

Feedstock Energy in Bitumen

Nicholas Santero, Ph.D.

Postdoctoral Scholar

Civil and Environmental Engineering

University of California, Berkeley

Defining “Energy”

- Not all energy is created equal
 - Primary energy
 - Energy in its raw form (e.g., petroleum, coal, uranium), generally measured by its lower or higher heating value
 - Secondary energy
 - Primary energy transformed into a different energy type (e.g., hydrogen, electricity)
 - Embodied energy (i.e., life-cycle primary energy)
 - Total primary energy used to create a product.
 - Process energy
 - Primary energy consumed during the manufacturing of a product. Considered as part of the embodied energy.
 - Feedstock energy
 - The chemical energy stored in a material when not used as a fuel. Typically considered part of the embodied energy.

ISO 14040 Standards and Feedstock Energy

– Definition

- *heat of combustion of a raw material input that is not used as an energy source to a product system, measured in higher heating value or lower heating value*

– Application

- *The various types of energy inputs and outputs shall include inputs and outputs relevant for the production of and delivery of fuels, feedstock energy and process energy used within the system being modelled.*

Feedstock Energy in Bitumen

- Bitumen is a residual product of petroleum refining
 - Considerable amount of primary energy stored in bitumen
 - Lower heating value: 40.2 MJ/kg (IPCC 2006)
 - Compare to between 0.5 – 6 MJ/kg of process energy (Zapata and Gambatese 2005)
- Decision to include or exclude feedstock energy is critical
 - Because feedstock energy \gg process energy, accounting decision can sway results

Current Asphalt Pavement LCAs

- Less than half of existing pavement LCAs include feedstock energy
 - When included, asphalt has a much higher life-cycle energy consumption compared to concrete
 - No rationale provided when feedstock energy is ignored
- Feedstock energy separated from process energy
 - Allows the different types of energy to be compared, but...
 - Conclusions are based on total life-cycle energy

Bitumen as a Fuel

- If we choose to treat bitumen as an energy source, what is its “alternative life” as a fuel?
 - Combusted directly in specialty boilers, cement kilns, etc.
 - Upgraded at the refinery to lighter petroleum products

Bitumen as Fuel

- When combusted directly, bitumen is a dirty fuel
 - As a residual product, bitumen contains many impurities (e.g., heavy metals, sulfur) that are released upon combustion
 - High carbon to energy ratio (e.g., kg C/MJ)
 - 53% higher than natural gas
 - 16% higher than gasoline
 - 4% higher than residual oil
 - 13% lower than coal
- When bitumen is upgraded to lighter fractions, it undergoes energy- and emission-intensive processes
 - Cracking
 - Hydrotreating
 - De-asphalting

Bitumen Issues Relevant to LCAs

- The use of bitumen in asphalt pavements alters its life cycle
 - Prevents the release of its feedstock energy into useful work
 - Sequesters fossil carbon and other pollutants that would otherwise be released upon combustion
 - Avoids upgrading into lighter petroleum fractions
- ISO 14040 Standards
 - Directly states that the feedstock energy should be considered
 - Does not discuss the repercussions of combusting bitumen

Outstanding Questions

- Should the feedstock energy of bitumen be considered in pavement LCAs?
 - Probably yes, but if yes how should it be reported?
- Should we consider the environmental impact of releasing that feedstock energy?
 - If so, how?
 - Should it be benchmarked? Relative to what?
- Do we consider the “alternative life” option of upgrading?
 - Potentially, feedstock energy can be “discounted” by the process energy needed to transform it into a more typical fuel