Life-Cycle Analysis of Water Use for Hydrogen Production Pathways

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The 2013 DOE Fuel Cell Technologies Program Annual Merit Review and Peer Evaluation Meeting

Arlington, VA

May 14, 2013

Project ID: an039

Project Overview

Timeline

- Start: April 2013
- End: Oct. 2013
- % complete: 15%

Barriers to Address

- Indicators and methodology for evaluating sustainability
- Overcome inconsistent data, assumptions, and guidelines
- Develop models and tools
- Conduct unplanned studies and analyses

Budget

- Funding received in FY12: $0K
- Funding for FY13: $100K

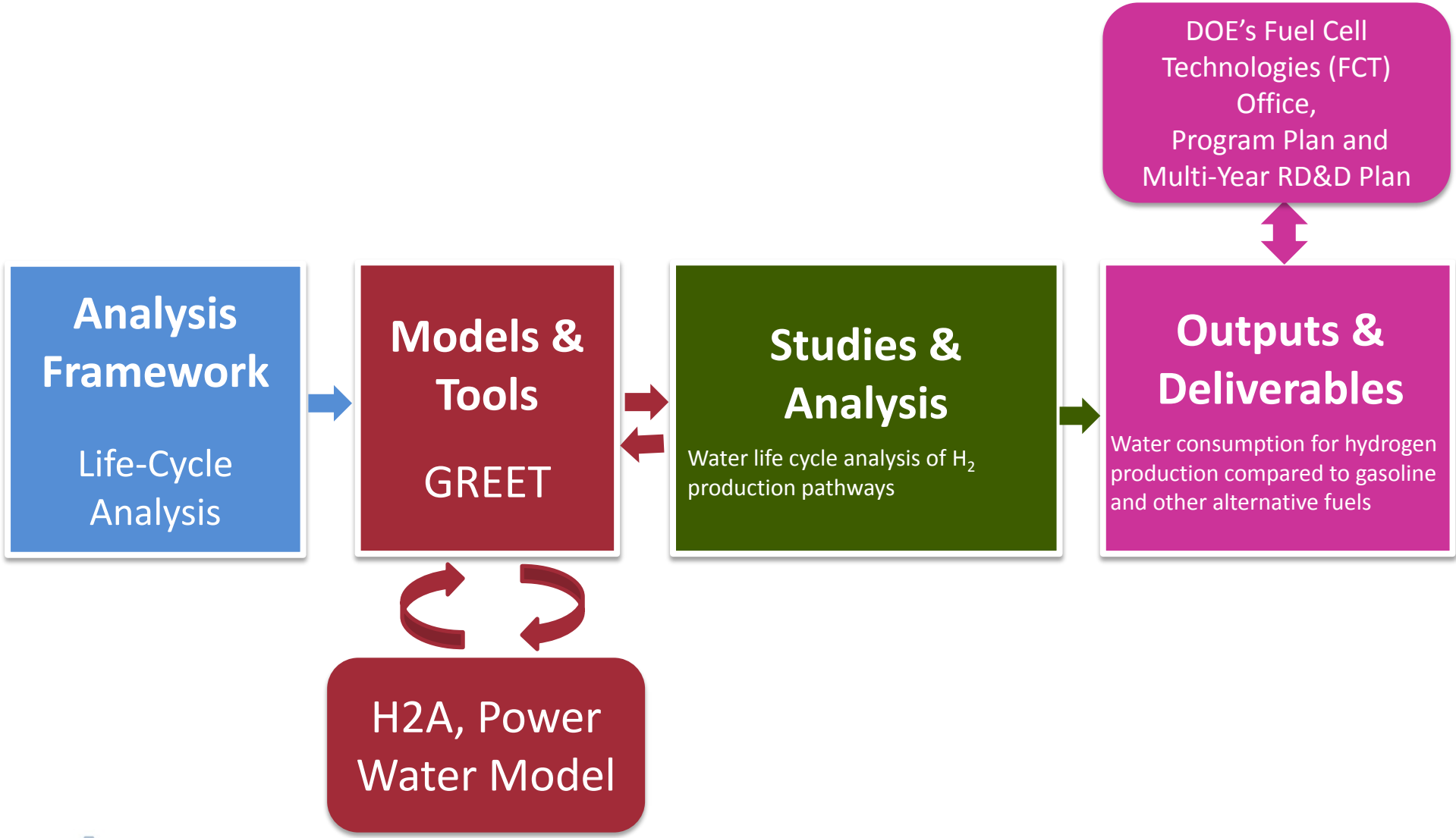
Partners/Collaborators

- Industry stakeholders

Relevance

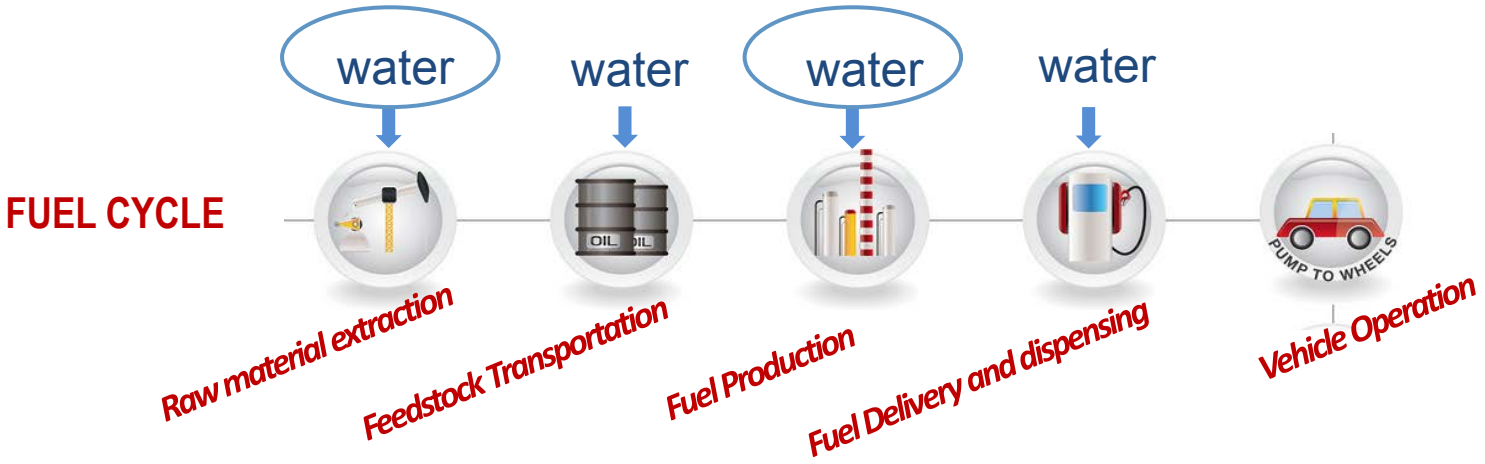
- Establish a baseline of life-cycle water consumption for baseline fuels and feedstock sources
- Evaluate water consumption for hydrogen production processes
- Assess impact of feedstock source on life-cycle water consumption for hydrogen production
- Identify major contributors in upstream supply chain to water consumption of hydrogen pathways and improvements of efficient water use
- Identify vulnerabilities with respect to resource availability by region for large scale hydrogen production

Water LCA of Hydrogen Production Pathways



Scope of Water LCA – Relevance

- Water consumption is not in current GREET version for any fuel pathways; Argonne water consumption analysis so far has been done outside of GREET
- New effort began recently for water consumption analysis with GREET platform
- Focus of this project is on fuel cycle water consumption for hydrogen and baseline fuels
- Assess water consumed per kg_{H2} and per mile relative to baseline gasoline vehicle



Approach and Data Sources

- Approach: build water LCA modeling capacity with the GREET model
  - Address water resource use across fuel production stages, with focus on production of feedstocks and fuels
  - Address emerging water LCA issues related to H_2 fuel pathways
  - Develop consistent methodology and system boundary
  - Maintain openness and transparency of LCAs
- Data Sources:
  - Water consumption data inventory and assessment tools developed at Argonne so far
  - ANL Power Water model
  - H2A models
  - Open literature

Key Milestones

- Evaluate water consumption for hydrogen production
  - Process water
  - Cooling water (wet vs. dry, once through vs. recycling)
  - Upstream and indirect water use
- Hydrogen pathways for initial evaluation:
  - Steam methane reforming of conventional and shale gas
  - Electrolysis with various power plant types
  - Biomass gasification with corn stover, forest residues, and dedicated energy crops
- Examine water consumption for baseline fuels and major feedstocks and process fuels – update of past ANL estimates
  - Gasoline and diesel from petroleum (conventional oil and oil sands)
  - Electricity generation (fossil, non-fossil, renewables)
  - Biomass feedstocks and biofuels

Hydrologic Cycle – Approach

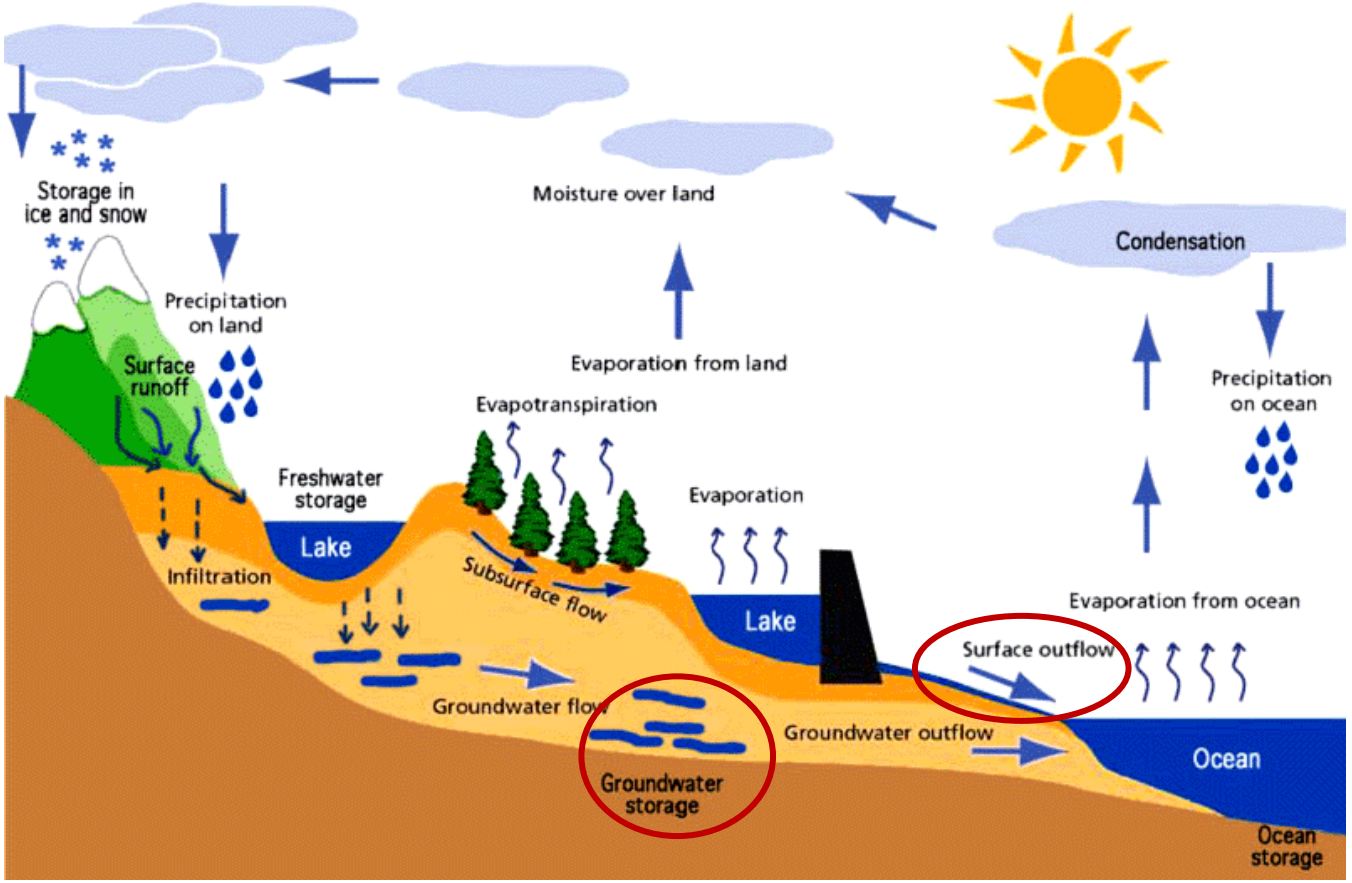
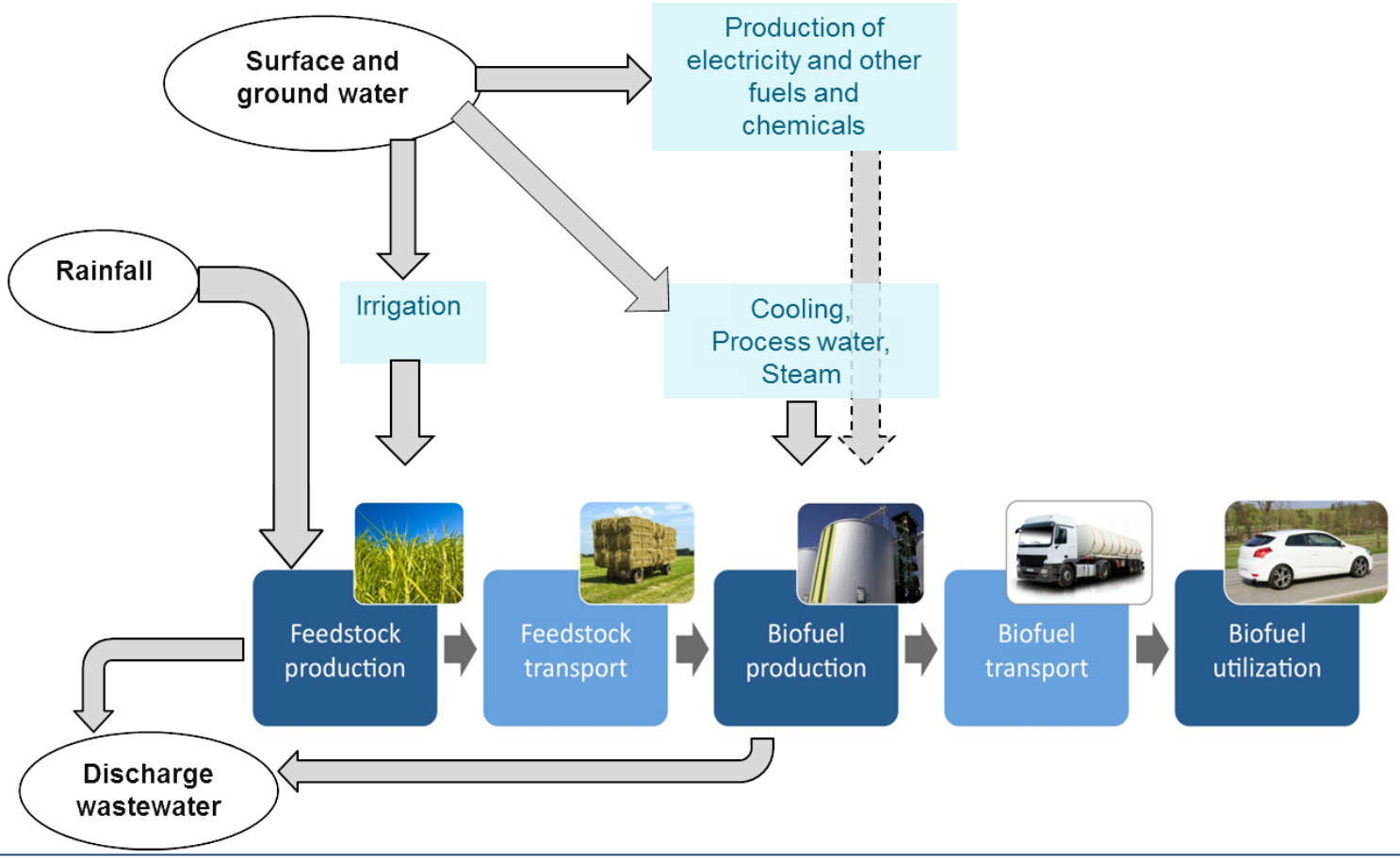


Image from: http://uncloaked.files.wordpress.com/2012/03/hydrologic_cycle.gif

- Only fresh surface water and groundwater will be considered for water LCA

Biofuel Water Footprint Accounting – Approach



- Water withdrawal: fresh water uptake from surface or groundwater
- Water consumption: net water consumed through the production process (evaporated or incorporated into the product)
- Fuel pathway water LCA in this analysis: accounts for water consumption of LCA stages of fuel pathways

Water use analysis at Argonne – Relevance

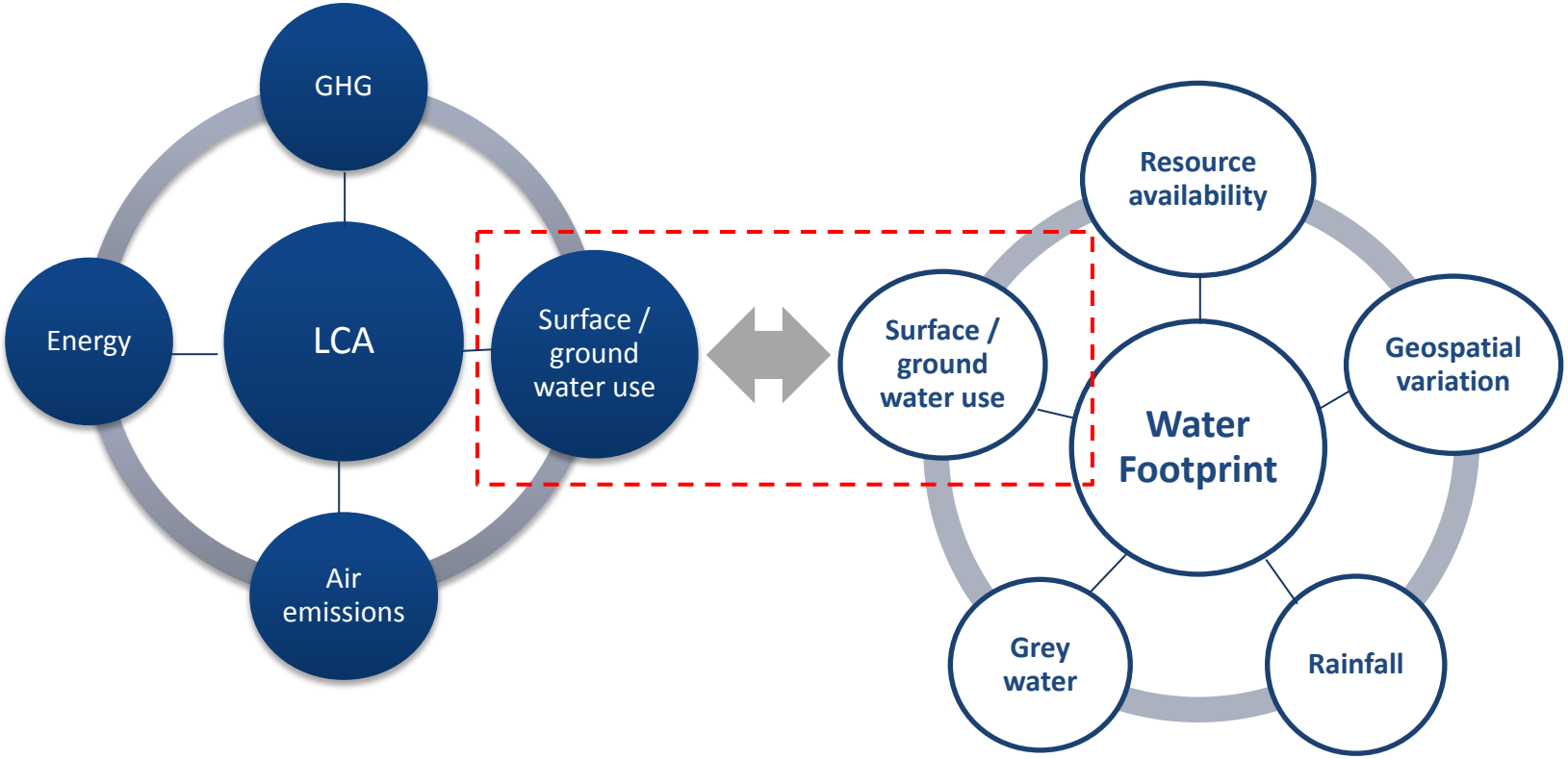
- Supported by BETO since 2007, Argonne assessed water use for:
  - ✓ Water consumption of biofuels
  - ✓ Water consumption of petroleum gasoline and diesel
  - ✓ Water withdrawal of electricity generation (fossil, non-fossil, renewables)
- Supported by VTP, currently assessing water use for conventional and shale gas

Selected Argonne reports on water analysis:

http://greet.es.anl.gov/publication-consumptive-water

http://greet.es.anl.gov/publication-watertool

Linkage of Water Resource Assessment and LCA – Relevance

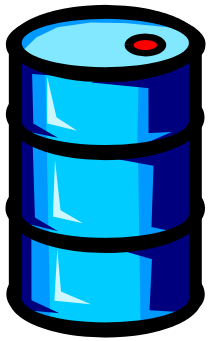


- Water resource (or water footprint) assessment is spatially specific
- LCA addresses total water use along fuel production pathways
- Water footprint assessment completed so far provides data needed for water LCA

Gaps with completed water footprint assessment – Relevance

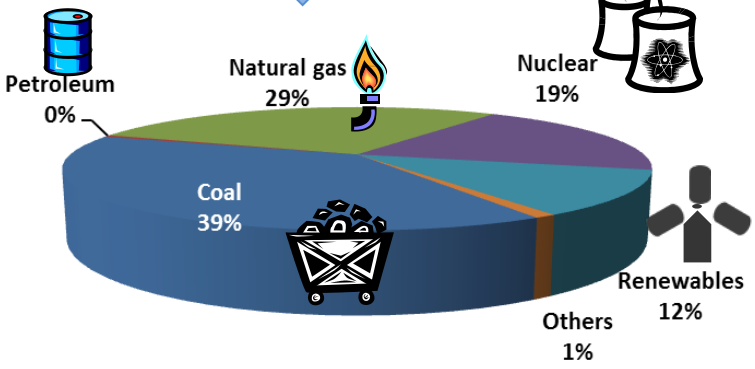
- Several feedstocks have not been examined in depth:
  - Natural gas
  - Coal
  - Nuclear
  - Crude oil
- Fuel production gaps include hydrogen production processes




Hydrogen pathways for water LCA – Approach (1) Electrolysis

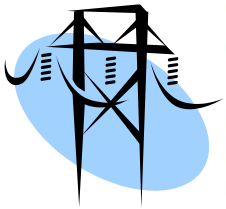
Water use for feedstock extraction



Electricity Generation Mix

Water use in power plant (done)

Water is the feedstock source of H2

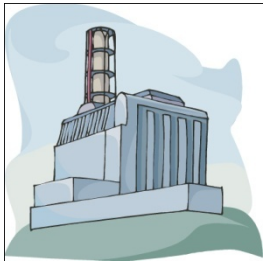


Electrolyzer

H2

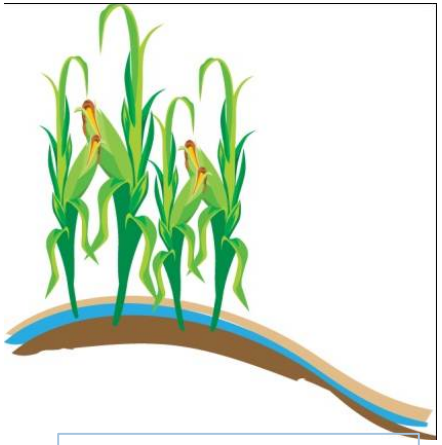
Hydrogen pathways for water LCA – Approach (2) Biomass gasification

Fertilizer Production



Water use for Fertilizer production

Biomass farming



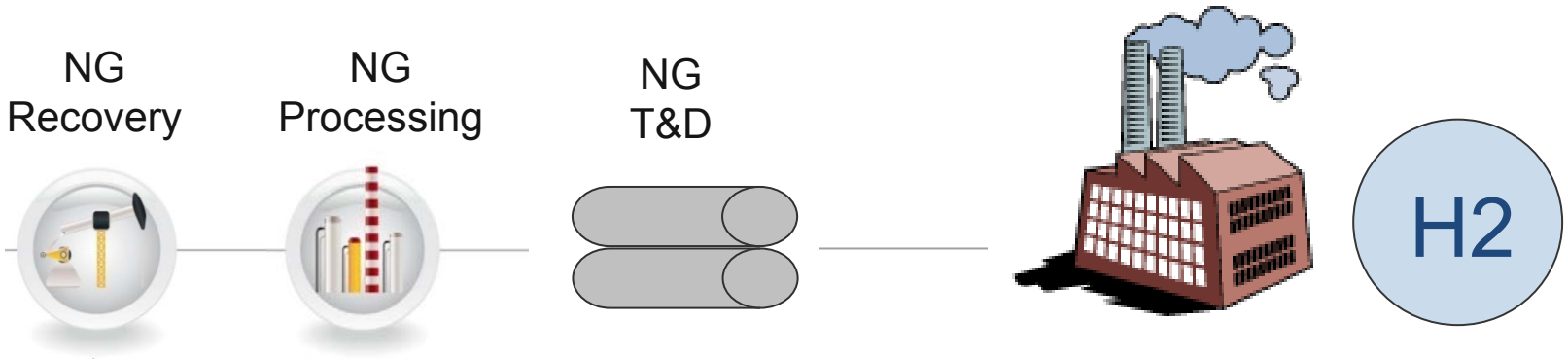
Water use for farming (done)

Biomass gasification

Water use for H2 production

H2

Hydrogen pathways for water LCA – Approach (3) Steam Methane Reforming



Water use in NG recovery and processing (in process)

Steam use for H2 produced via SMR

Summary

- Project is in initial phase
- Project scope and major tasks have been defined
- Analysis approach and data sources have been decided
- Gaps and research issues have been identified

Collaborations and Acknowledgments

Key Investigators/ Major Participants:

– Argonne National Laboratory: Michael Wang (PI), Amgad Elgowainy (CO-PI), and May Wu

– DOE, Fuel Cell Technologies Office, AAA Fellow: Jeni Keisman

Acknowledgement:

– DOE, Fuel Cell Technologies Office, Systems Analysis Program Manager: Fred Joseck

– DOE, Biomass Energy Technologies Office: Kristen Johnson

Future Work

- Address outstanding issues related to water consumption in the upstream supply chain
- Upgrade GREET model by adding water use
- Evaluate emerging hydrogen feedstocks and production processes
- Continue to provide LCA technical support to DOE FCT program and industry stakeholders

Acronyms

- ANL: Argonne National Laboratory
- BETO: Biomass Energy Technologies Office
- DOE: Department of Energy
- FCT: Fuel Cell Technologies
- GHG: Greenhouse Gases
- GREET: Greenhouse gases, Emissions, and Energy use in Transportation
- H2: Hydrogen
- LCA: Life Cycle Analysis
- NG: Natural Gas
- RD&D: Research, Development, and Demonstration
- SMR: Steam Methane Reforming
- VTP: Vehicle Technologies Program