Lifecycle energy & carbon footprint of sewered and non-sewered sanitation

Evidence from India and Zambia

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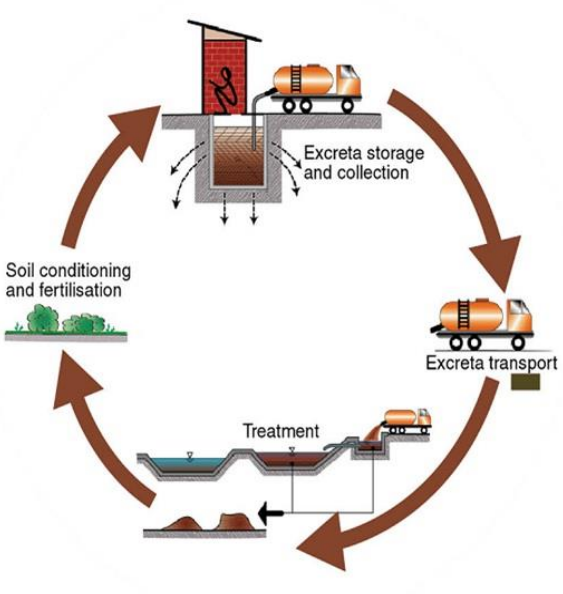
Motivations

Population growth & urbanization

Images: UN-Habitat (Julius Mwelu), 2014; NYT (Joao Silva), 2016; Laramee, 2015

Alternative sanitation approaches

Non-sewered ('FSM')



(UNESCO-IHE, 2014)

Decentralized sewered ('DEWATS')

(BORDA, 2009)

SDGs – 'safely managed sanitation services'

- New approaches and increasing investment
- Limited knowledge on the long-term environmental impacts

Research questions

1) What are the energy and carbon costs and benefits of decentralized sewered and non-sewered sanitation approaches?

2) To what extent does energy recovery affect costs and benefits?

Methods: Life Cycle Assessment (LCA)

- Methodology “to assess the environmental impacts associated with all the stages of a product or system’s life” (ISO, 2006)
- Functional unit: *“Lifecycle management of excreta, urine and wastewater along the entire sanitation value chain: per-capita per-year”*

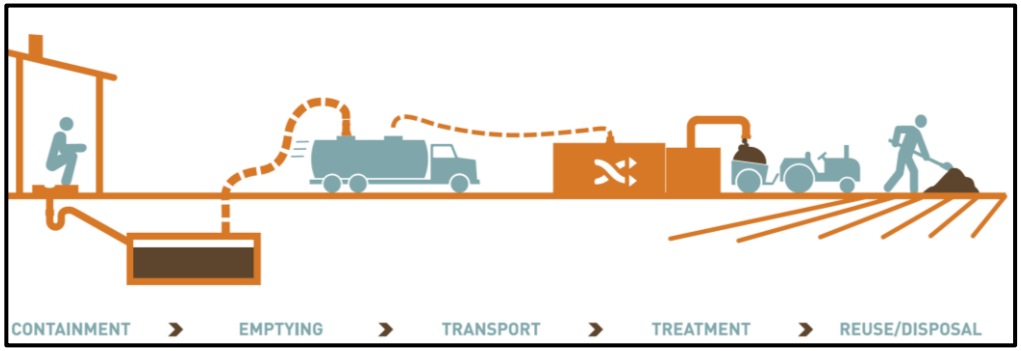
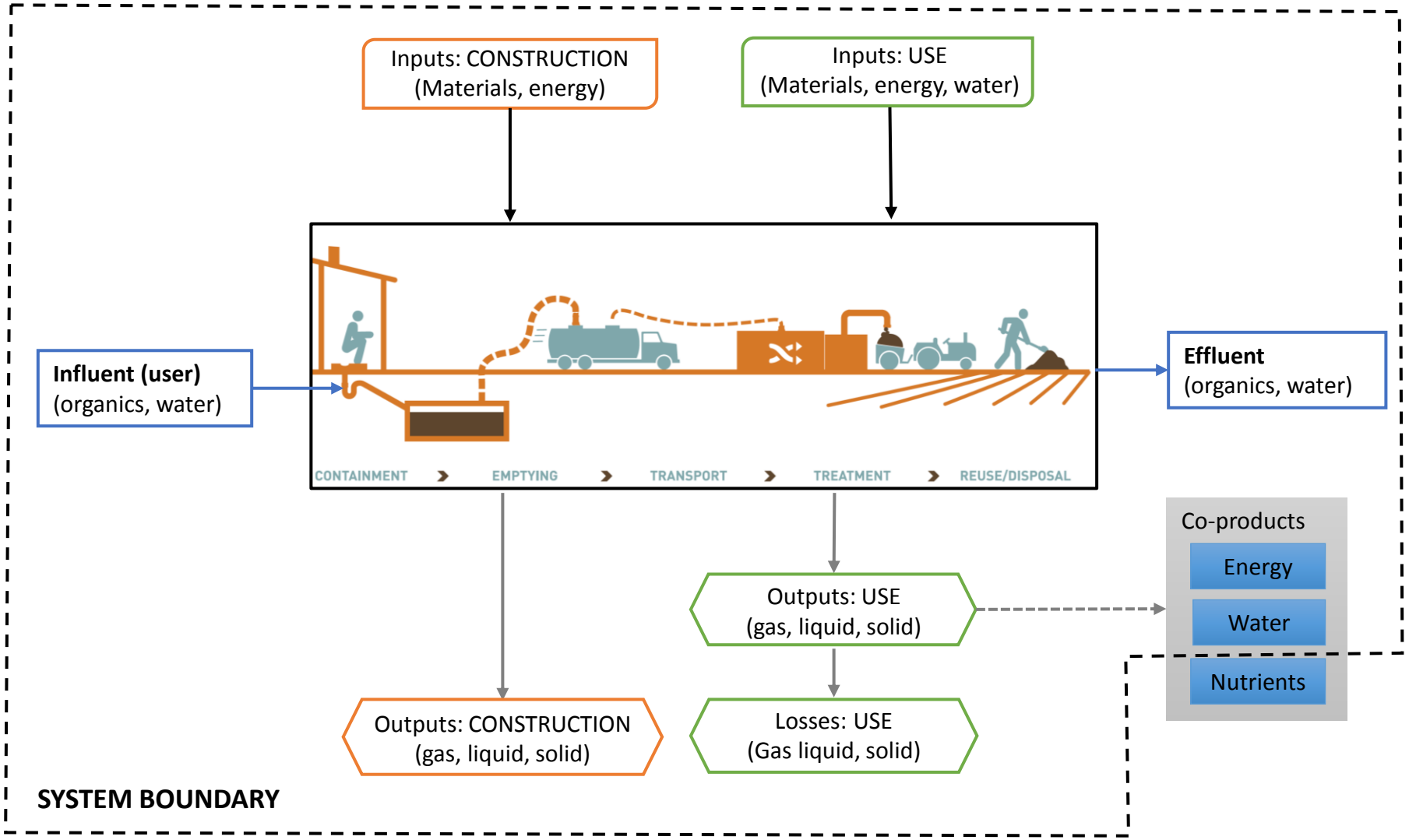


Figure: (BMGF, 2015)

Methods: System boundary

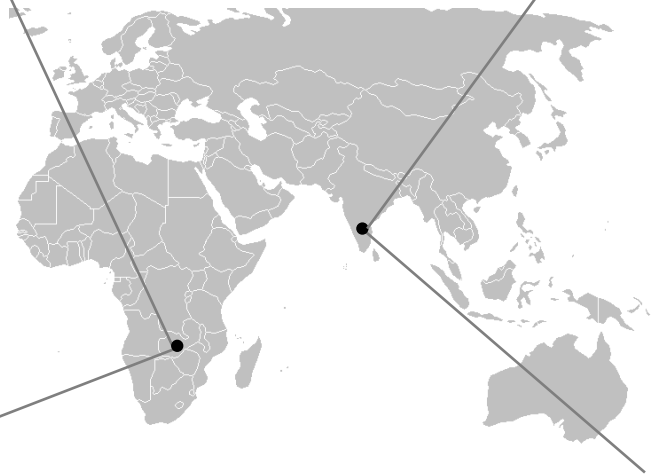
- Construction and use phase (20-year lifespan assumed)



Methods: Case studies

Non-sewered, Zambia
(12,000 people)
Dry pit latrine, manual conveyance, AD+SDB, biogas recovery

Decentralized Sewered, Zambia
(400 people)
Small-bore sewerage, DEWATS, biogas recovery



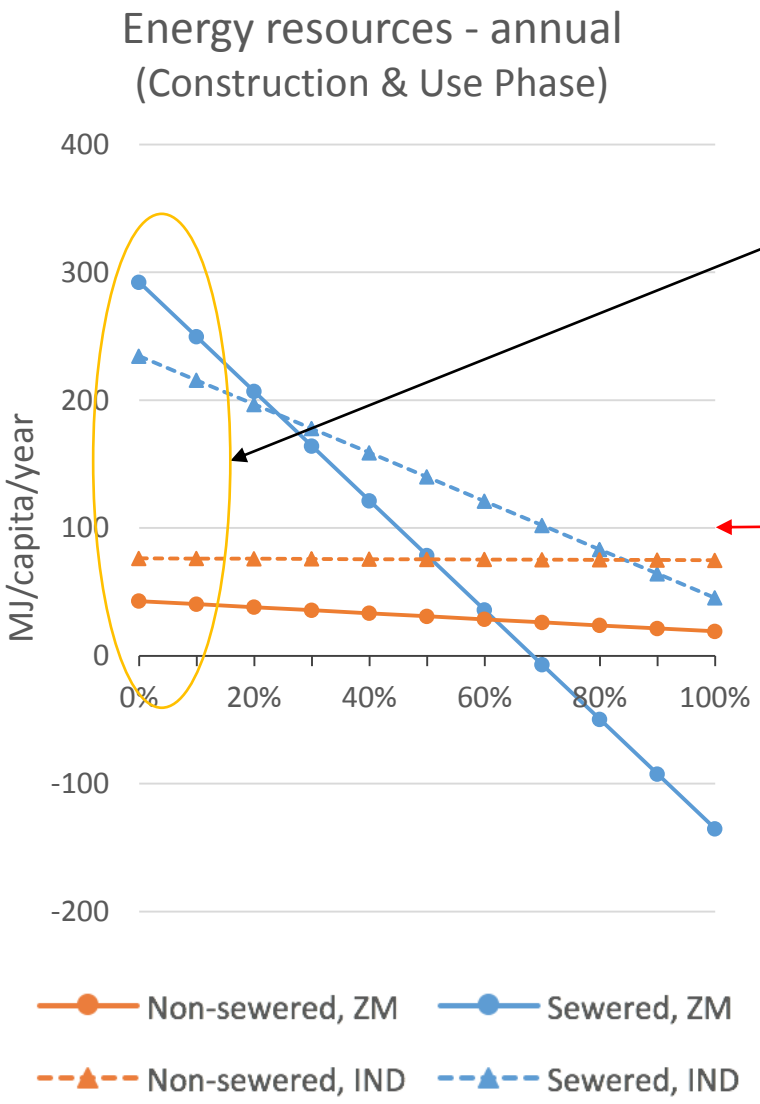
Non-sewered, India
(7,000 people)
Flush pit latrine, motorized conveyance, AD+SDB, biogas recovery

Decentralized Sewered, India
(600 people)
Small-bore sewerage, DEWATS, biogas recovery

PRELIMINARY FINDINGS

1. Overview - energy and carbon impacts at varying percentages of energy recovery
2. Construction Phase
3. Use Phase

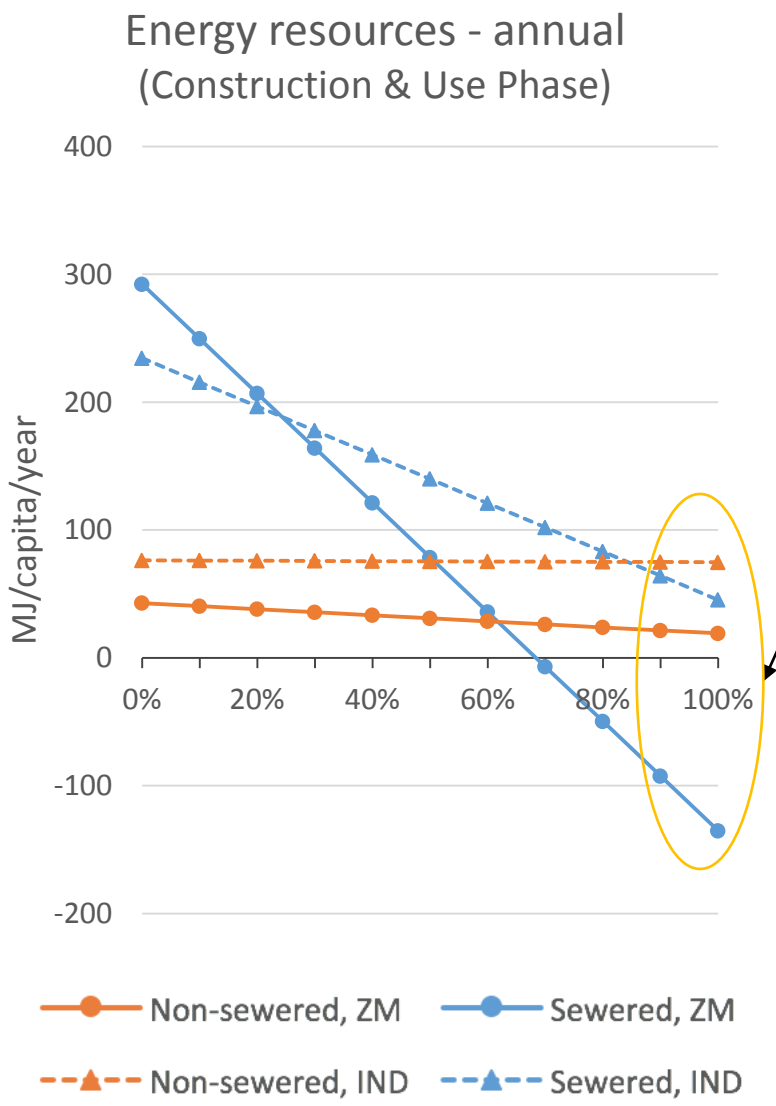
Findings: Energy and carbon *per* % energy recovery



NON-SEWERED: Lower per-capita energy required at no energy recovery

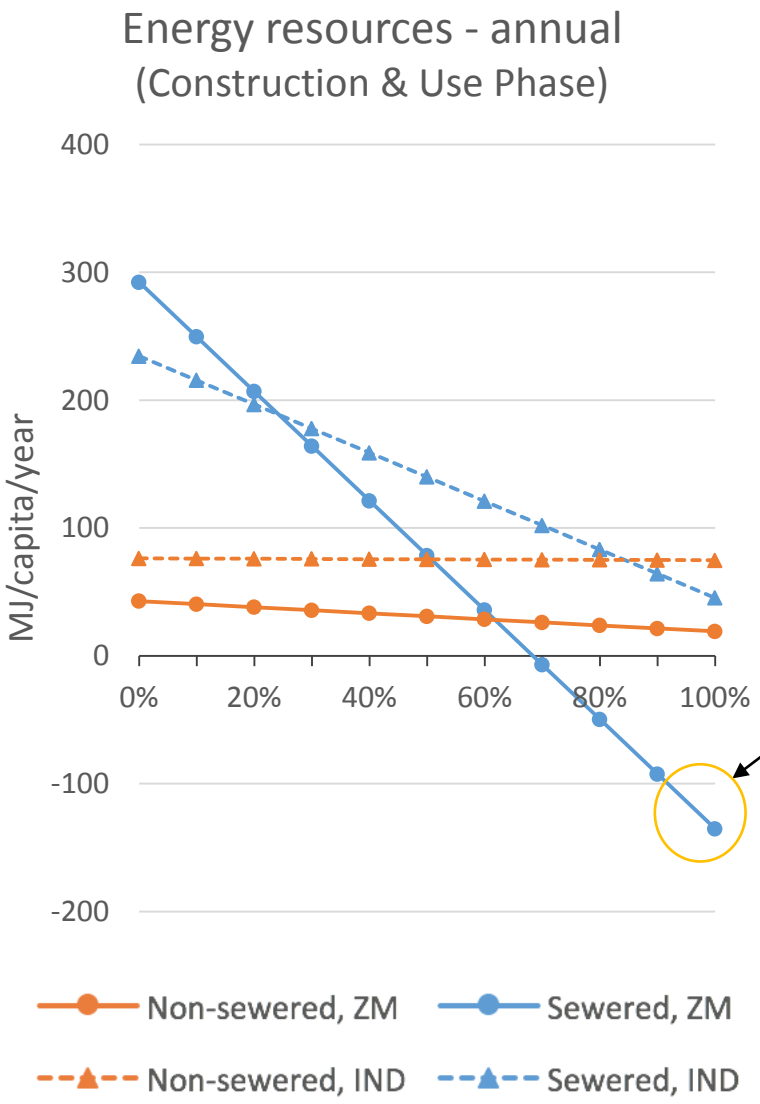
(100MJ ~ 3L Diesel)

Findings: Energy and carbon *per* % energy recovery



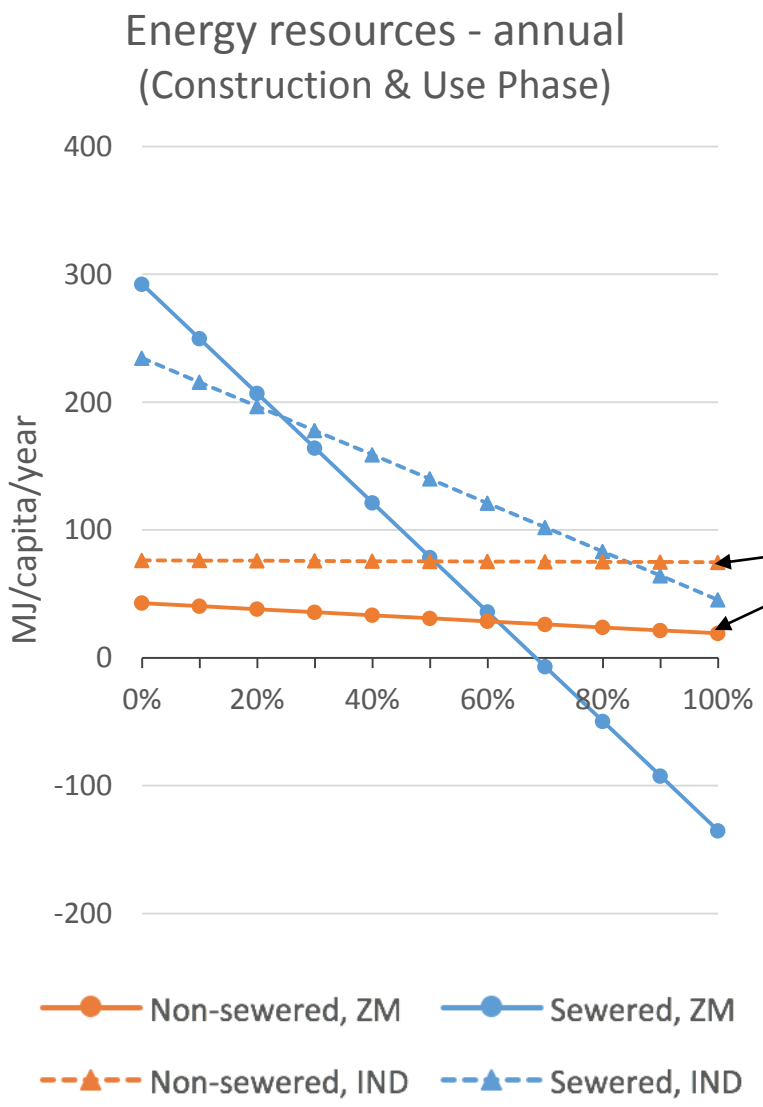
SEWERED: Greater potential to reduce energy resources at 100% energy recovery

Findings: Energy and carbon *per* % energy recovery



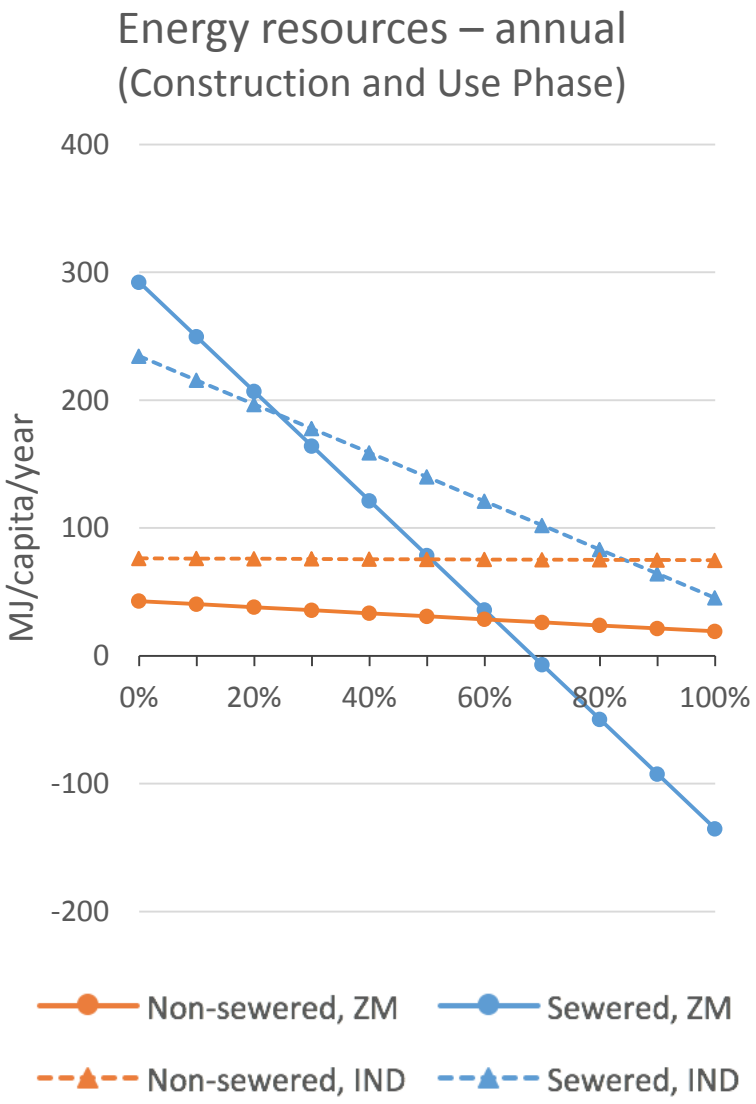
Sewered, Zambia: greatest potential to reduce energy (charcoal replaced)

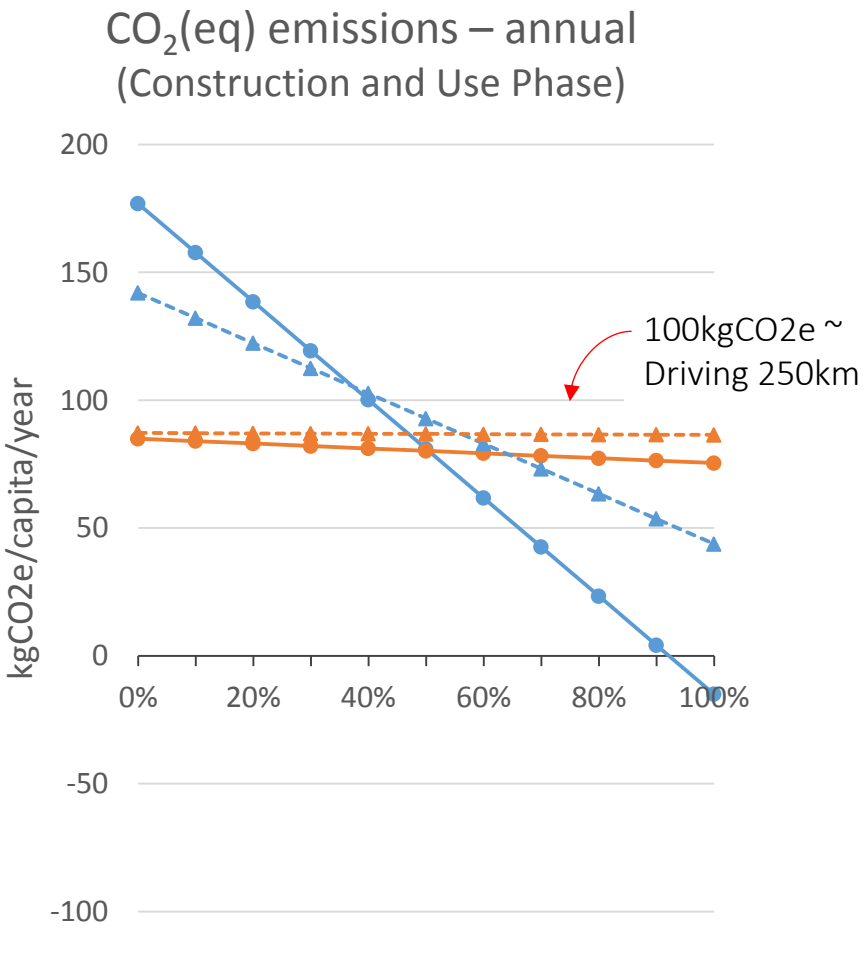
Findings: Energy and carbon *per* % energy recovery



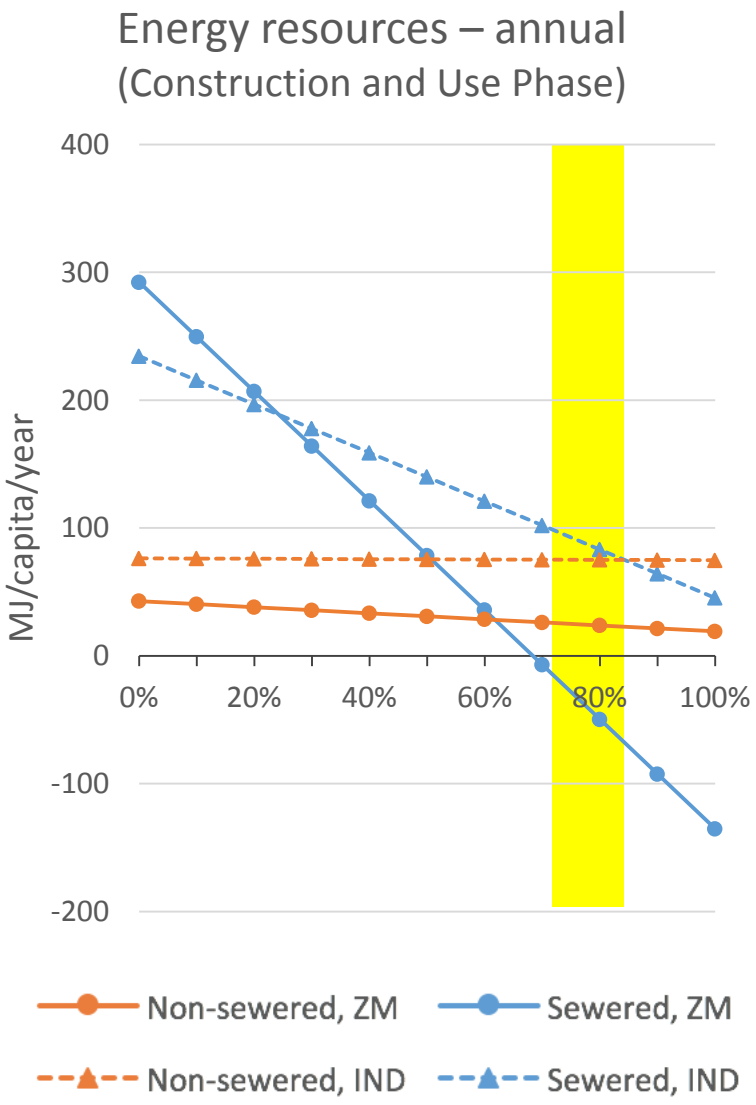
NON-SEWERED: Minimal potential to reduce per-capita energy resources *(most biogas lost during containment)*

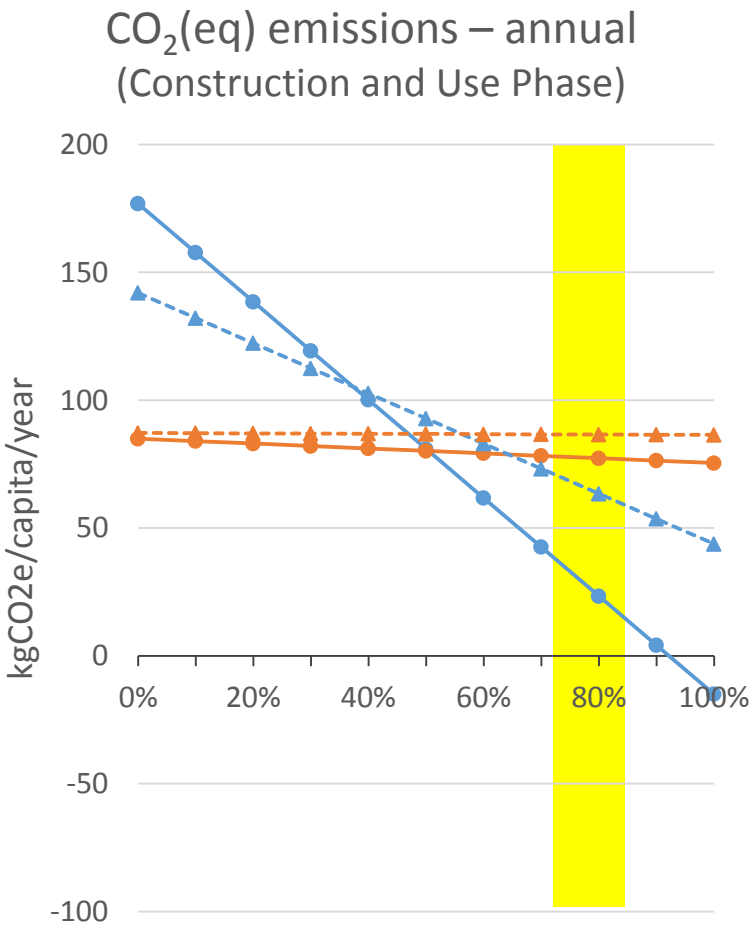
Findings: Energy and carbon *per* % energy recovery



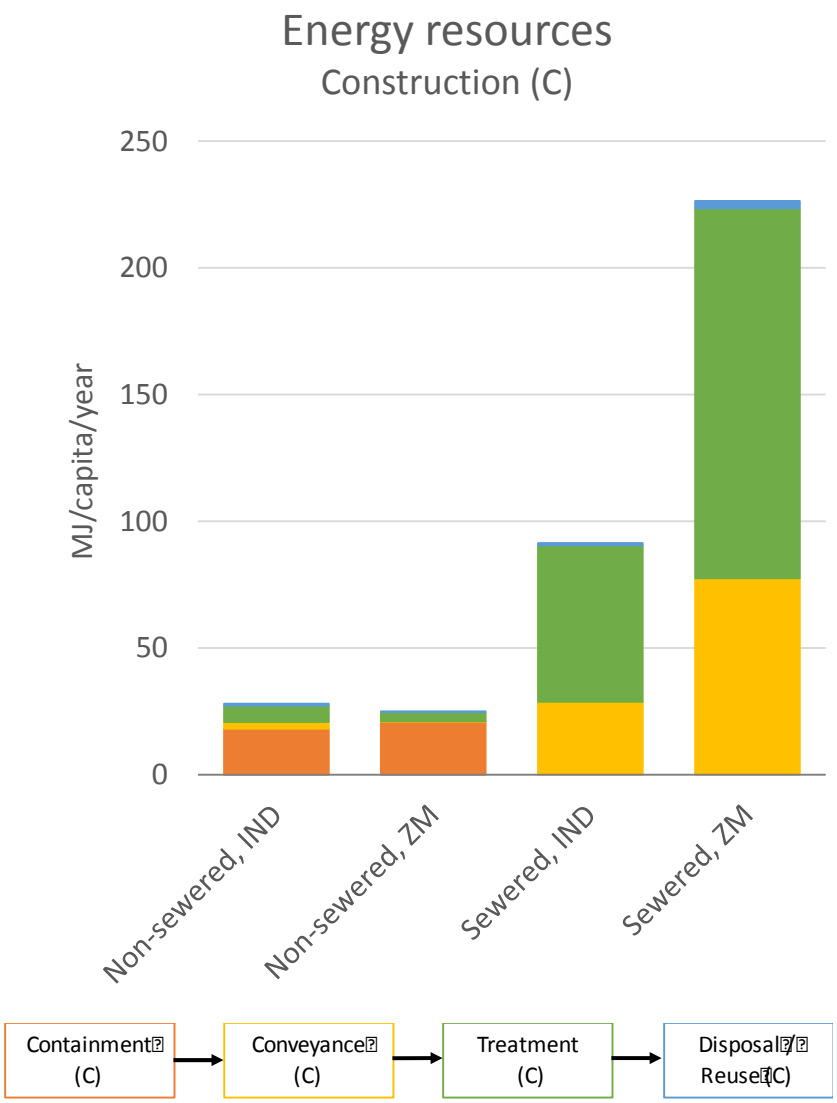


Findings: Energy and carbon *per* % energy recovery





Construction: energy and carbon impacts



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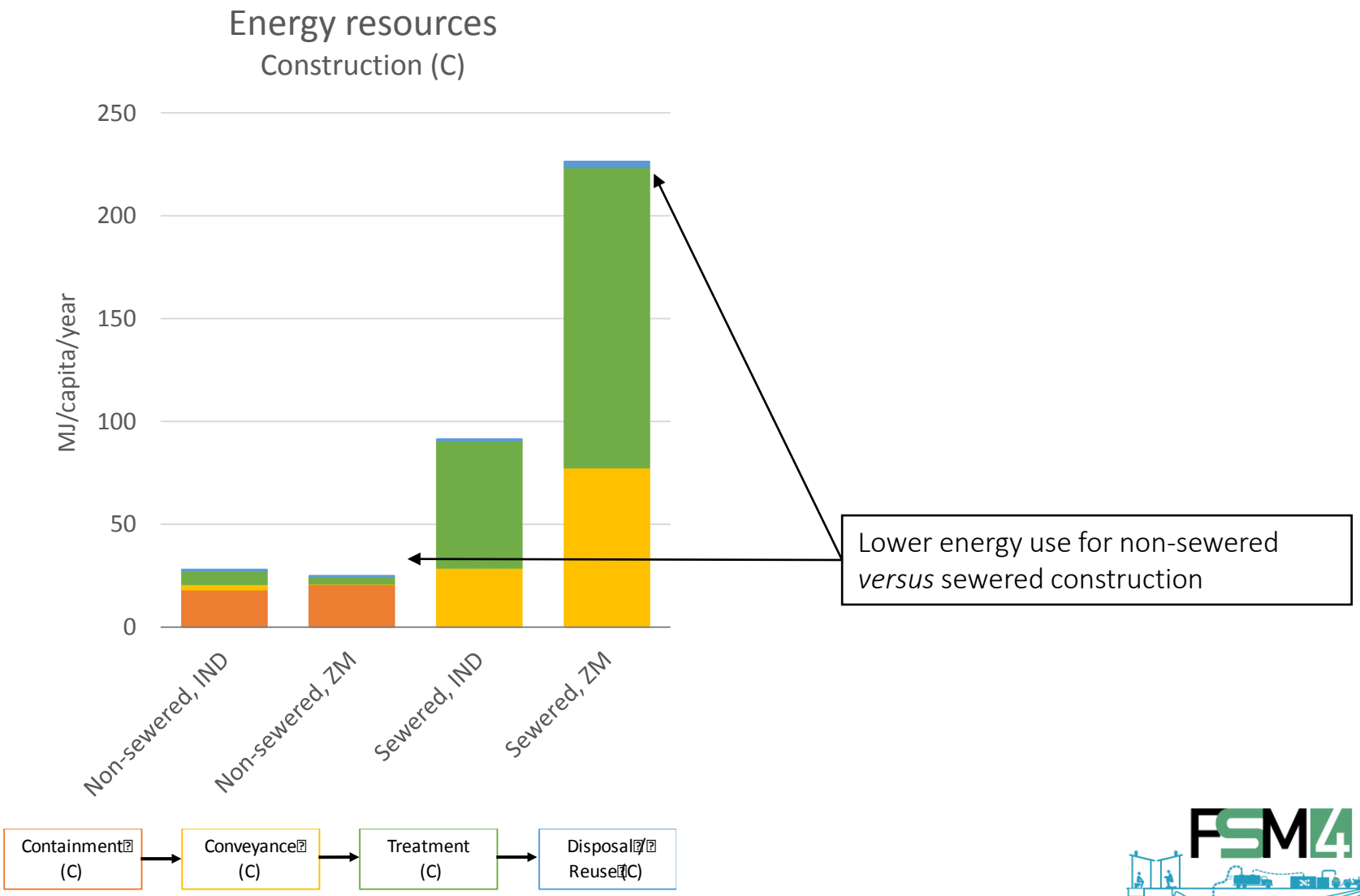
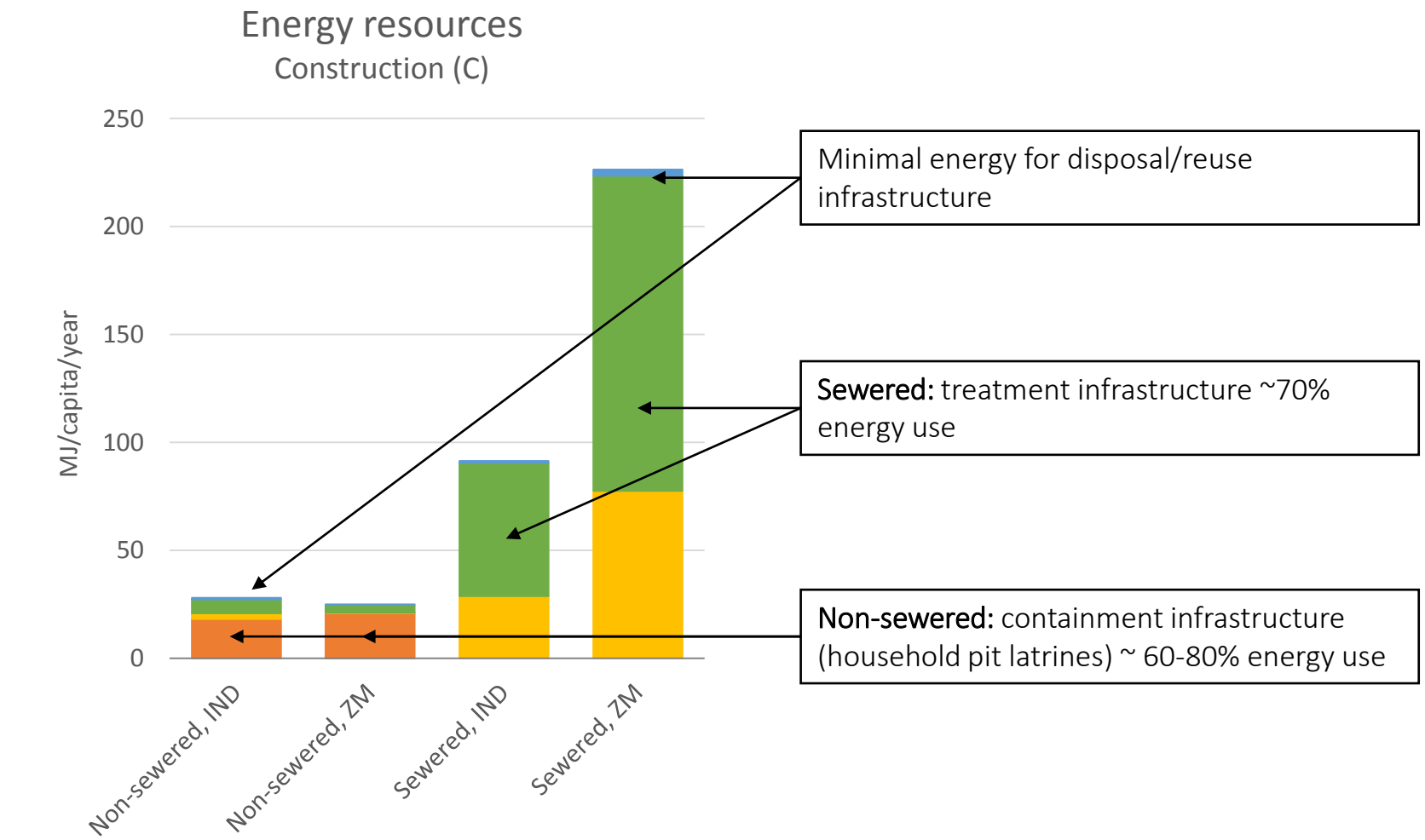
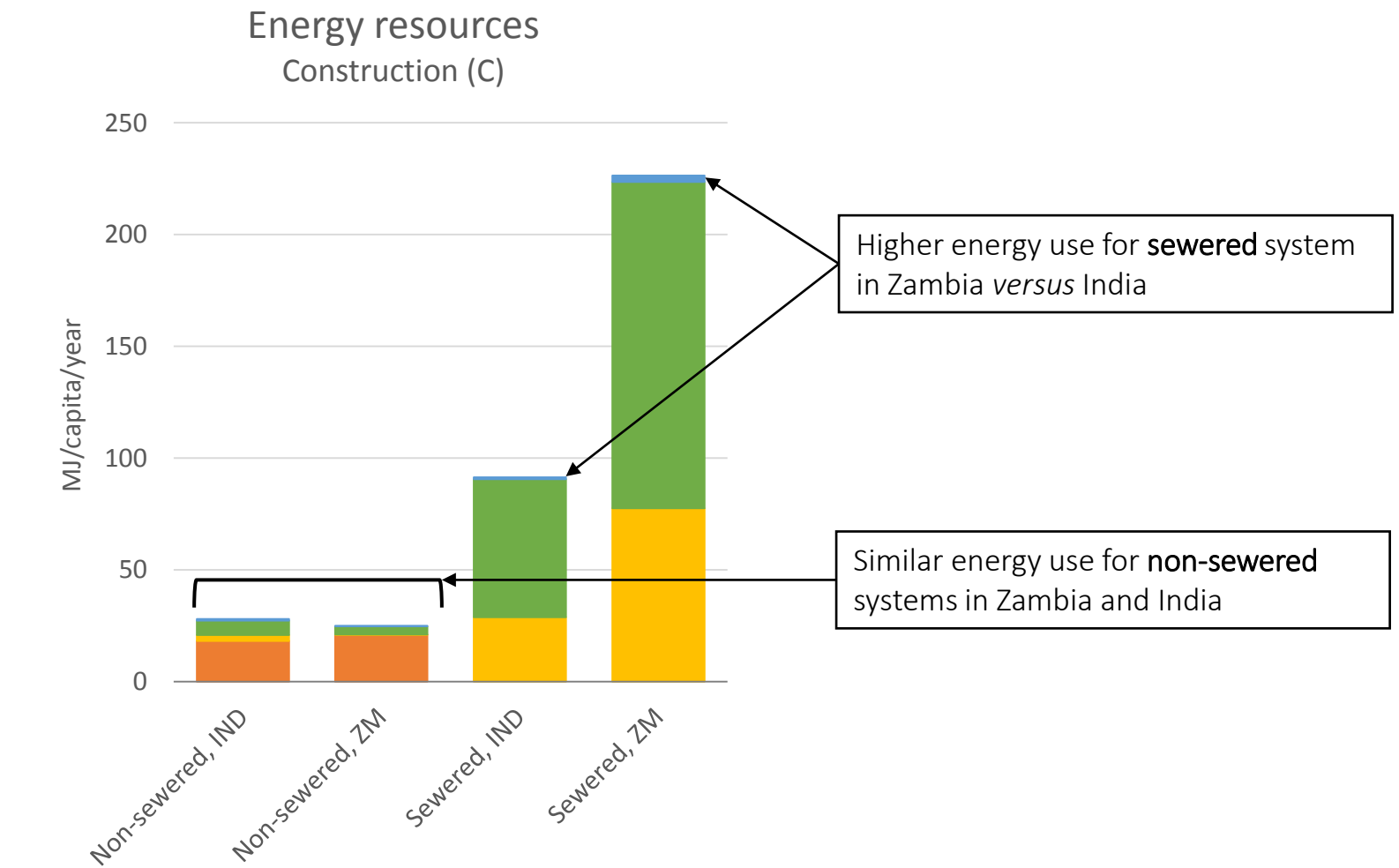


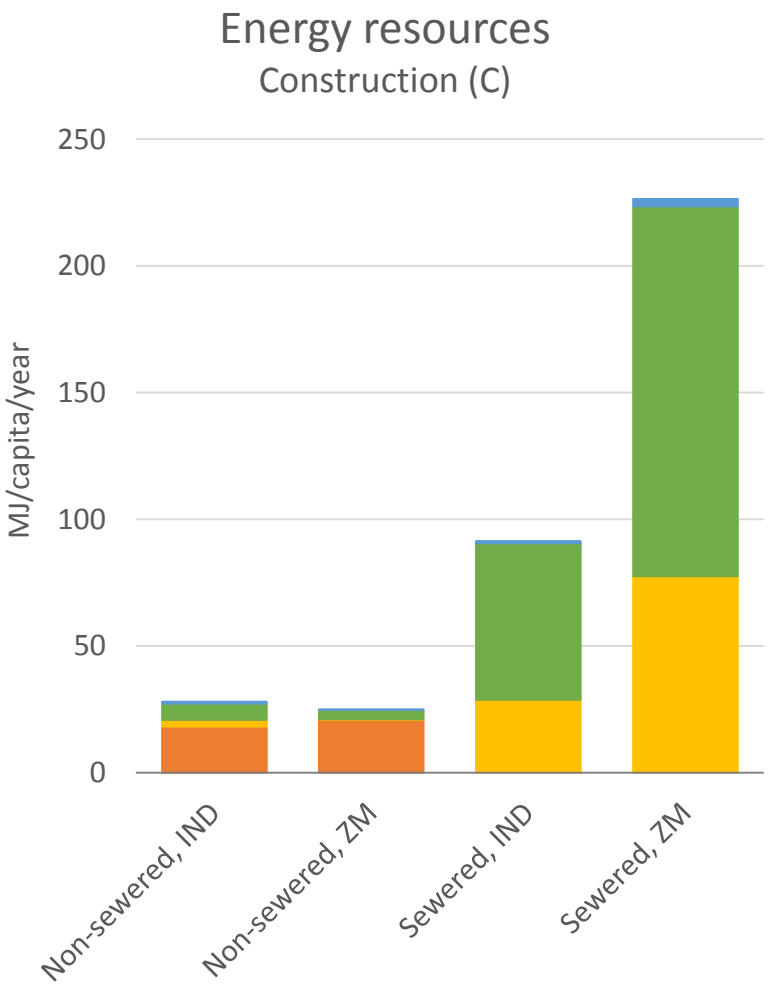
Construction: energy and carbon impacts

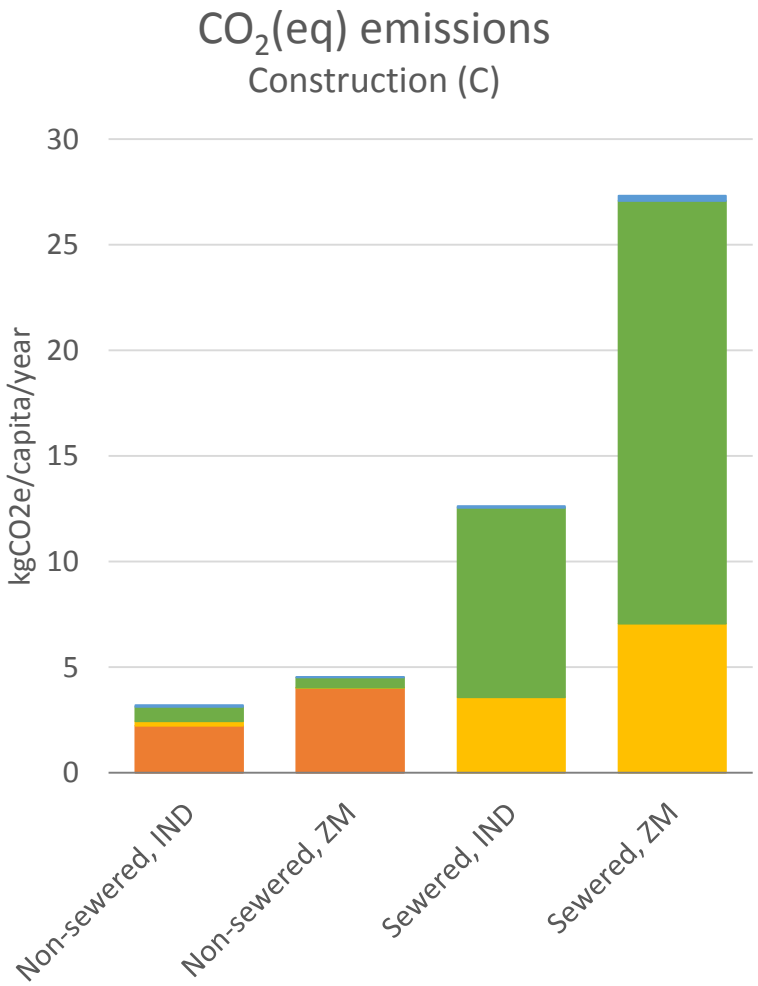


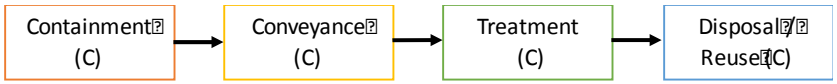
Construction: energy and carbon impacts



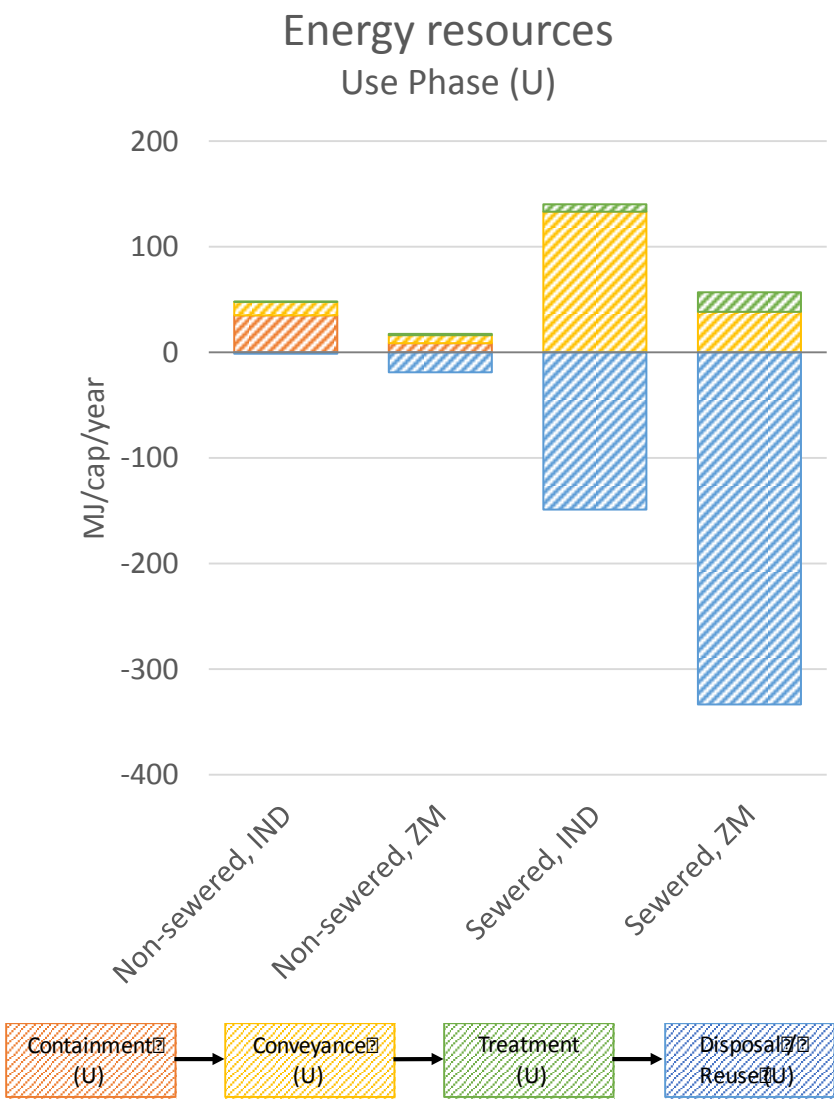
Construction: energy and carbon impacts







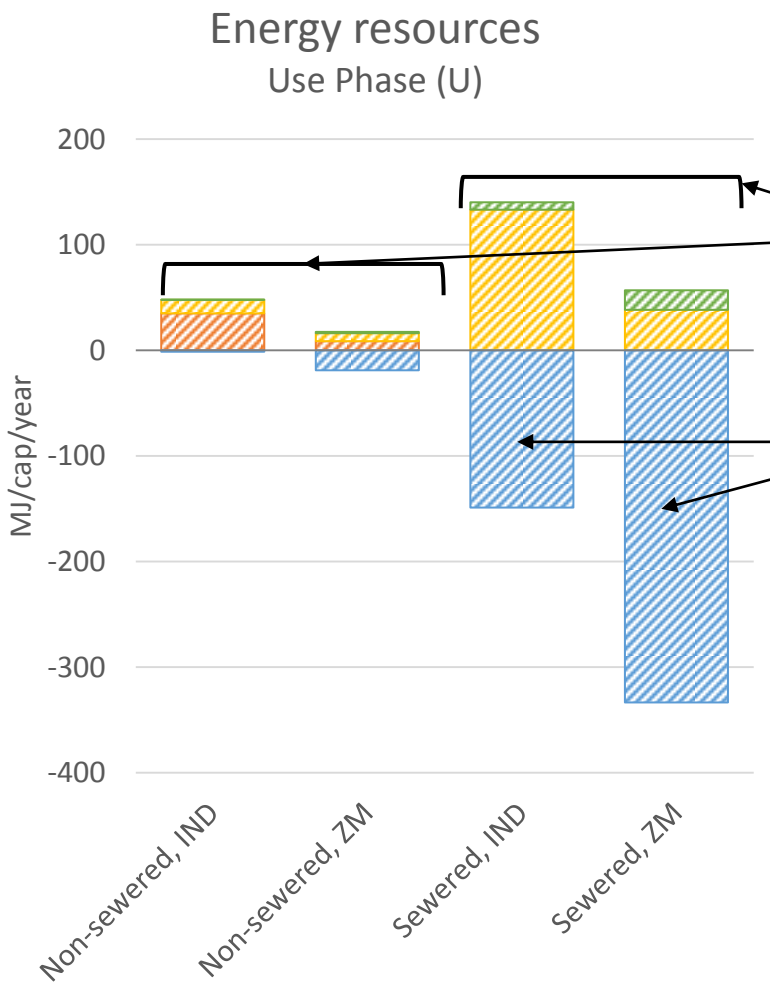
Use phase: energy and carbon impacts



Assumptions ('realistic' scenario):

- 80% biogas production recovered
- Conventional fuel offset per energy content and fuel efficiency

Use phase: energy and carbon impacts

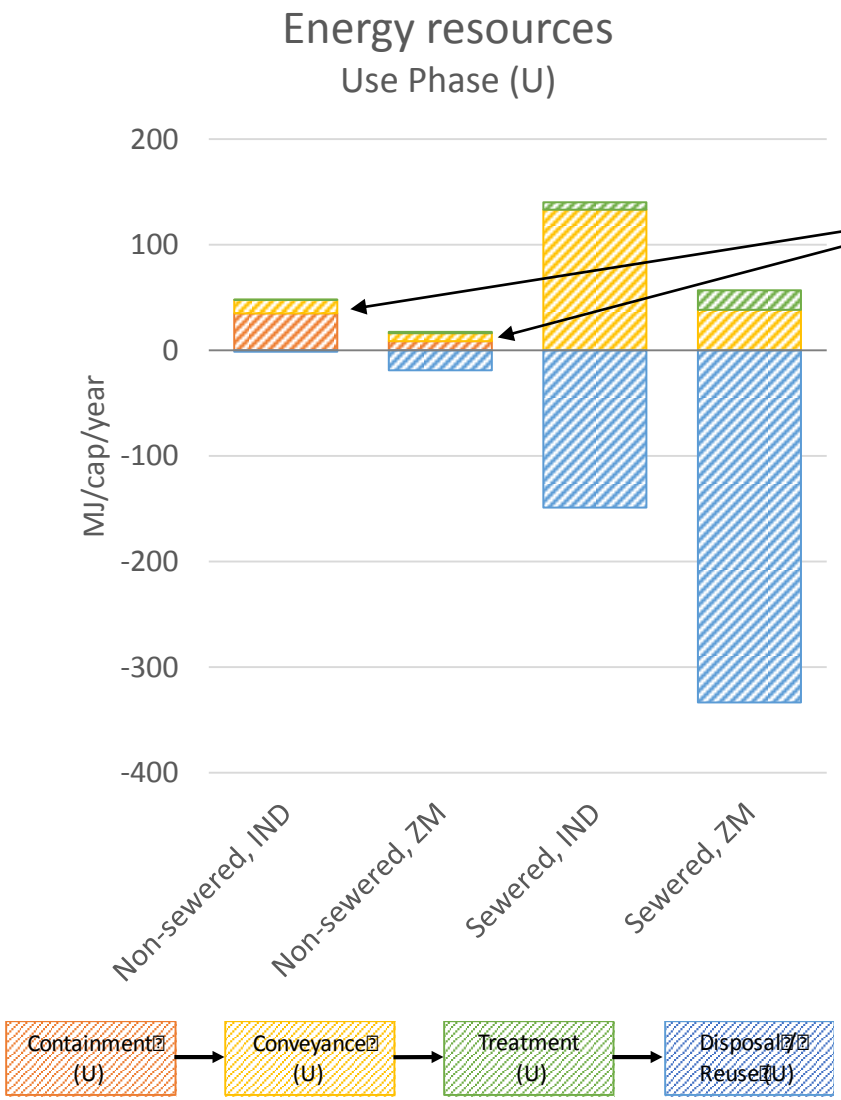


Lower energy requirements for non-sewered *versus* sewered systems

Sewered - higher potential energy recovery:

- Most biogas lost during containment phase (non-sewered)
- Higher energy recovery for Zambia system due to charcoal use

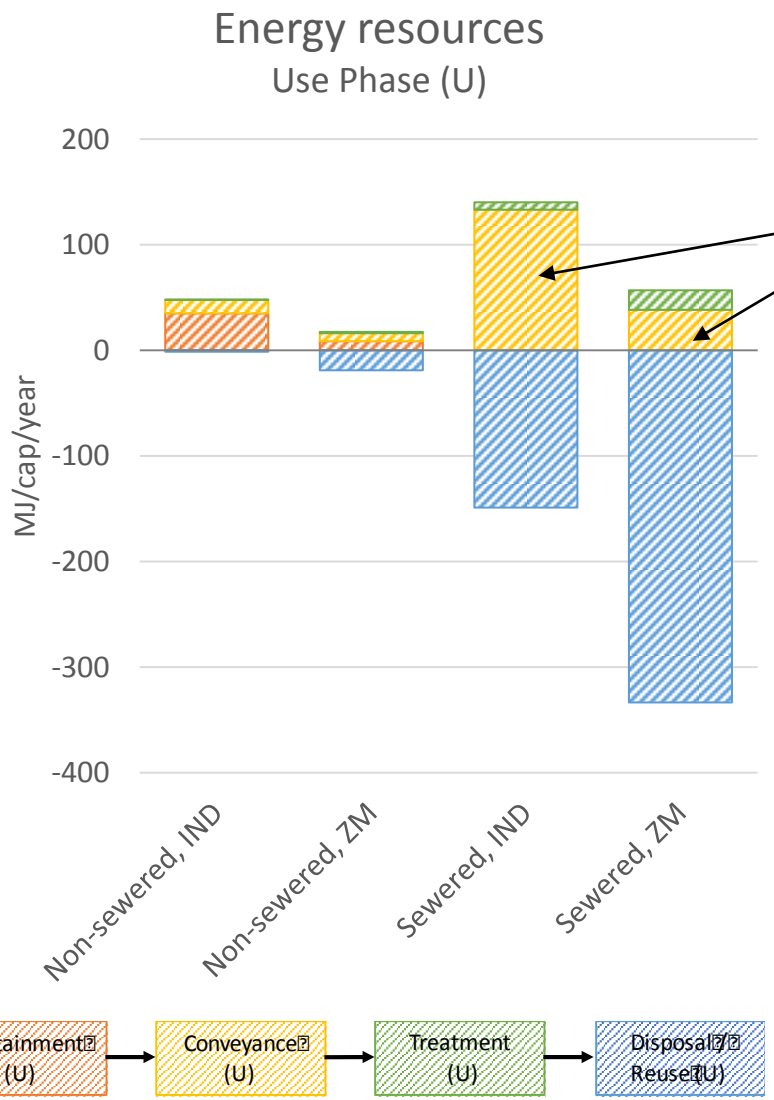
Use phase: energy and carbon impacts



Non-sewered systems:

- Minimal energy use for conveyance

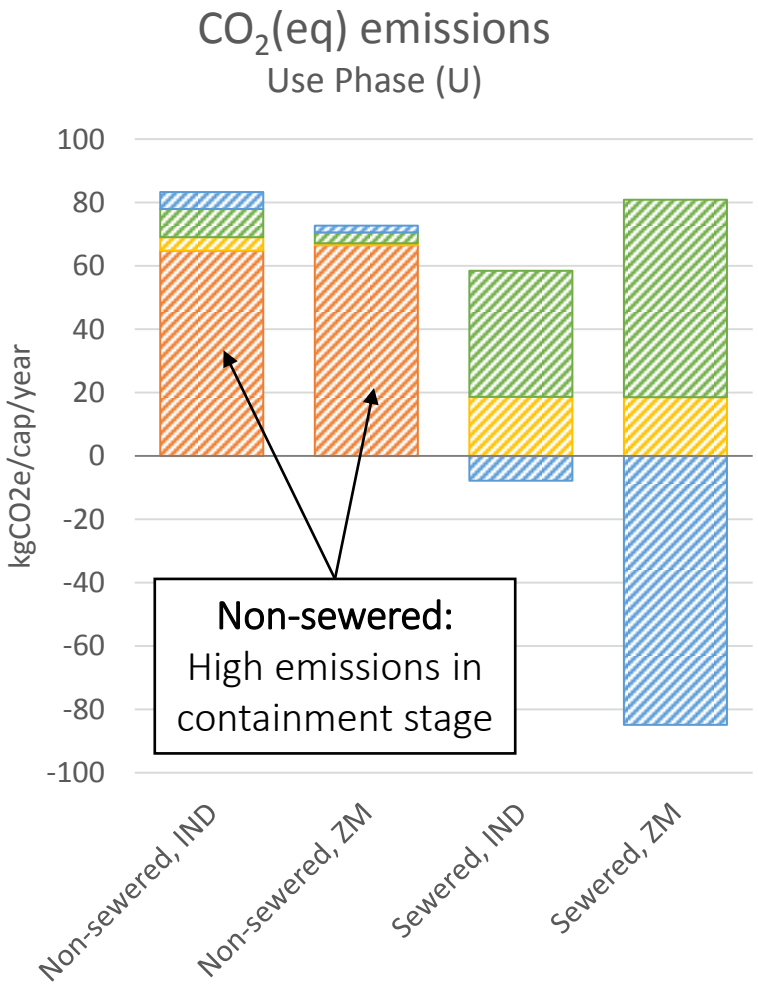
Use phase: energy and carbon impacts

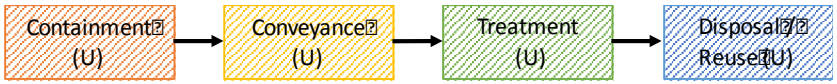


Sewered systems:

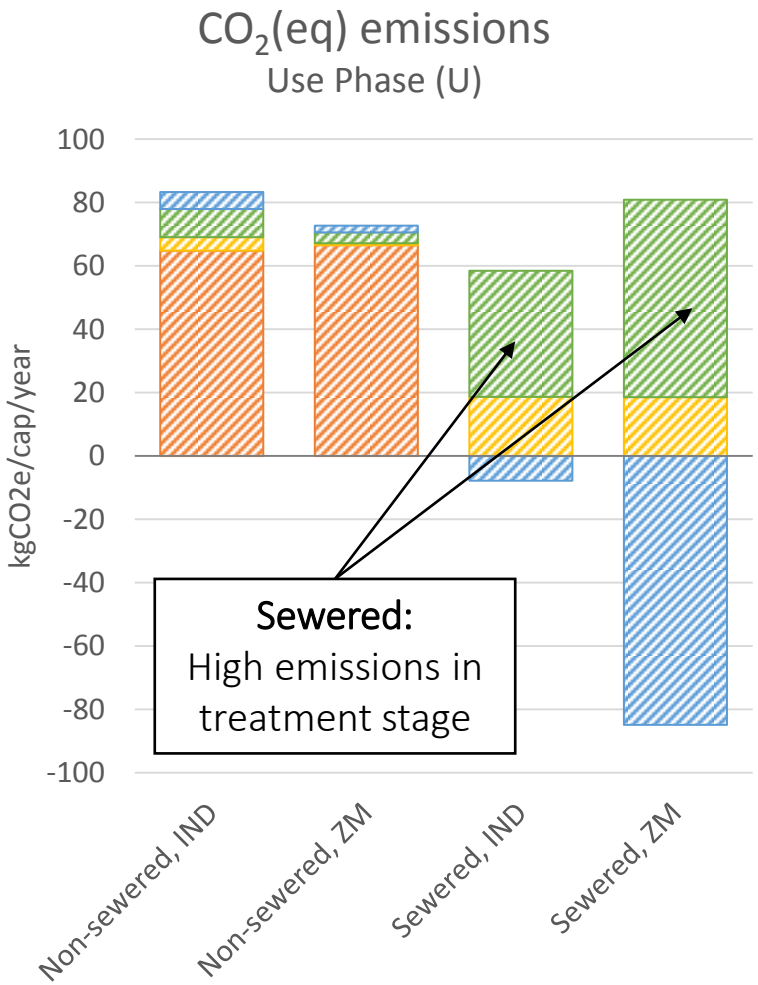
- Conveyance (water supply): 60-90% energy use
- Higher for India system due to water supply *via* deep borehole and tanker truck
- Minimal energy use for treatment

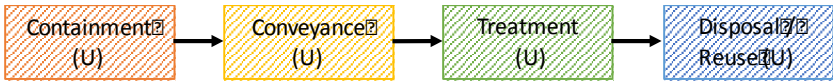
Use phase: energy and carbon impacts



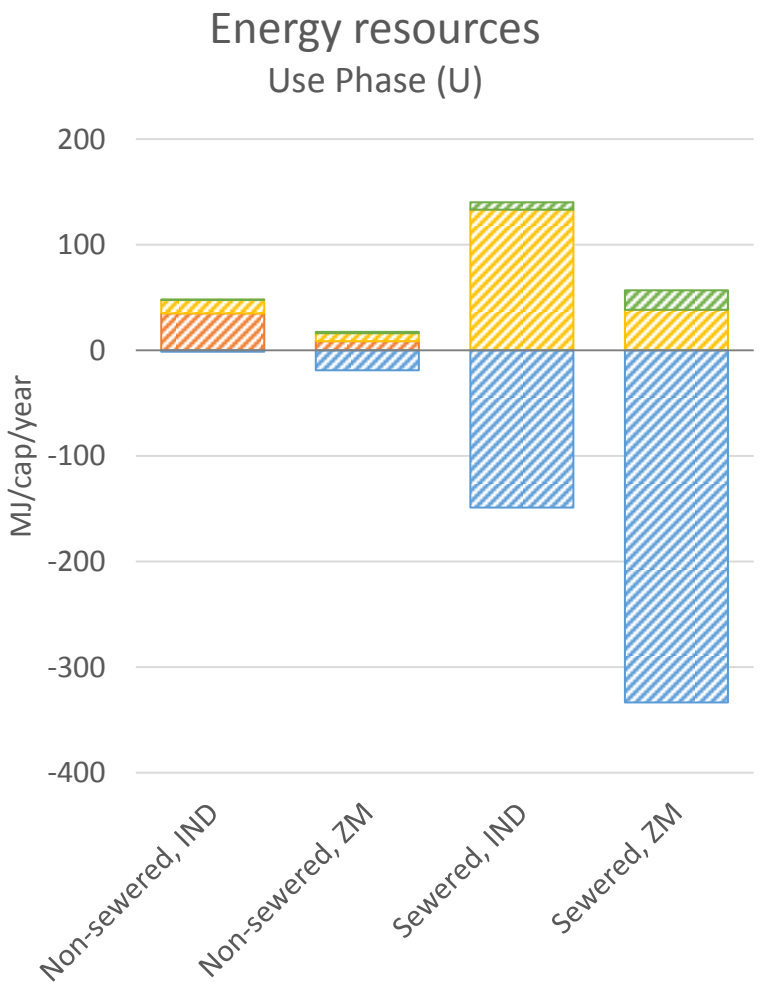


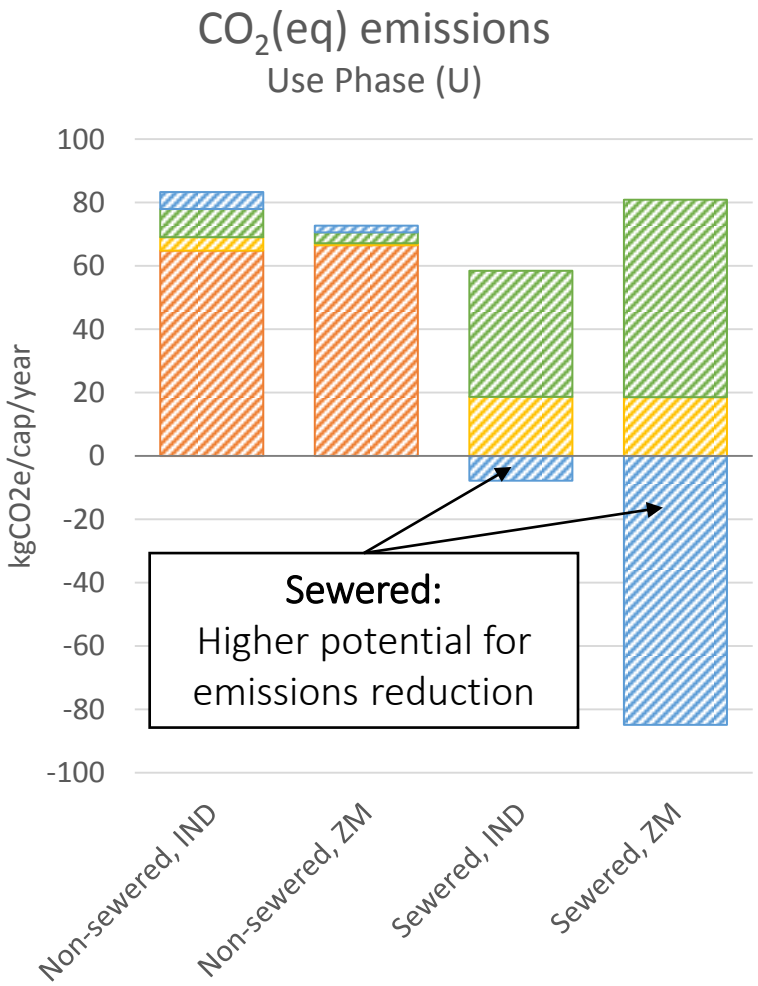
Use phase: energy and carbon impacts

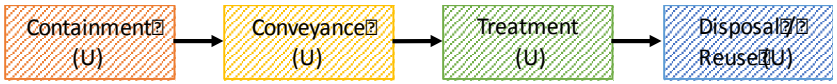




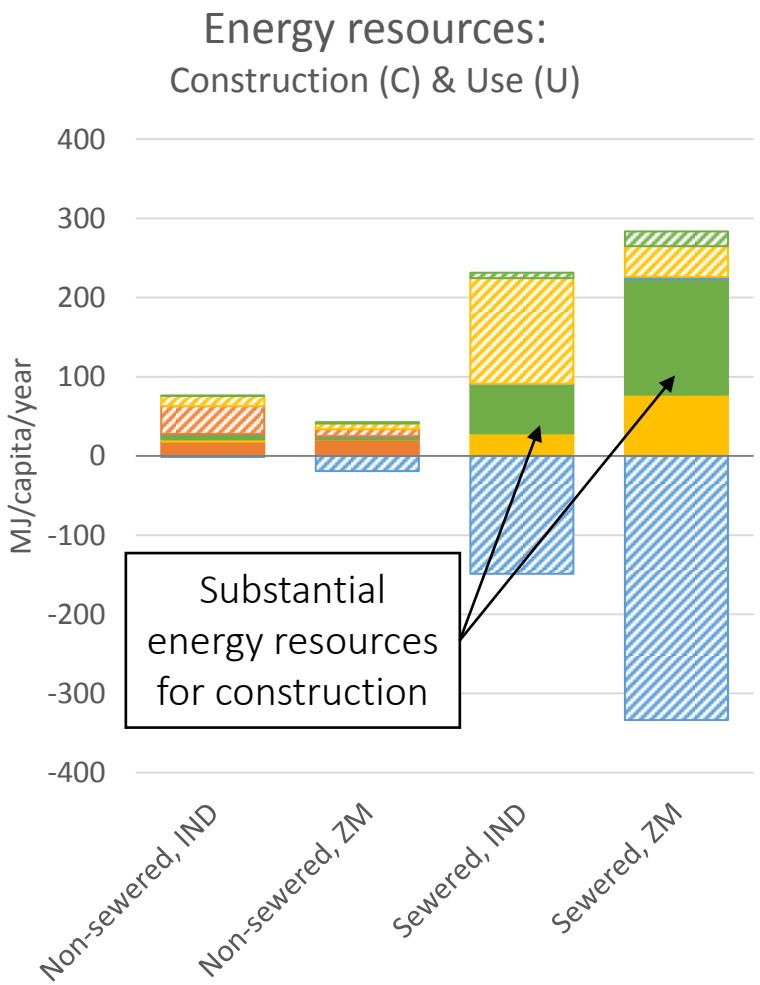
Use phase: energy and carbon impacts

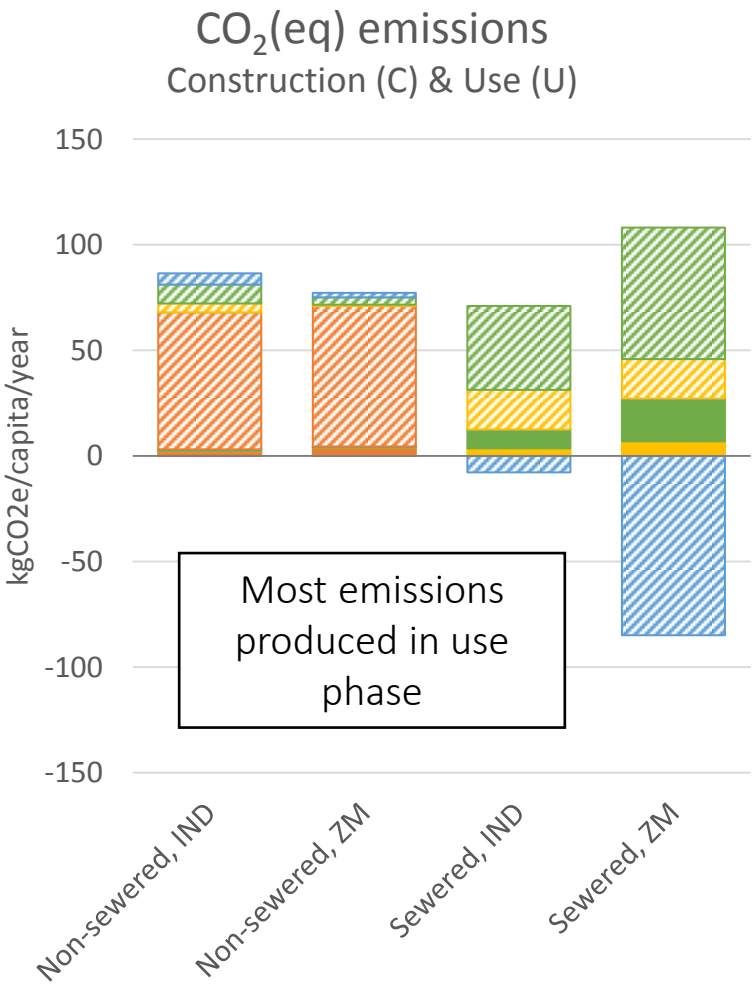




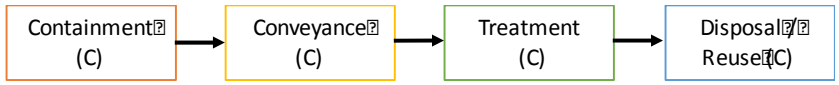


Combined construction and use phase

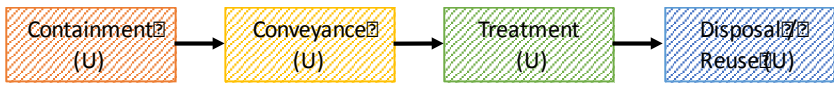




Construction phase:



Use phase:



Key takeaways – what matters?

- **Non-sewered:**
  1) Substantial carbon emissions during **containment**
  2) Minimal impact from **motorized conveyance**
  3) Minimal potential to reduce energy and carbon impacts *via* biogas recovery

- **Sewered:**
  1) **Water supply** may have a substantial impact on energy use
  2) **Anaerobic treatment** may produce substantial CO_2(eq) emissions
  3) **Biogas recovery** can substantially reduce energy use and CO_2(eq) emissions, particularly when replacing inefficient fuels

Thank you

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Net energy and carbon impacts