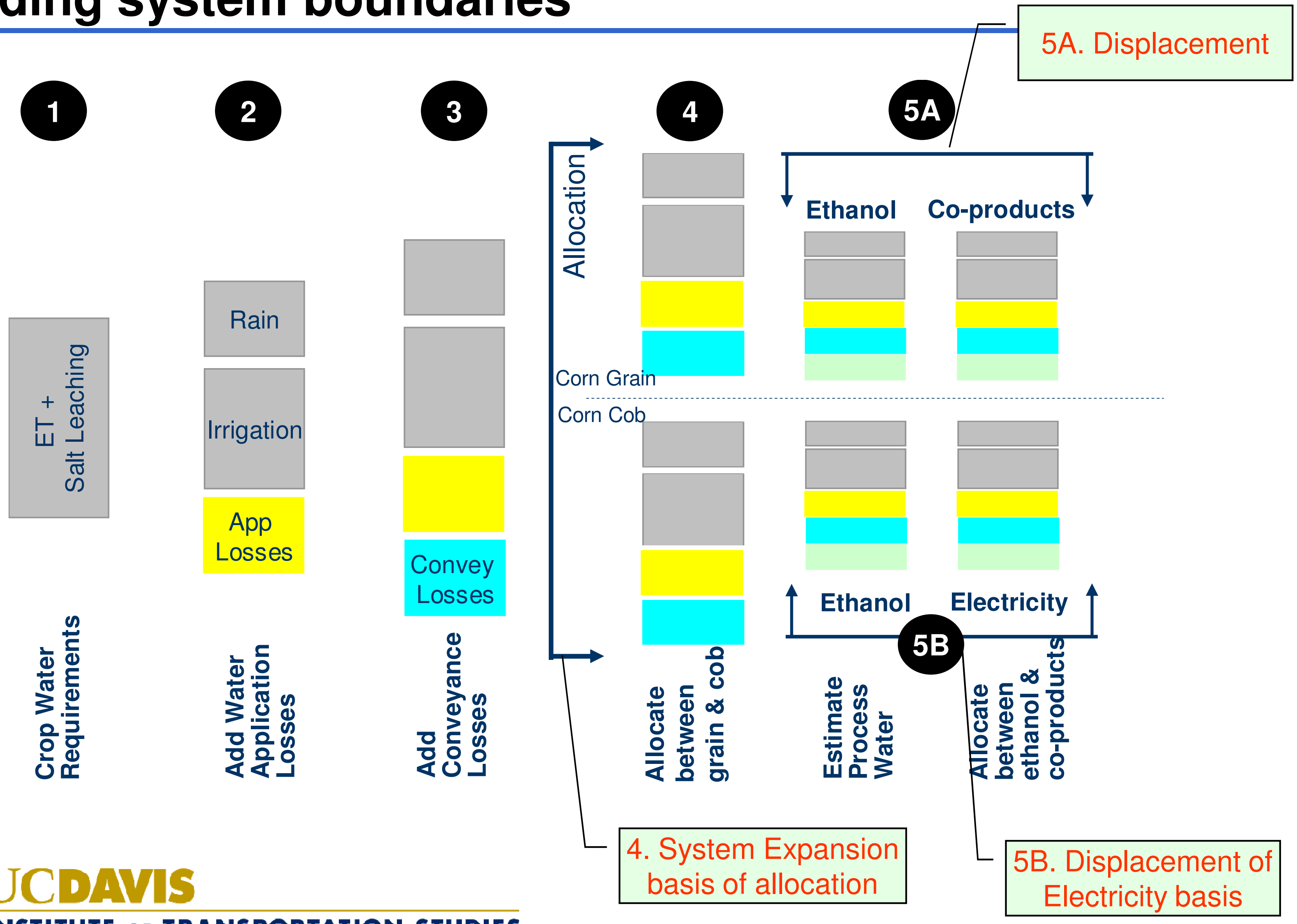
Methodology of allocating water use between grain, cob (cellulosic ag residue), and coproducts – Expanding system boundaries



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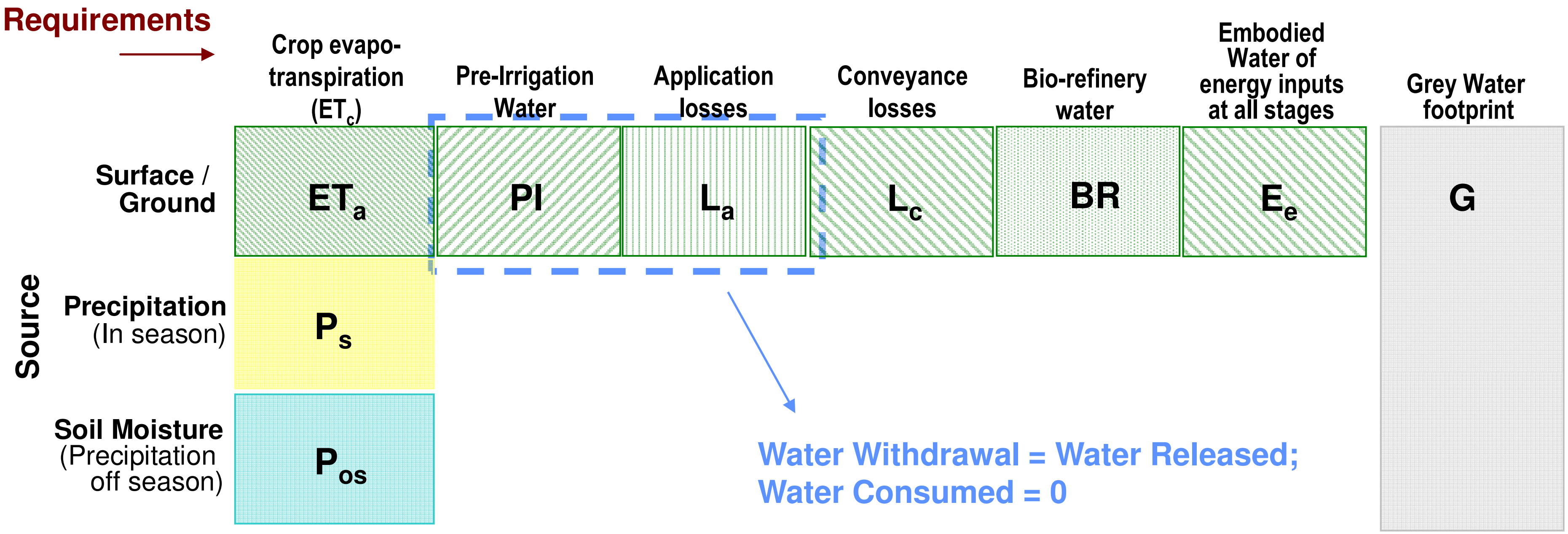
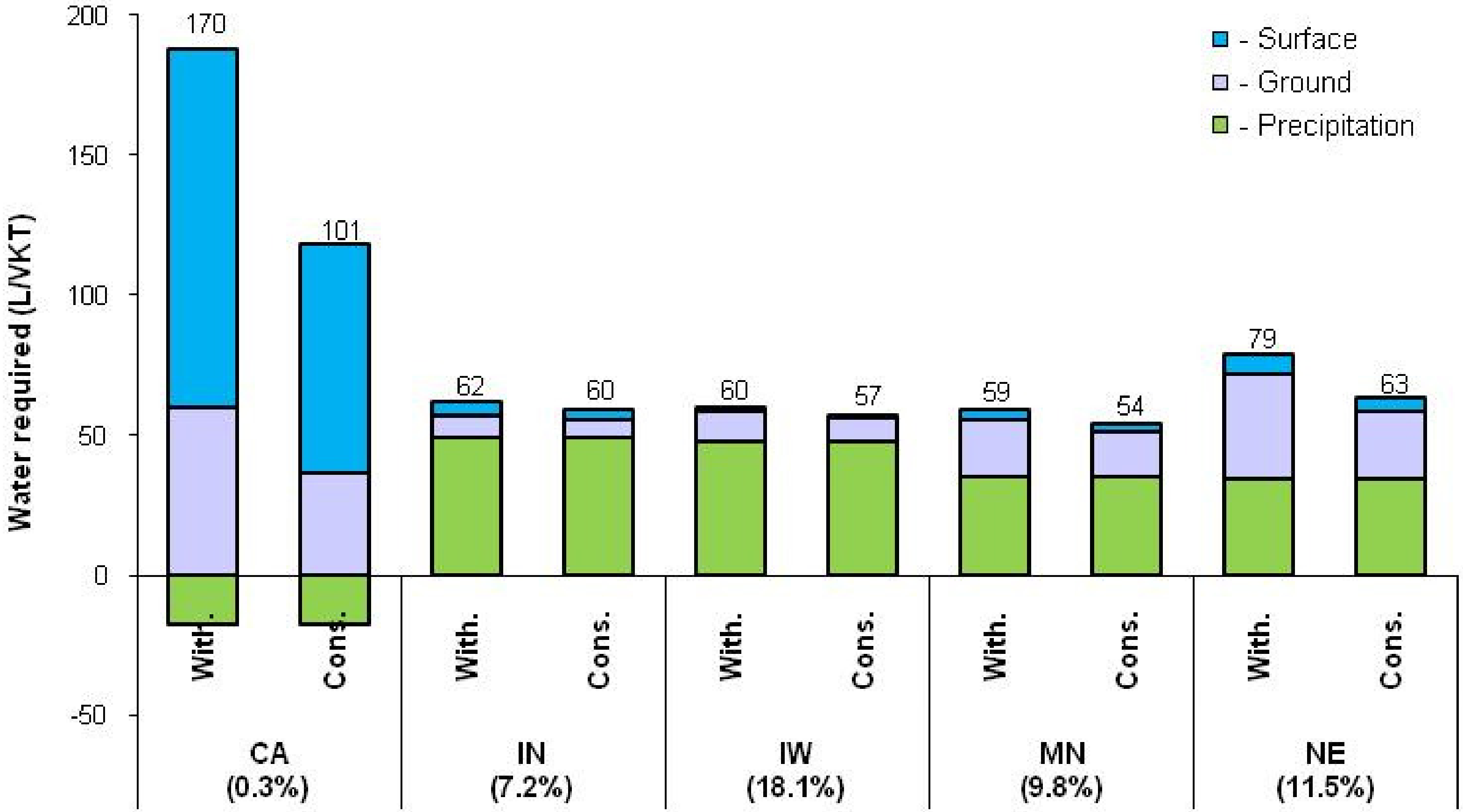
Water withdrawal versus water consumption

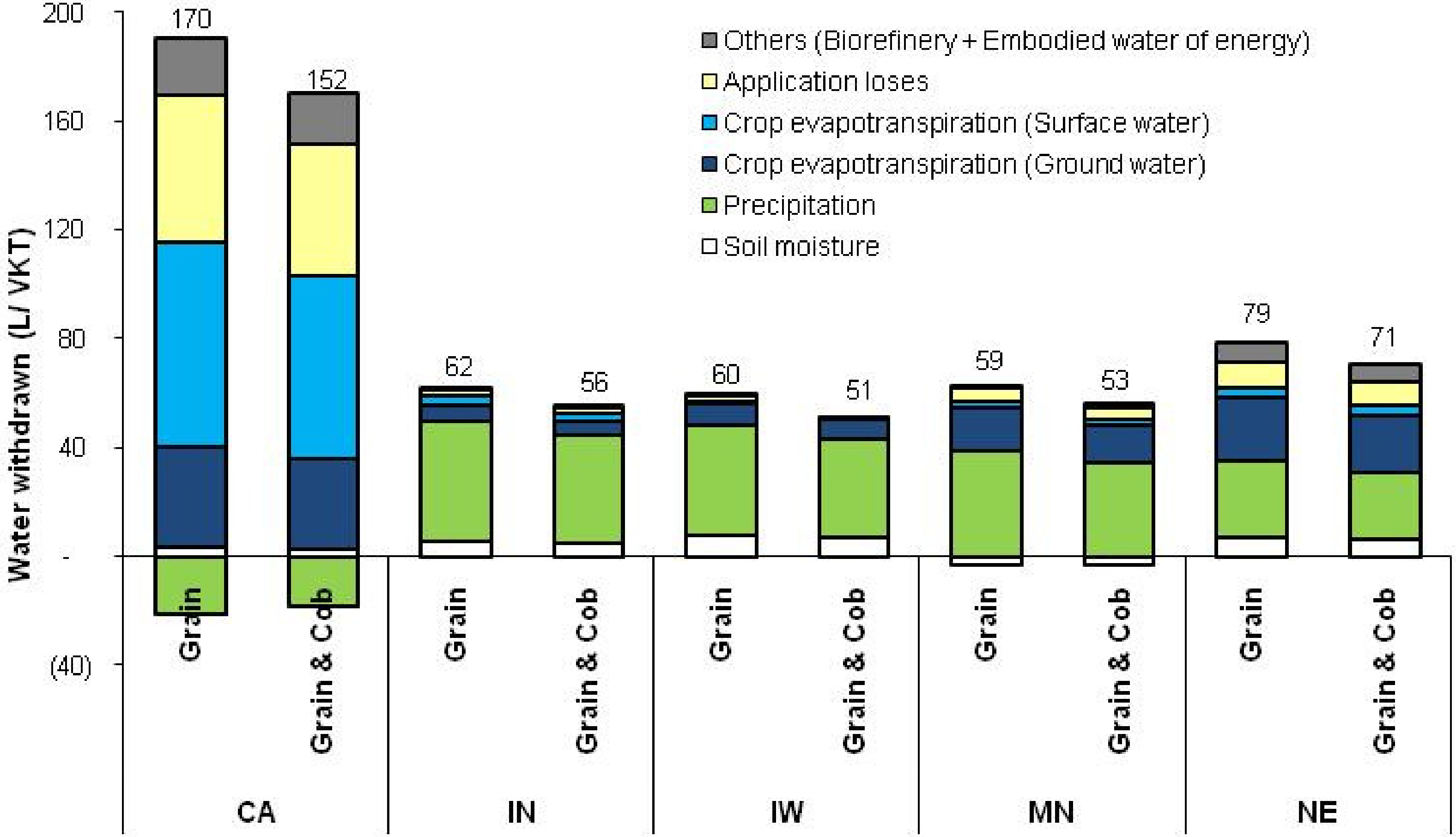


Results: Ethanol from corn grown in US Midwest have lower water intensity and depend less on irrigation



Major finding #1: surface/ground (non-precipitation) water constitute 16 - 117% of lifecycle water need, of which 31-87% is from ground water

Results: The total non- evapotranspiration (crop-growth) water use range from 5 - 44% of the lifecycle



Major finding #2: the total non-evapotranspiration water use range from 5 - 44% of the lifecycle

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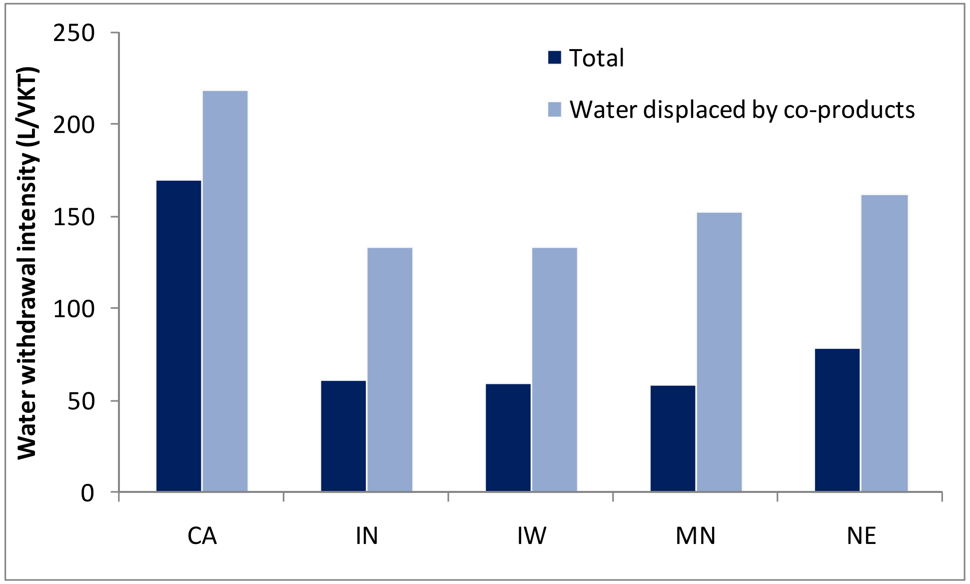
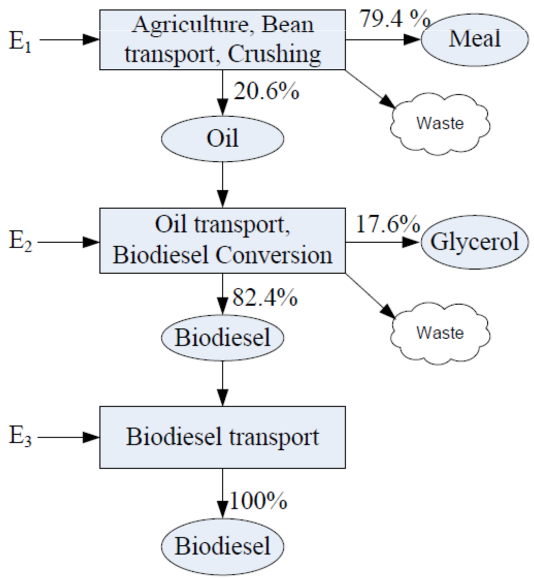
The importance of co-product allocation / displacement

Major finding #3: water displaced by co-products ranges from 1.25 - 2.6 times the water credited to ethanol



Example: 6,200 gallons of water per gallon biodiesel…*

- ~17% if using mass-based energy allocation
- work is ongoing in developing displacement method



Mass-based energy allocation for biodiesel coproducts. Source: USDA (2009)

** (DOE 2006)*

Variability in "*system boundary*" (what is being measured)

i. Types of water use considered
   - precipitation and soil moisture
   - conveyance losses
   - embodied water of energy inputs
   - gray water use

ii. Nature of water use:
   - withdrawal vs. consumptive
   - freshwater (TDS <1000mg/L) vs. "degraded" water (TDS > 1000 mg/L)

iii. Application efficiency
   - efficiencies increase as we move from field and farm to a water district or water basin

Variability in "*estimation*" of water use

i. Selection of parameter values
   - crop co-efficient

ii. Section of data
   - estimation of reference evapotranspiration
     - "representative" meteorological data: e.g. monthly or daily data? geographic representation of weather stations.

iii. Marginal vs. average
   - intensified production and expansion onto marginally suitable lands could lead to greater water use

Variability in "*actual*" water requirements

i. Meteorological and other factors
   - planting date/season (affects the ratio between blue/green water needs)
   - crop variety
   - soil type

ii. Management practices

iii. Irrigation
   - type of irrigation system installed
   - maintenance of irrigation system

iv. Idea vs. actual conditions
   - factors like presence of pests and diseases, and water shortage or water-logging may reduce crop yields and the standard evapotranspiration rate

Procedure for co-product allocation (also a system boundary issue)

i. System Expansion method:
   - applicable for certain feedstocks only initially

ii. Allocation method
   - energy basis – **economic value basis** – mass basis

iii. Displacement method:
   - product(s) being displaced and displacement ratios will vary between locations and over time
   - Consistent with LCA and indirect land use change analysis that takes into account the role of co-products in reducing demands for new cropland conversion

Variability in economic values of water resource and technological change

i. Economic/social costs:
   - likely lower for precipitation and higher for ground and surface water
   - vary spatially for surface water: use water stress index
   - likely to increase over time for ground water
   - competing demands of water such as food, residential usage and industrial activity

ii. Technological change
   - improve water management
   - increase water use efficiency though the use of technology
   - lower water demand (e.g. drought tolerant varieties or yield improvement)