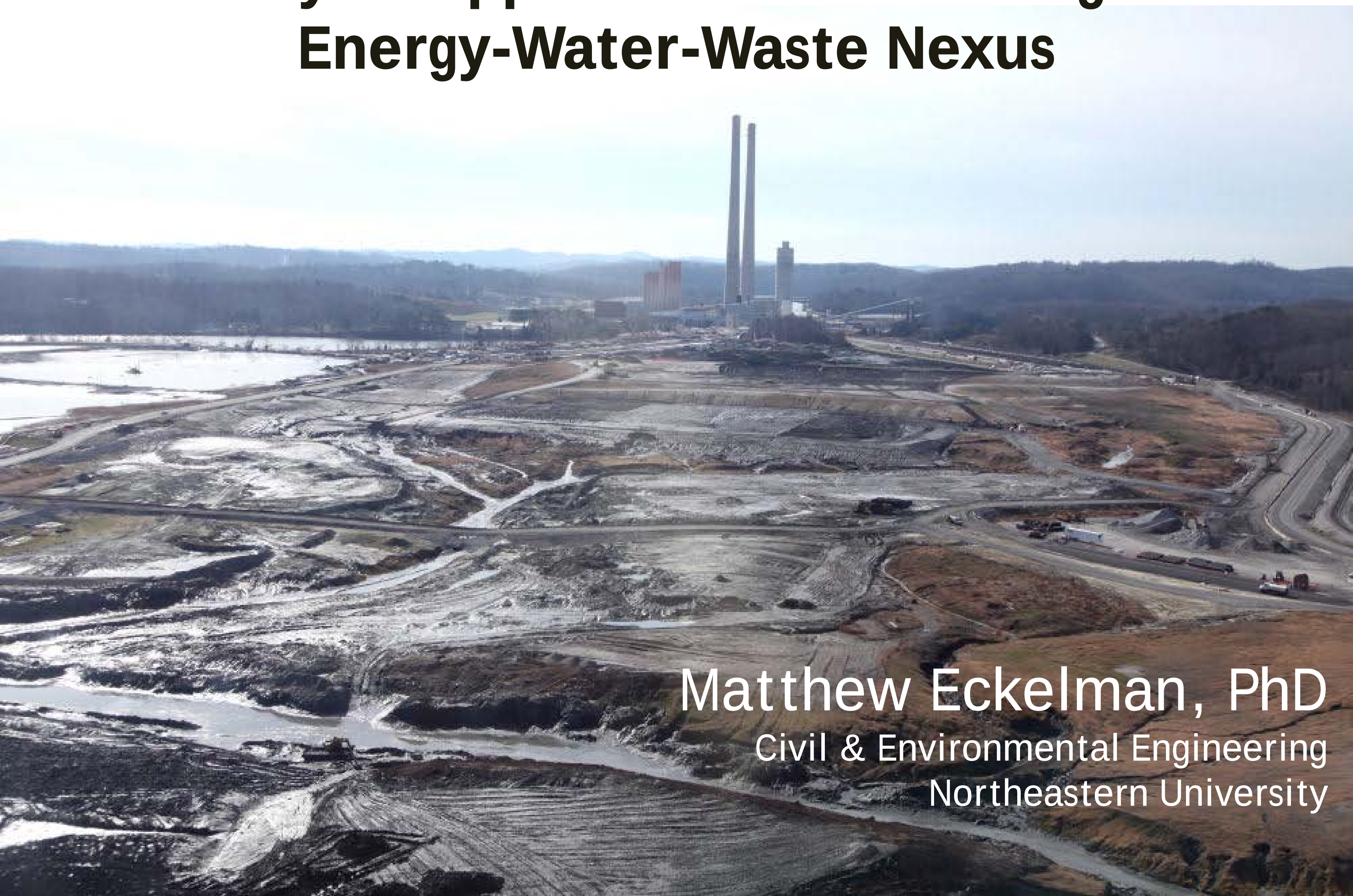
Life Cycle Approaches to Assessing the Energy-Water-Waste Nexus



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Life Cycle Assessment (LCA)

A ***systems modeling tool*** for quantifying the total resource inputs and environmental burdens of a particular product

Material production → Product manufacturing → Use & distribution → Recycling or disposal

The life cycle of a newspaper

Commonly used to consider benefits of reuse and recycling

Inherent model linkages among energy, water, and waste

Life Cycle Considerations in Energy-Water-Waste

Energy Use

UPSTREAM: Water use, water quality impacts, solid & liquid wastes

DOWNSTREAM: indirect thermal effects

Water Use

UPSTREAM: Pumping energy, chemicals, heating

DOWNSTREAM: WW treatment, biosolids wastes

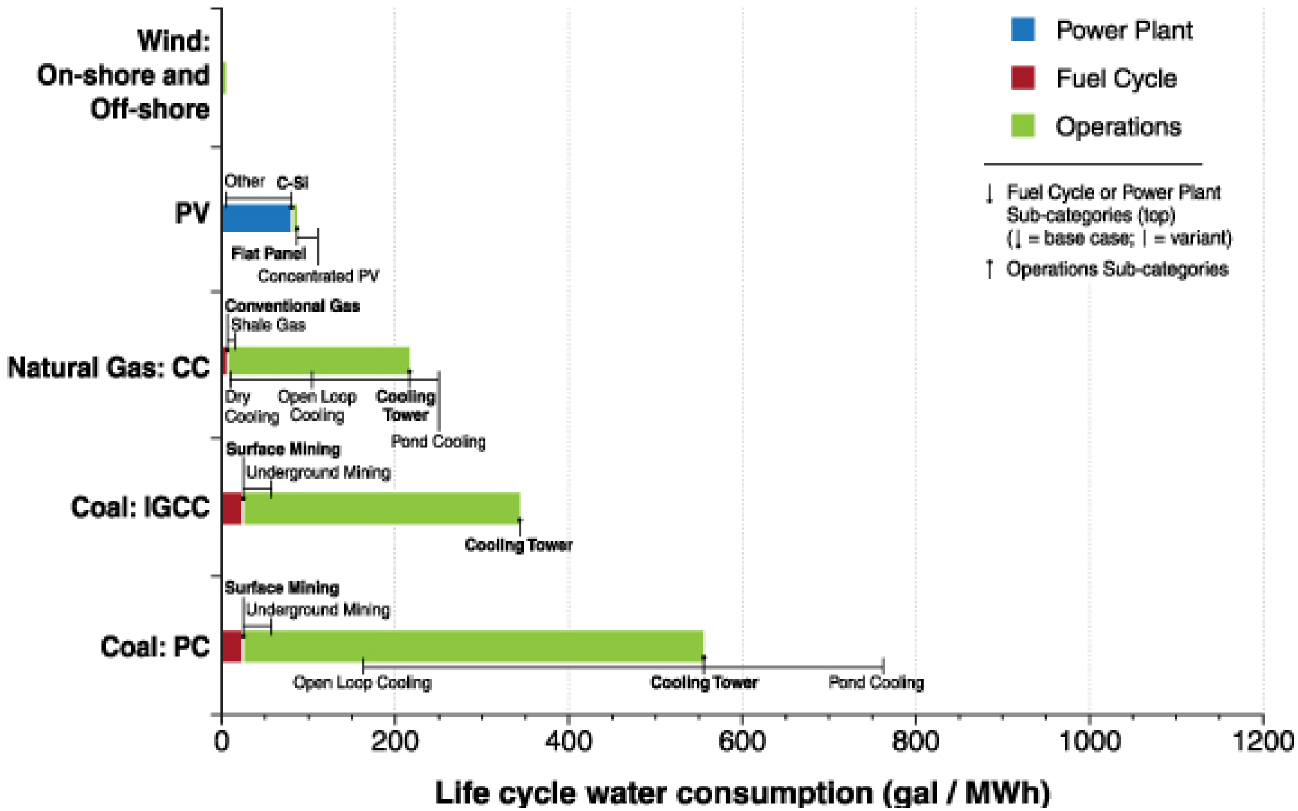
Materials Mgmt.

UPSTREAM: Fuel for collection/sorting, water for cleaning/dust

DOWNSTREAM: energy production, leachate wastewater

Life Cycle Water Impacts of Energy Production

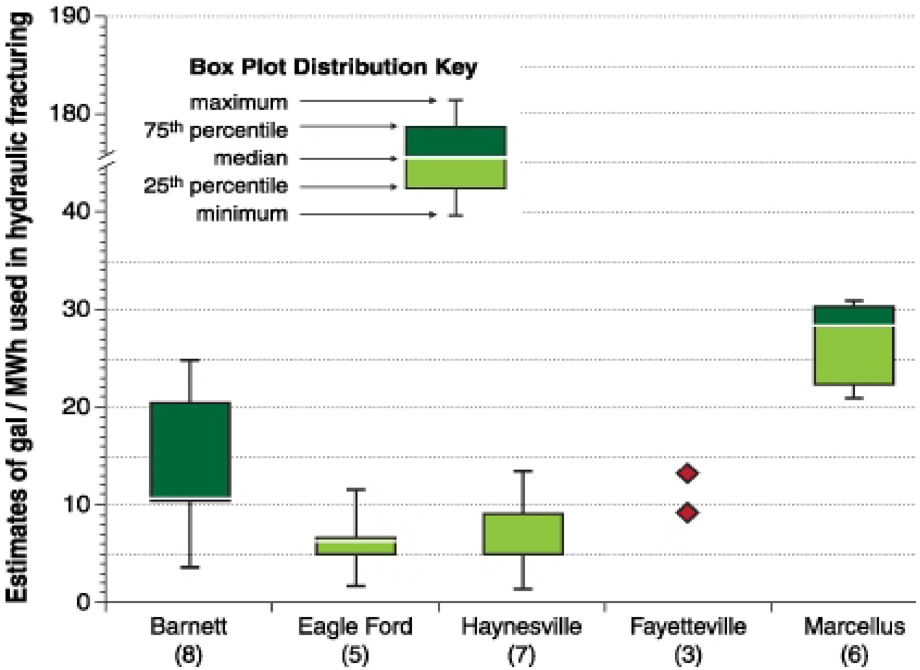
Water consumption/withdrawals have been well-quantified



Meldrum *et al* (2013) *ERL* 8 015031

Life Cycle Water Impacts of Energy Production

Water treatment demands are receiving more attention



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Life Cycle Waste Impacts of Energy Production

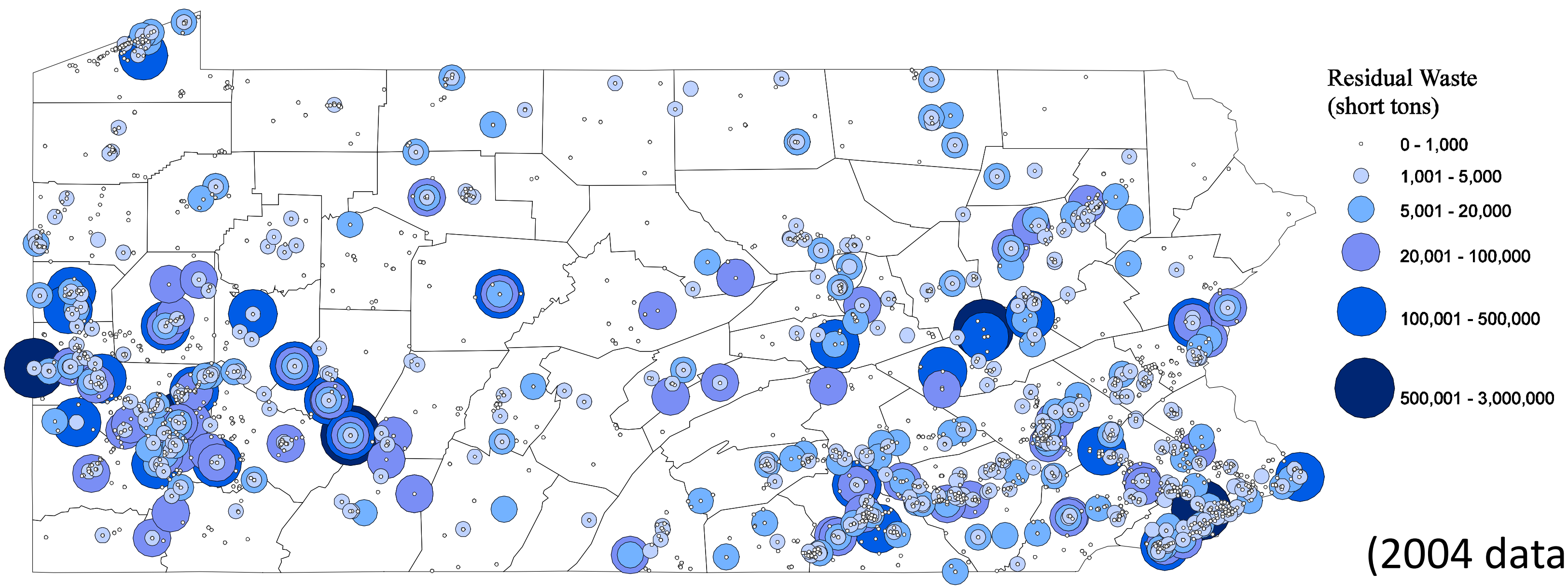
Waste generation has *not* been well-characterized

- Solid waste generation data collected by States
- Waste treatment /disposal capacity not seen as limiting
- BUT, industrial wastes dominate by mass

MSW: 250-400m tons

NHIW: 7-8bn tons

Life Cycle Benefits of NHIW Reuse

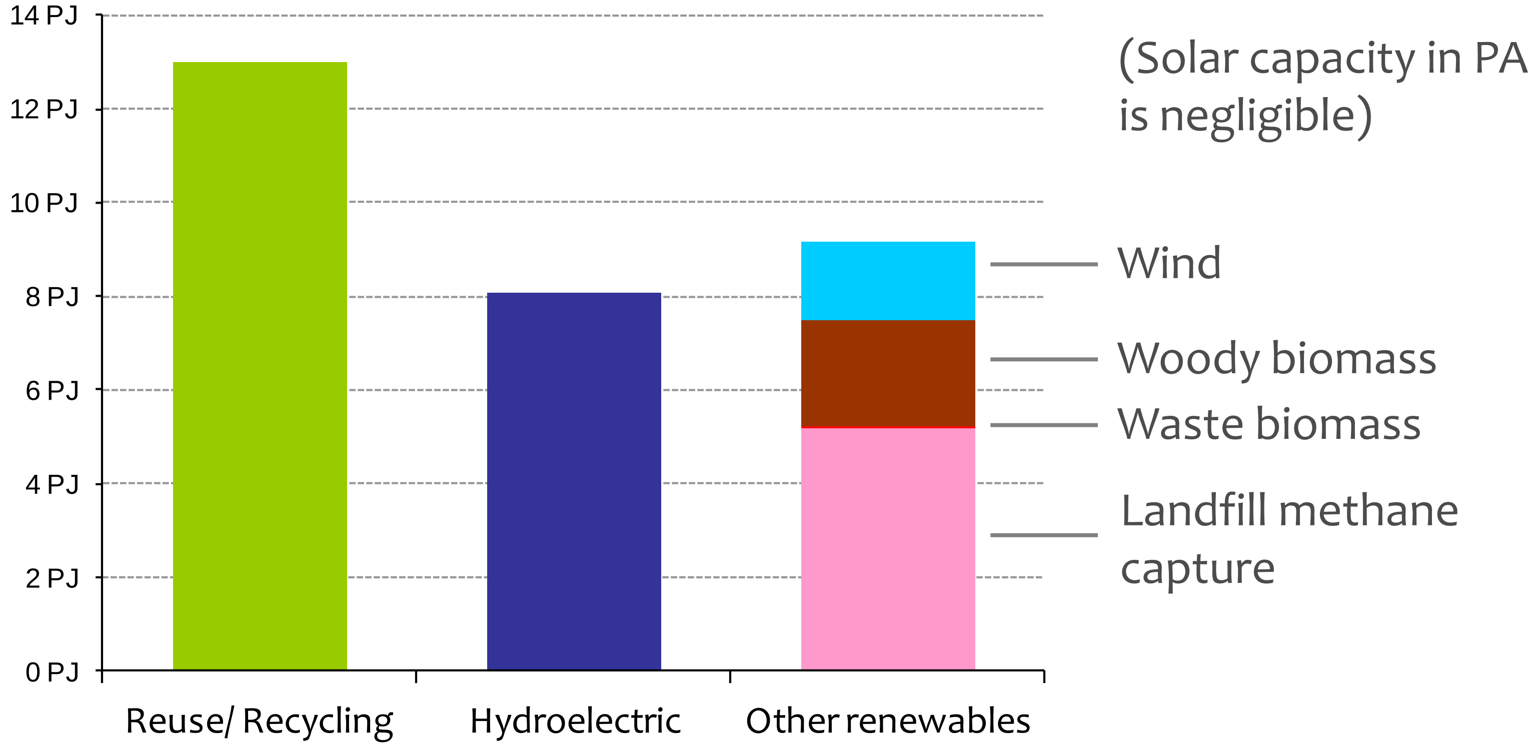


(2004 data)

Eckelman and Chertow (2009) *Environ. Sci. Technol.*, 43 (7), 2550–2556

- State of PA registry of NHIW reuse
- LCA of entire state policy, assuming substitution of primary materials

Life Cycle Benefits of NHIW Reuse



Eckelman and Chertow (2009) *Environ. Sci. Technol.*, 43 (7), 2550–2556

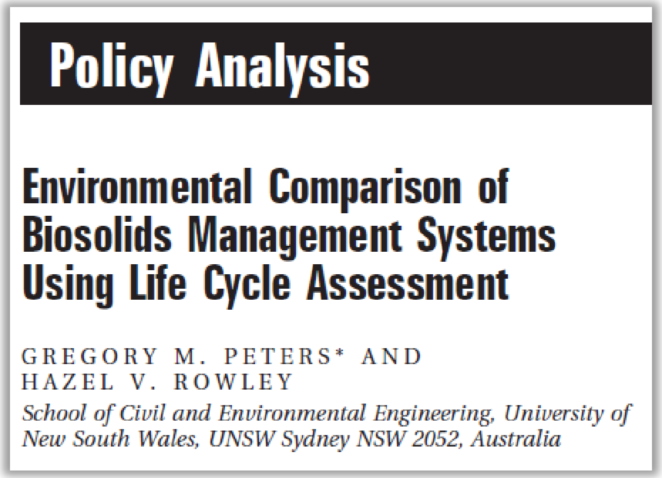
Life Cycle Impacts of Nutrient Recycling

One of the largest waste reuse opportunities worldwide is in biosolids (sewage sludge)

- Significant agricultural benefits
- Reuse can close the nutrient cycle

- Reuse benefits depend on dewatering technology, transport distances

- Assumed substitution of N and P macronutrients OR coal in cement kiln



Policy Analysis

Environmental Comparison of Biosolids Management Systems Using Life Cycle Assessment

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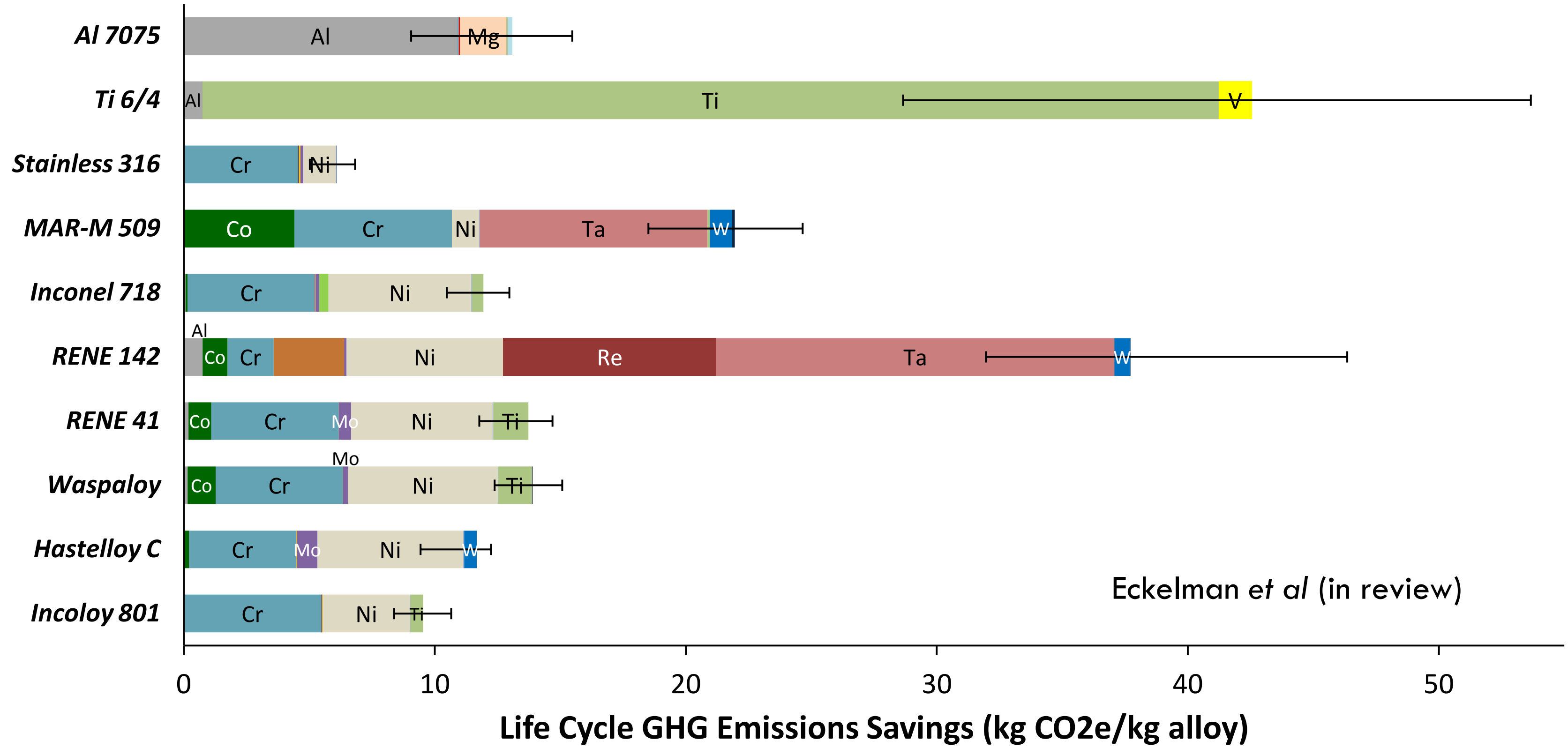
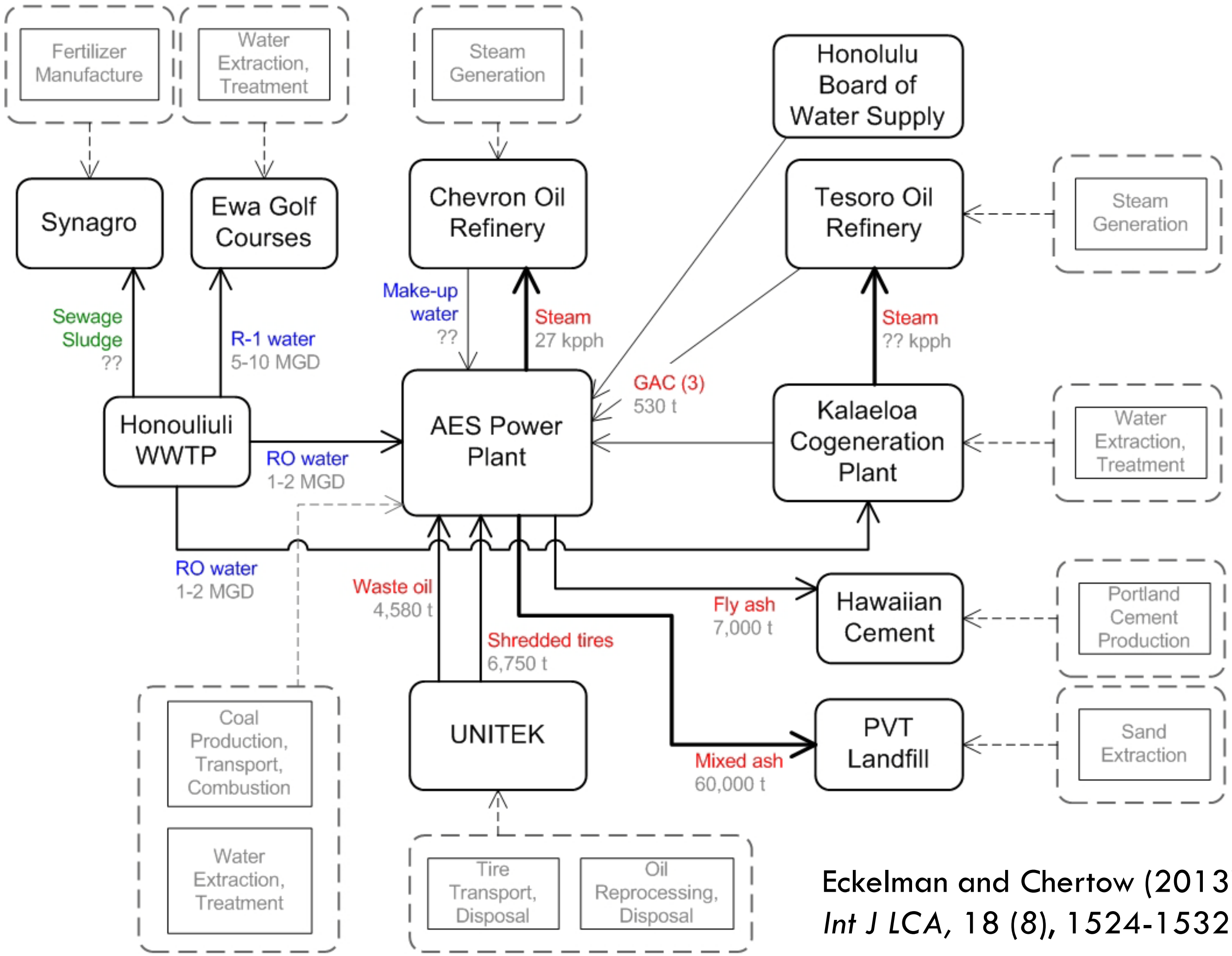
Life Cycle Benefits of Metal Recycling



- Assumes substitution of primary metal elements in aerospace alloys
- Can also compare with downcycling of alloys into stainless steels

LCA of Water, Energy, *and* Waste Reuse

LCA of Water, Energy, and Waste Reuse



Eckelman and Chertow (2013)
Int J LCA, 18 (8), 1524-1532

Reuse/Recycling Contributes to Policy Goals

- Hawai'i Clean Energy Initiative
- Calls for transformative changes in energy supply and technology adoption
- *Current* reuse and recycling at Campbell Industrial Park represents **25%** of that goal on a life cycle basis

40% RENEWABLE
+ 30% EFFICIENCY
= 70% CLEAN ENERGY

LCA flexibility and limitations

PRO:

LCA can be used to quantify the upstream energy and water use or waste generation of any generic industrial process (or combination)

CON:

Does not capture economies of scale

Uses (mostly) average data by geography

Inherent assumption of substitution of materials (under intense methodological development)

Thanks!

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