TREASoURcE

# Applying system dynamics sustainability assessment (SDSA) to circular economy solutions in cities and regions: 3 different cases

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GreenDelta

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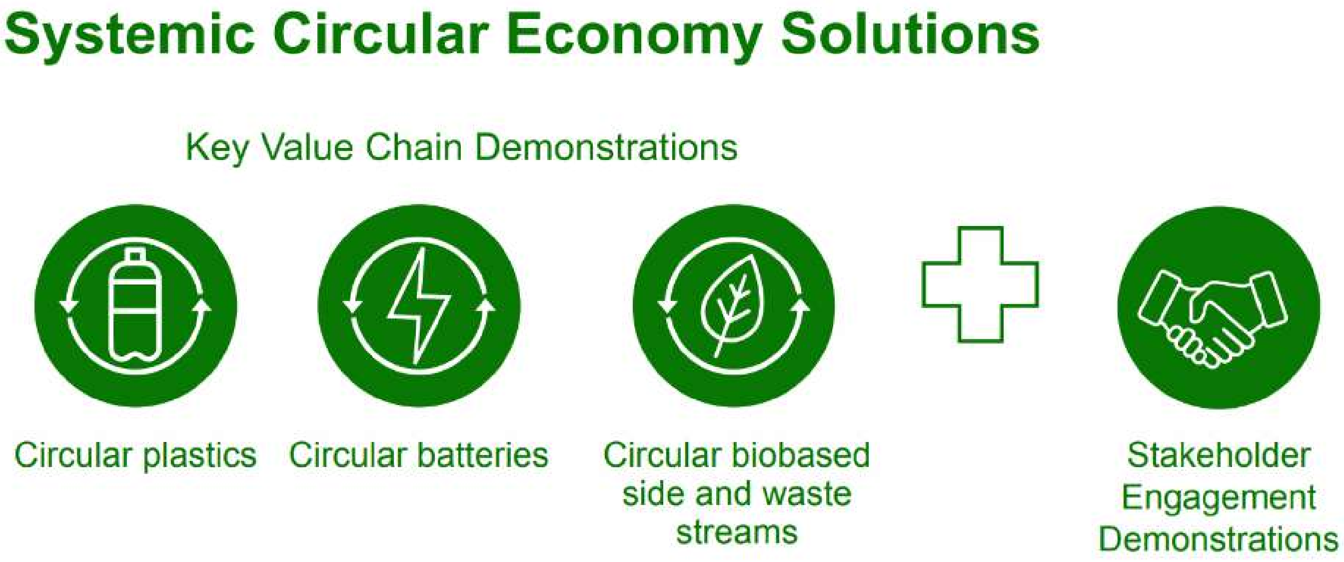
# Motivation




- The TREASoURcE project is demonstrating and replicating circular economy solutions for 3 key value chains (plastics, batteries, biomass) in selected regions and municipalities
- A context-based sustainability assessment approach is needed
- This will allow localized decision-making for sustainable solutions

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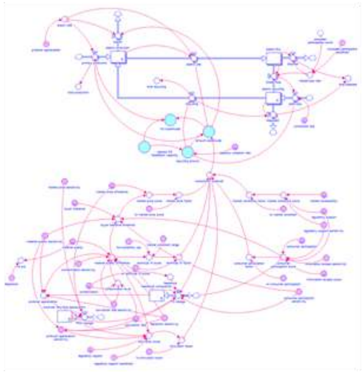
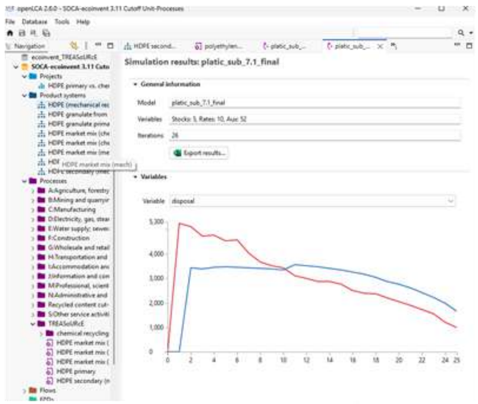
# Method

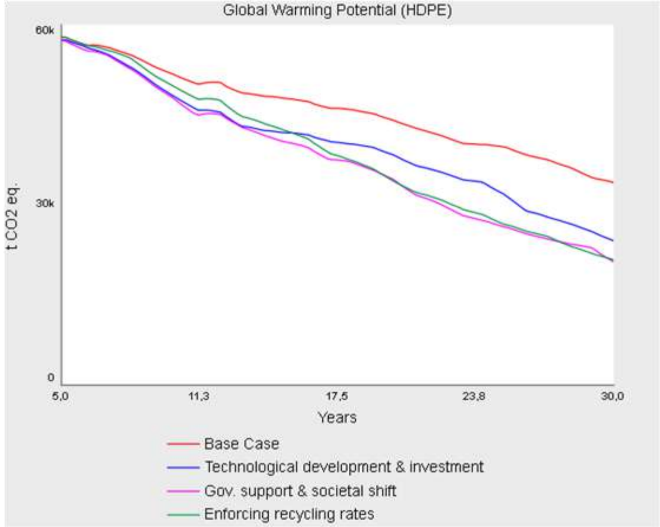
System dynamics + openLCA → Context-specific sustainability assessment of different scenarios over time

System dynamics model



openLCA



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# Case 1
## Circular plastics value chain sustainability assessment

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# SDSA of plastics

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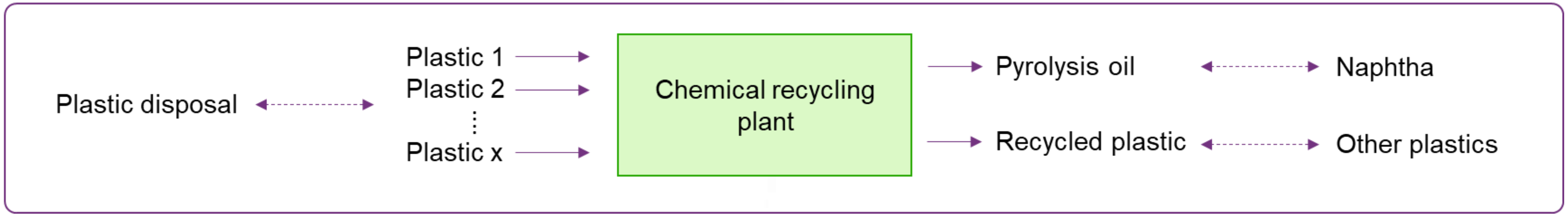
***Goal***: The goal is to assess the introduction of a chemical recycling plant in terms of its environmental impact.

***Region***: Gothenburg, Sweden

***Material flows***: Agricultural, industrial, and municipal plastics: high-density polyethylene (HDPE), low-density polyethylene (LDPE), polypropylene (PP) and polyethylene terephthalate (PET).

***System boundaries***:

System: Chemical recycling in Gothenburg, Sweden

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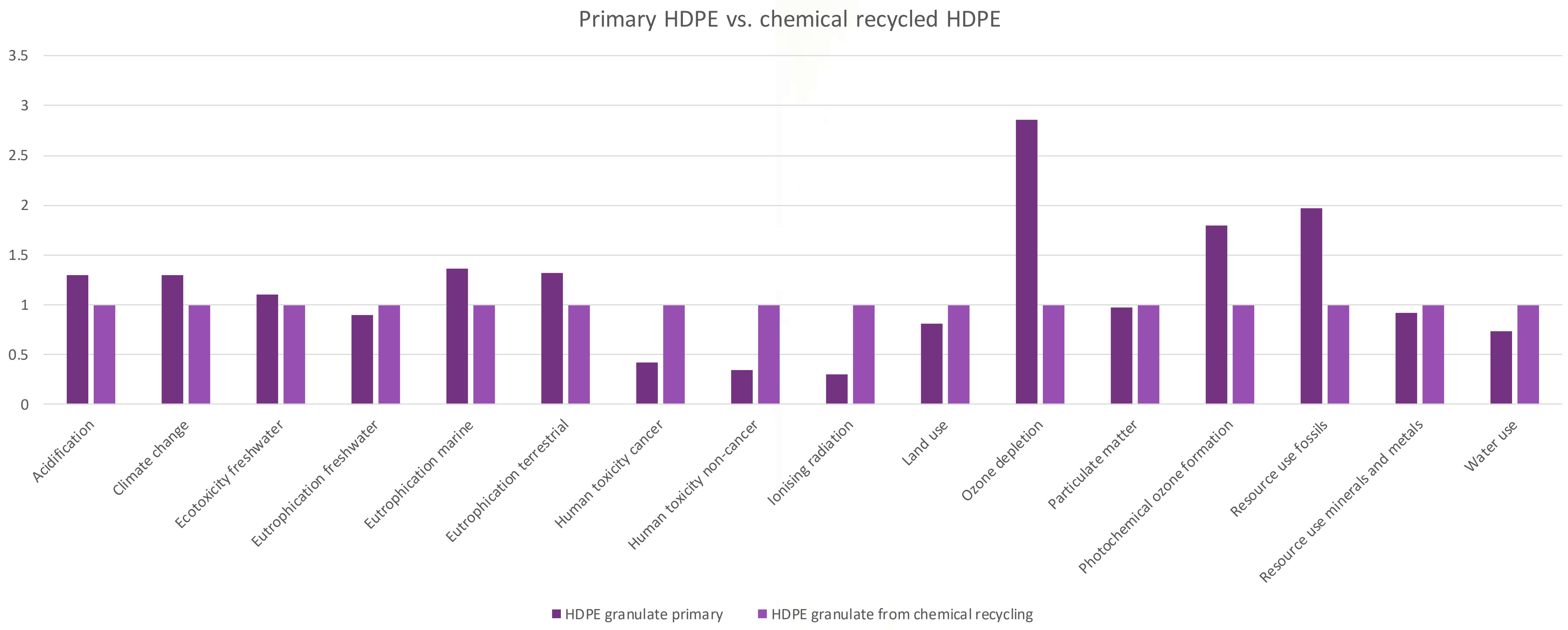
# Plastics – LCA results

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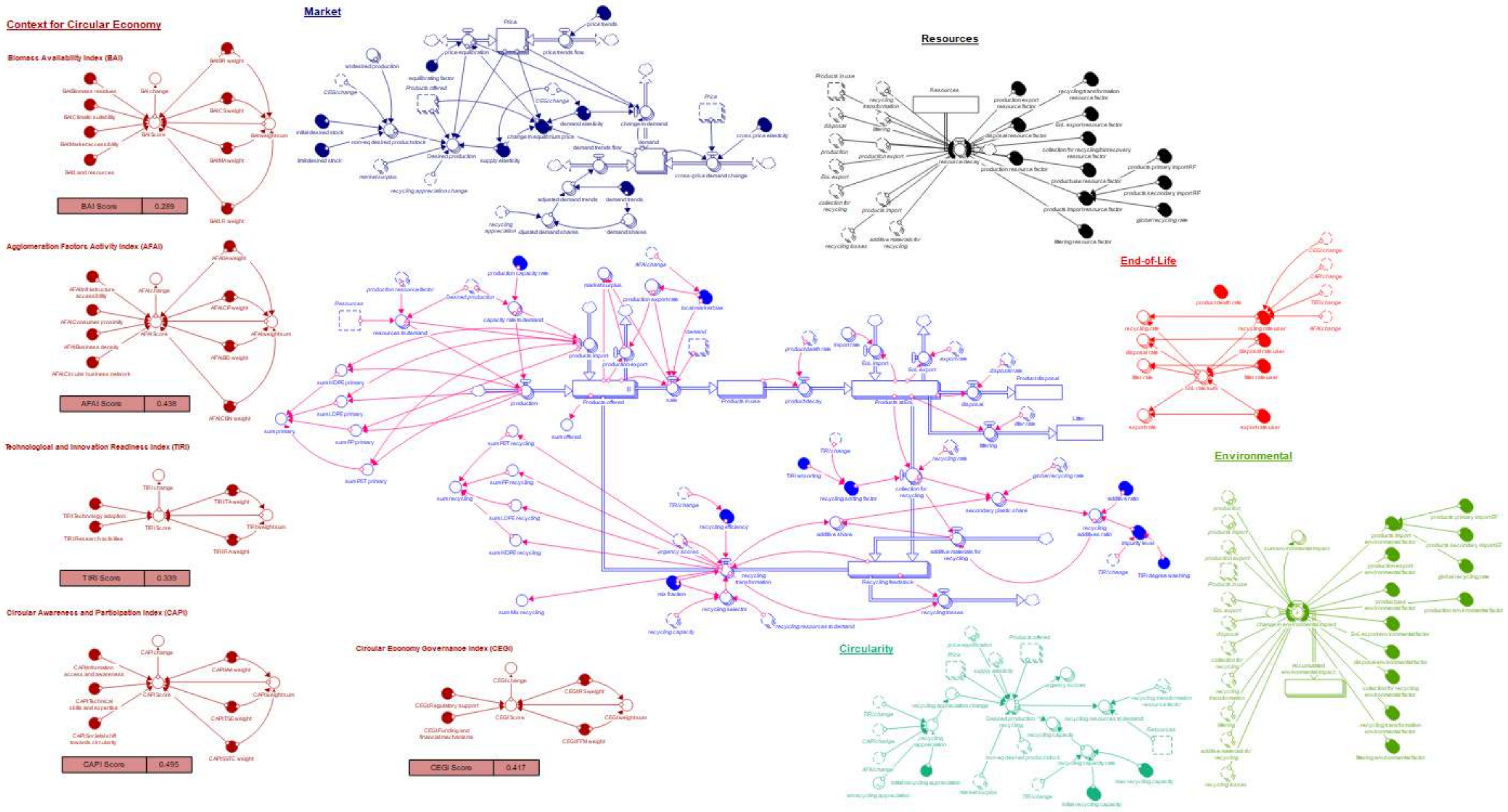
# Plastics – System dynamics model



# Plastics – Assessed scenarios

1. Business as usual (BAU), where demand trends follow historic trends and there is only a minor increase of recycling rates over time.
2. Increasing chemical recycling (CR) capacity. This increases chemical recycling capacities of the region, thereby introducing new products to the market.
3. Increasing government support (GS) and funding, both for producers and consumers.
4. Increasing consumer awareness (CA) towards the benefits of waste prevention and plastic recycling.

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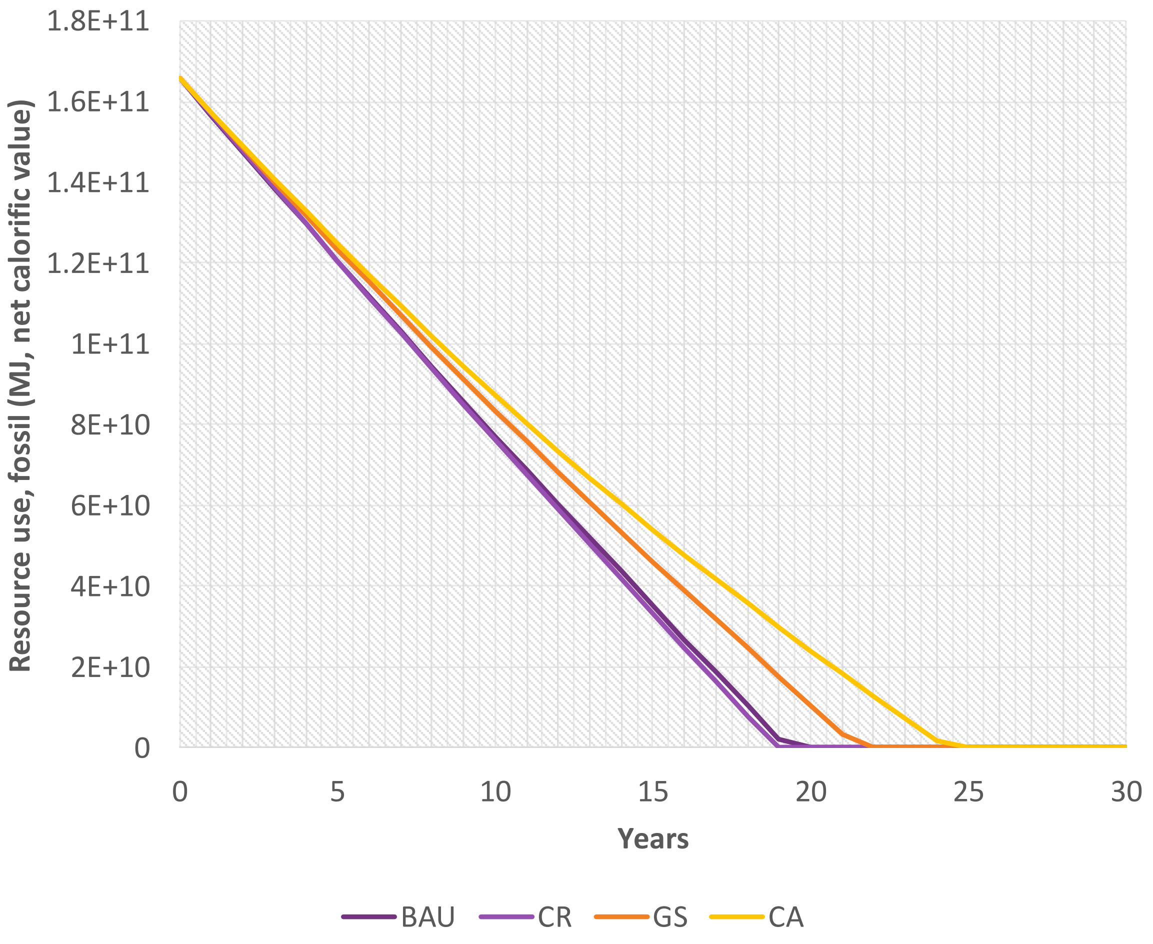
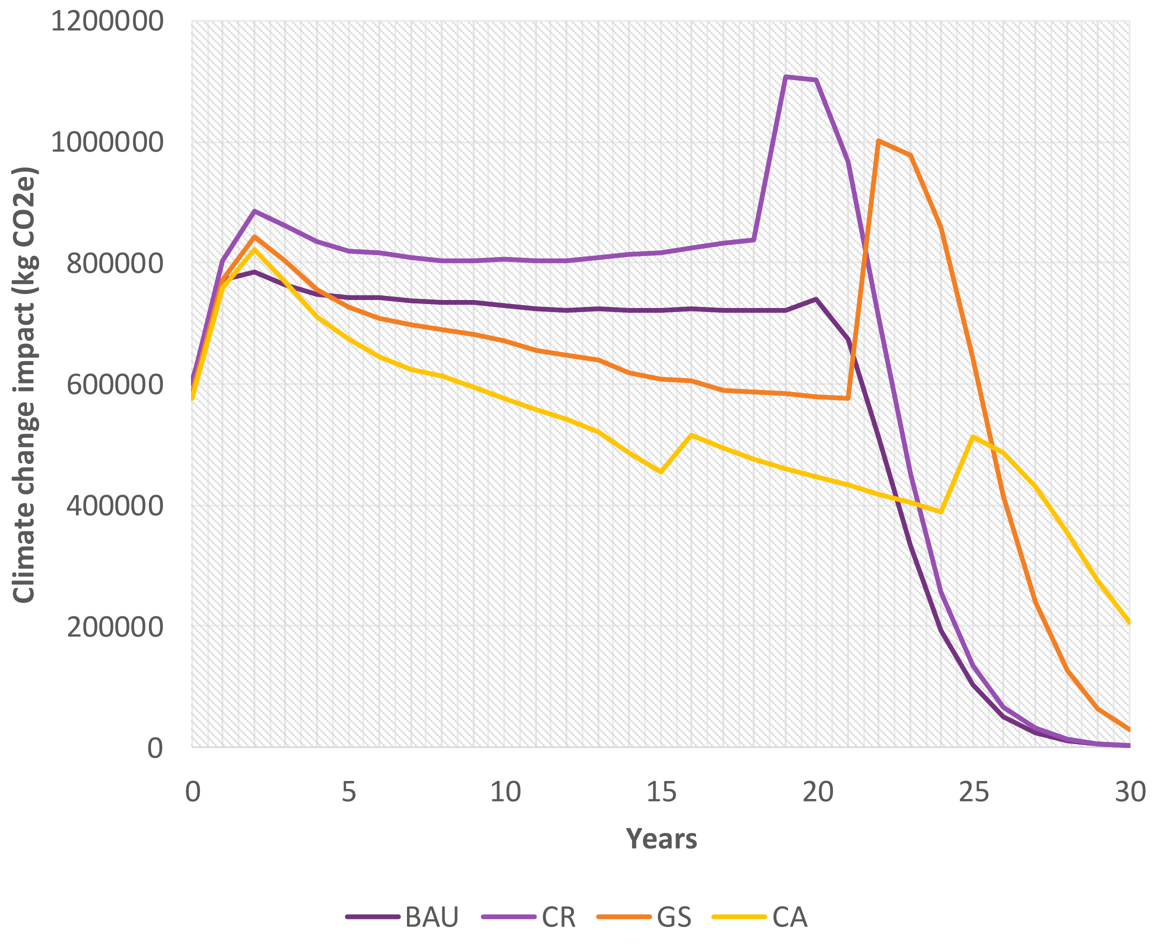
# Plastics – Regional impacts over time

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# Plastics – Conclusion

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- LCA results show a decrease in impact for recycled plastics in several impact categories
- But chemical recycling is not necessarily better when considering the wider system
- Competes with mechanical recycling, resulting in a rebound effect, as more virgin additives are needed
- Improvements only with additional strategies, such as technological development or raising consumer awareness

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# Case 2
Batteries reuse and recycling value chain assessment

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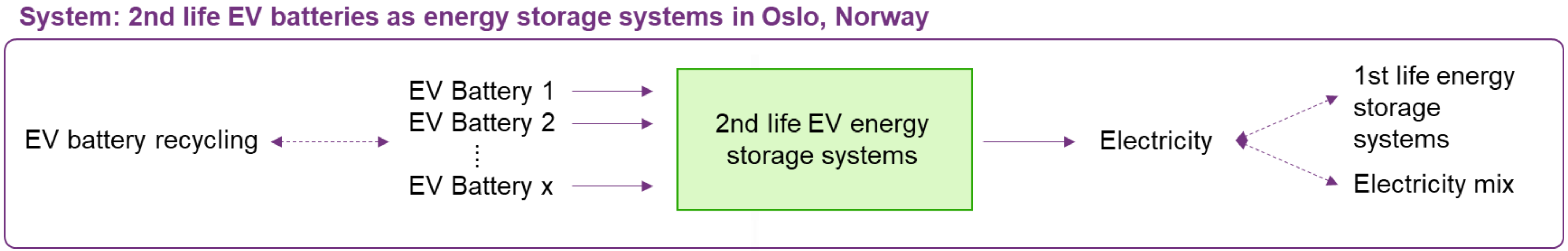
# SDSA of batteries

**_Goal_**: Assess and understand the regional sustainability of repurposing EV batteries into stationary battery energy storage systems (BESS).

**_Region_**: Lempäala, Finland & Stor-Oslo Region, Norway

**_Material flows_**: 4 battery chemistries (EV, ESS, repurposed)

**_System boundaries_**:

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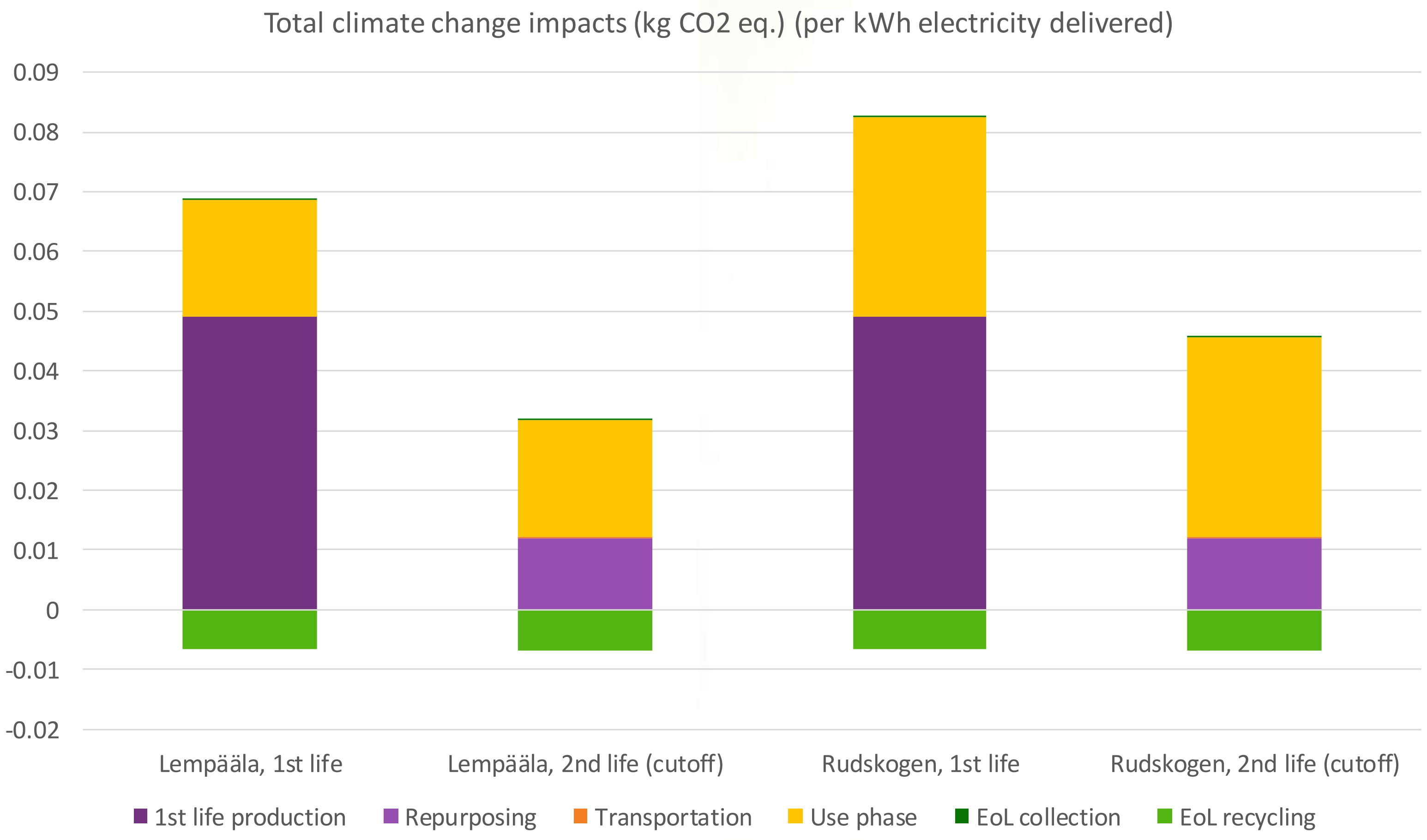
# Batteries – LCA results

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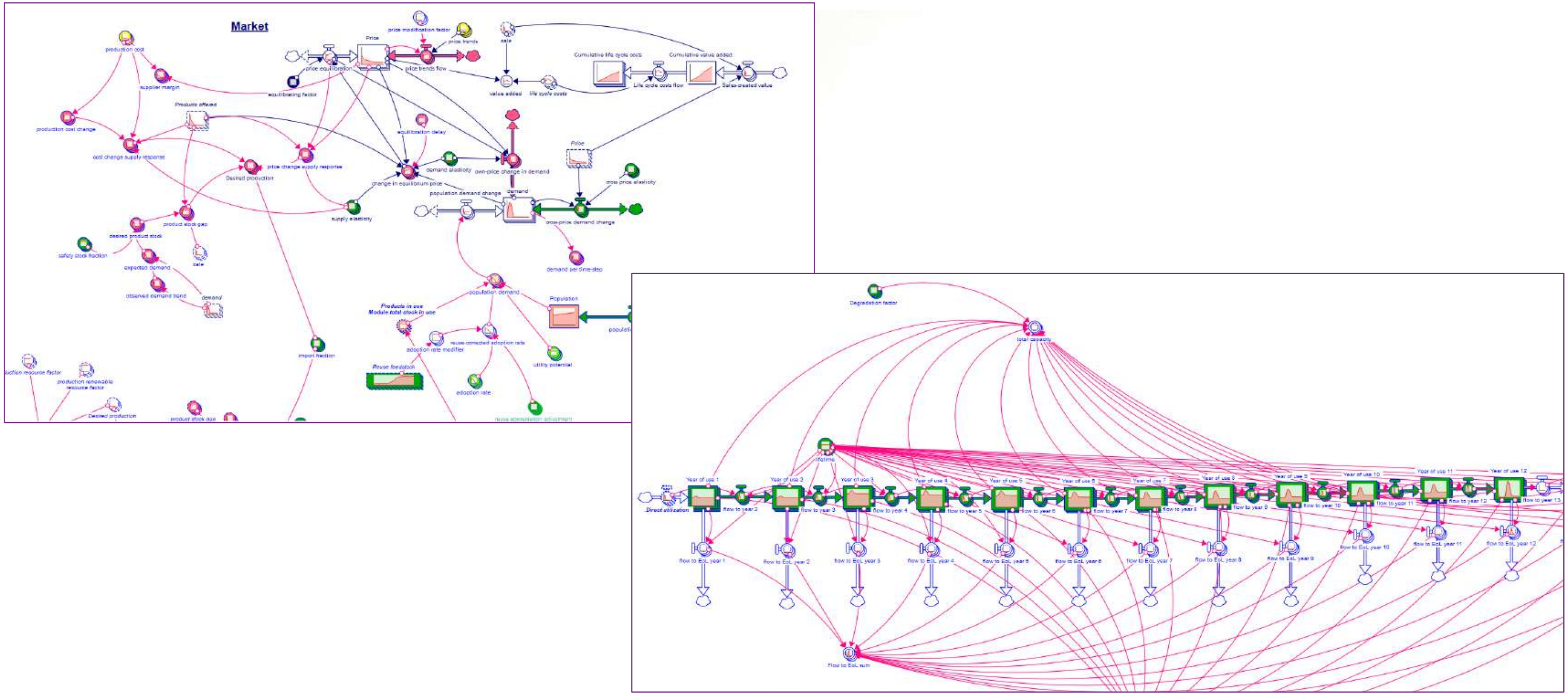
# Batteries – System dynamics model



# Batteries – Regional flows over time

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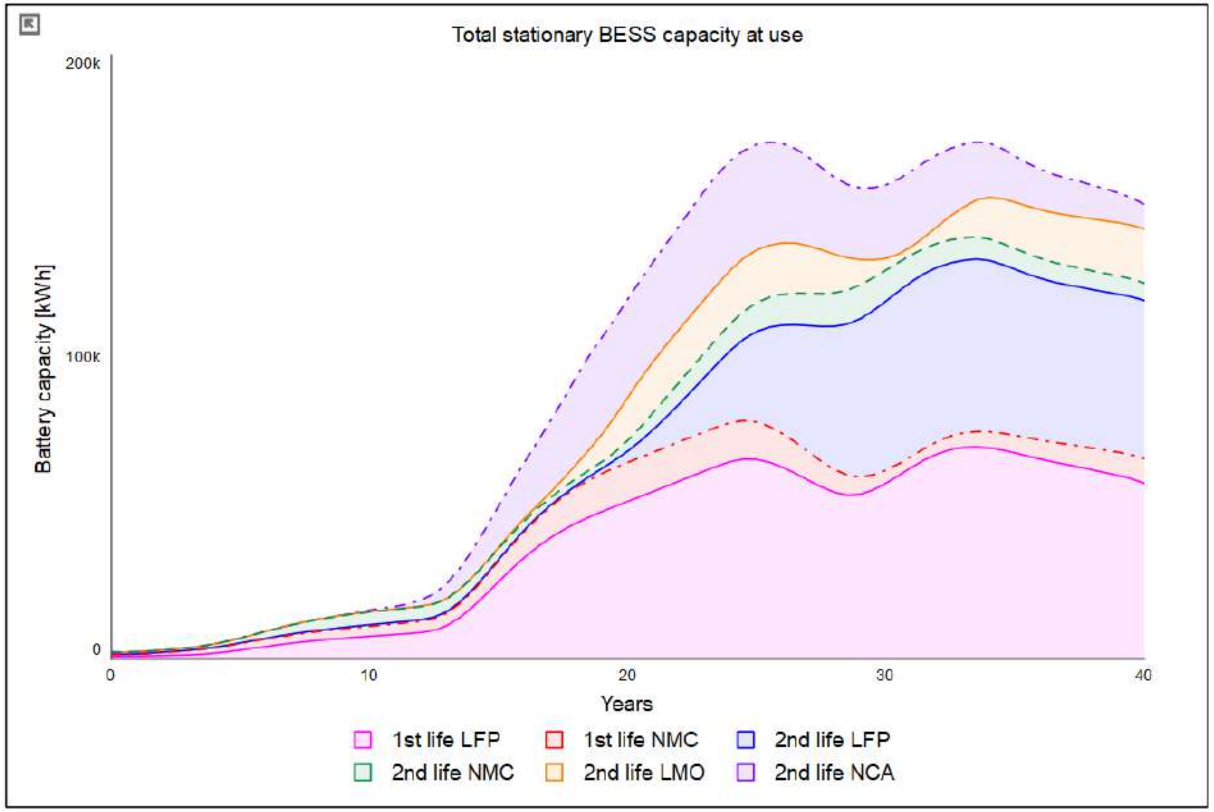
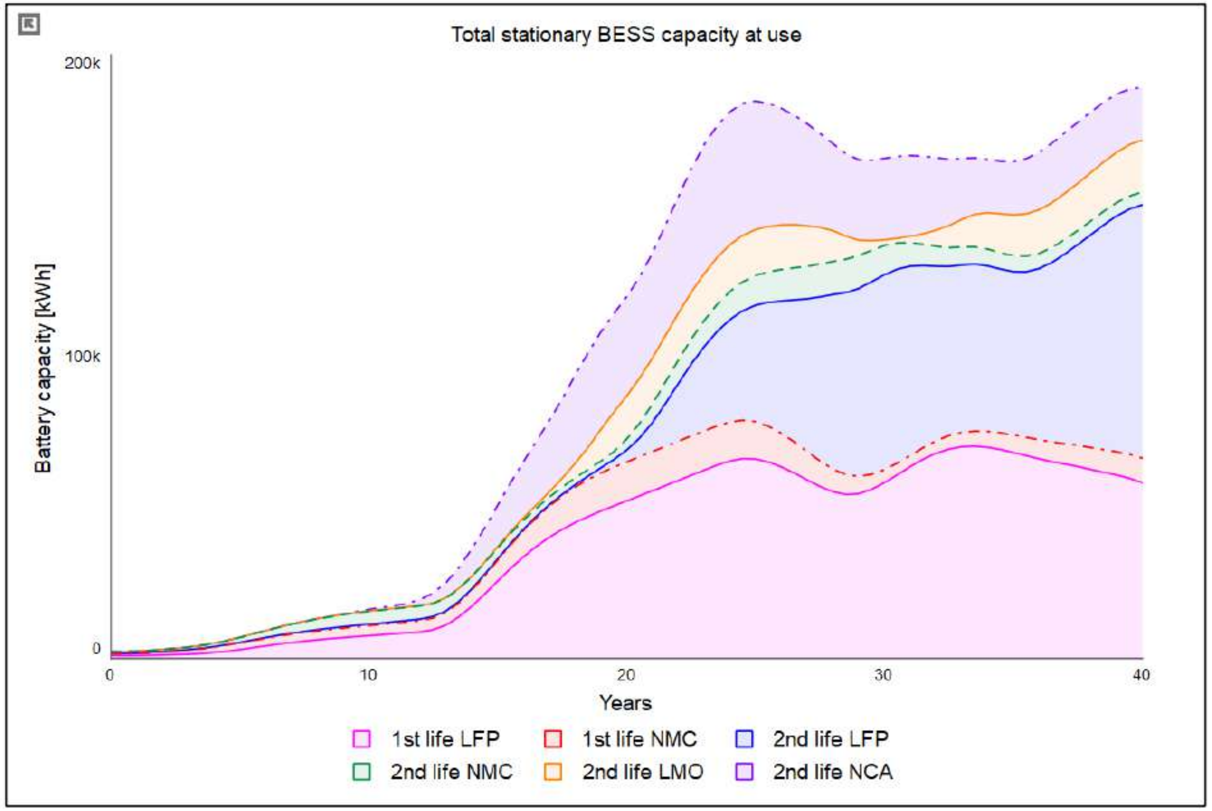
Status-quo




10x increase in repurposing capacity

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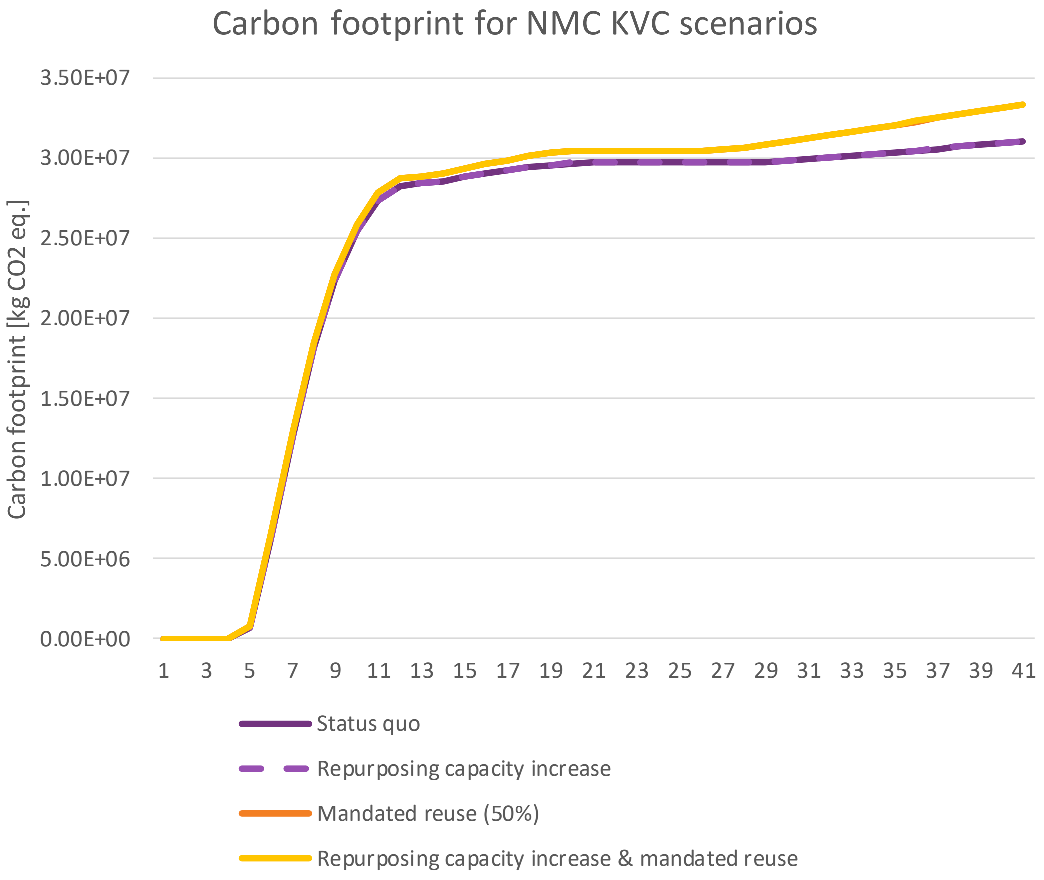
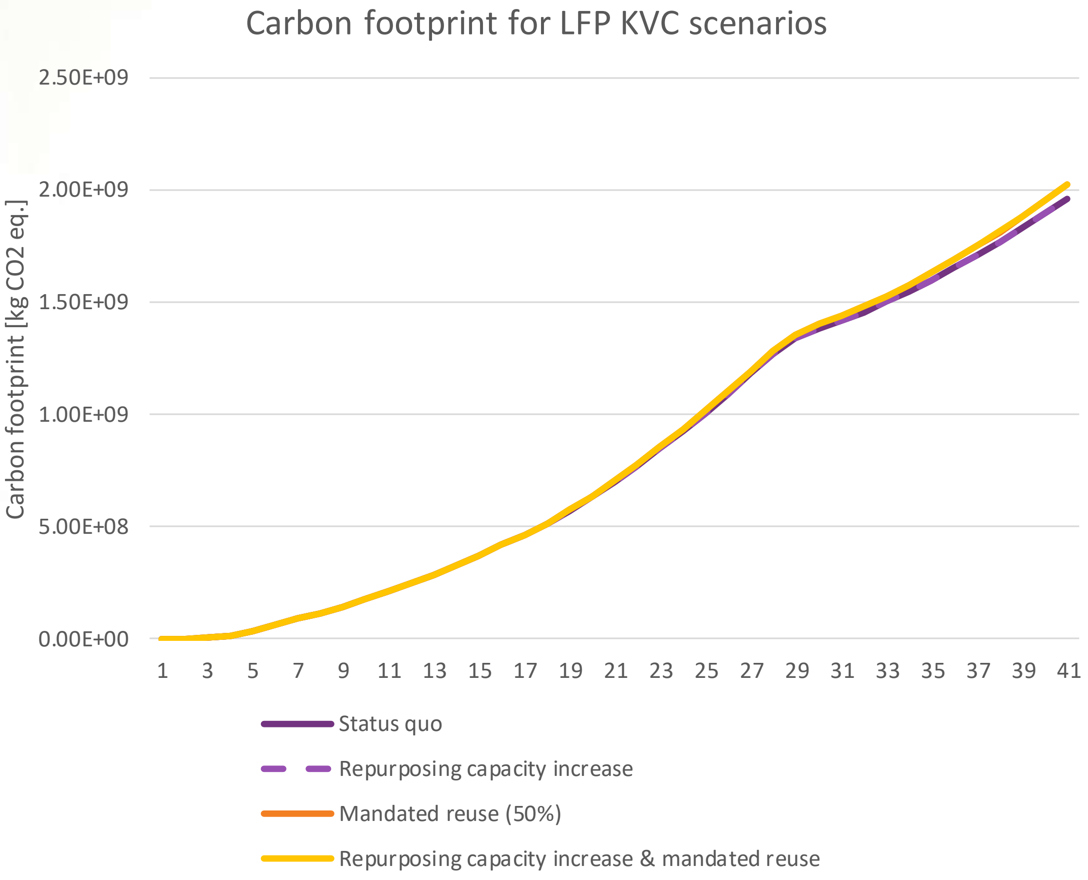
# Batteries – Regional impacts over time

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# Batteries – Conclusion

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- Repurposed BESS enables stationary energy storage with lower environmental burden compared with the 1st life BESS
- Repurposing capacity increase → limited influence on the system impacts

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**Case 3**

# Bio-based waste streams for biogas and fertilizers assessment

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# SDSA of bio-based side and waste streams

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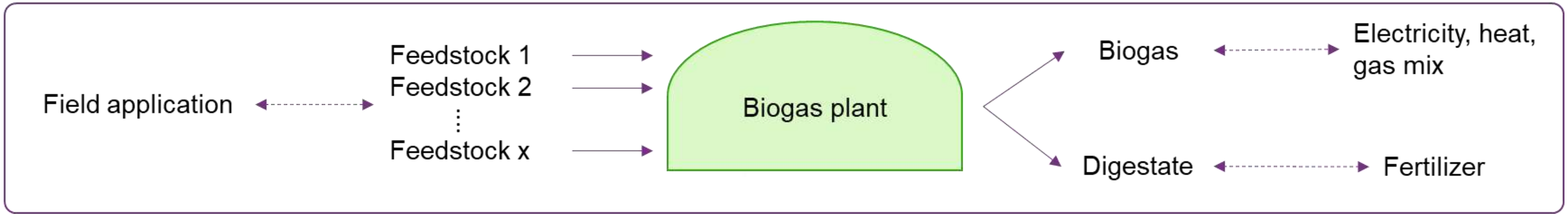
***Goal***: To assess the installation of a biogas plant in terms of their impact on the environment.

***Region***: Hämeenkyrö, Finland

***Material flows***: crops and their by-products (cereal straw, pea stems, potato tops, sugarbeet tops), animal husbandry by-products (manure), forestry products and their by-products (bark, woodchips), food waste, sludge

***System boundaries***:

System: Bio-based side and waste streams for biogas production in Hämeenkyrö, Finland

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# Biomass – LCA results

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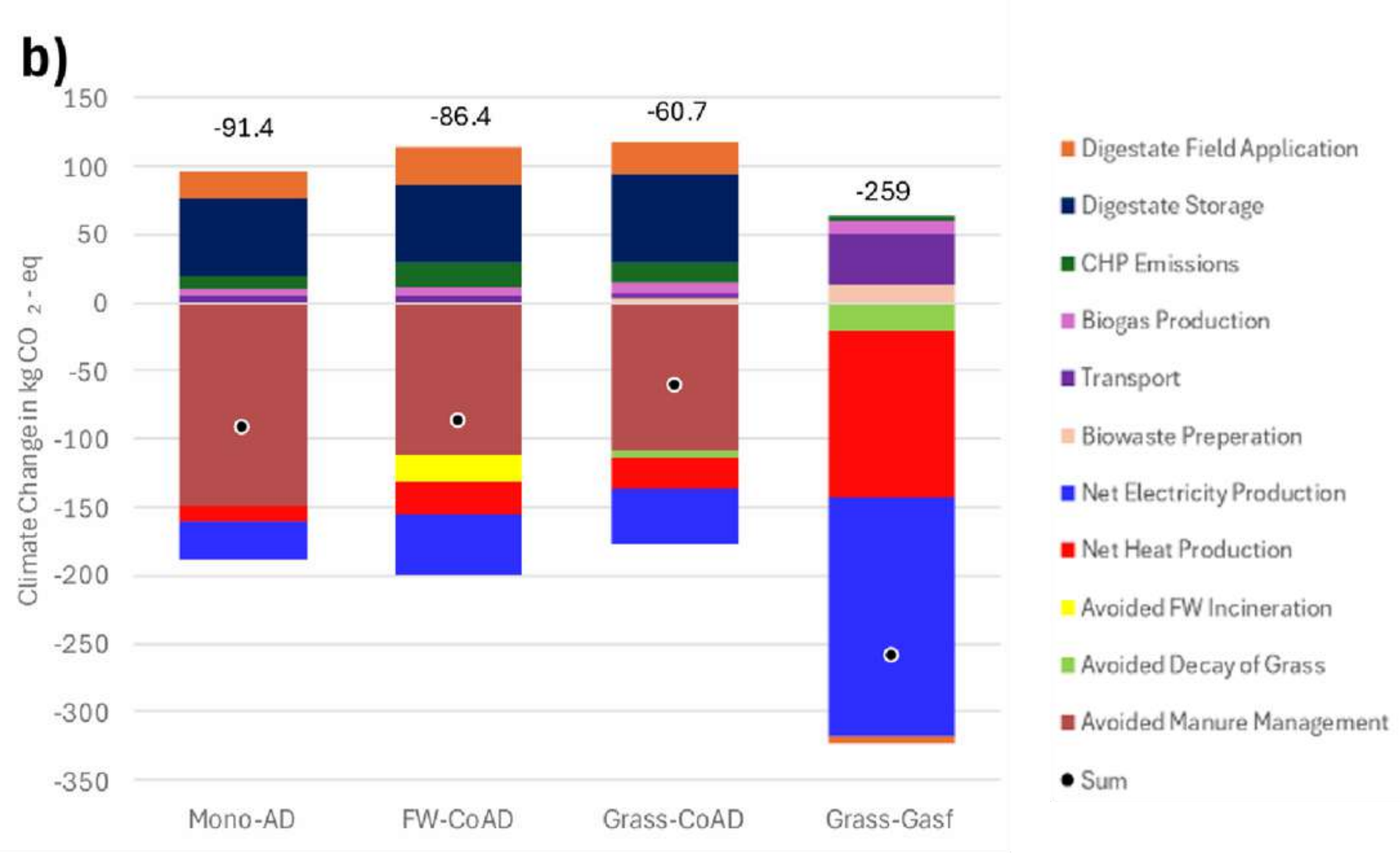


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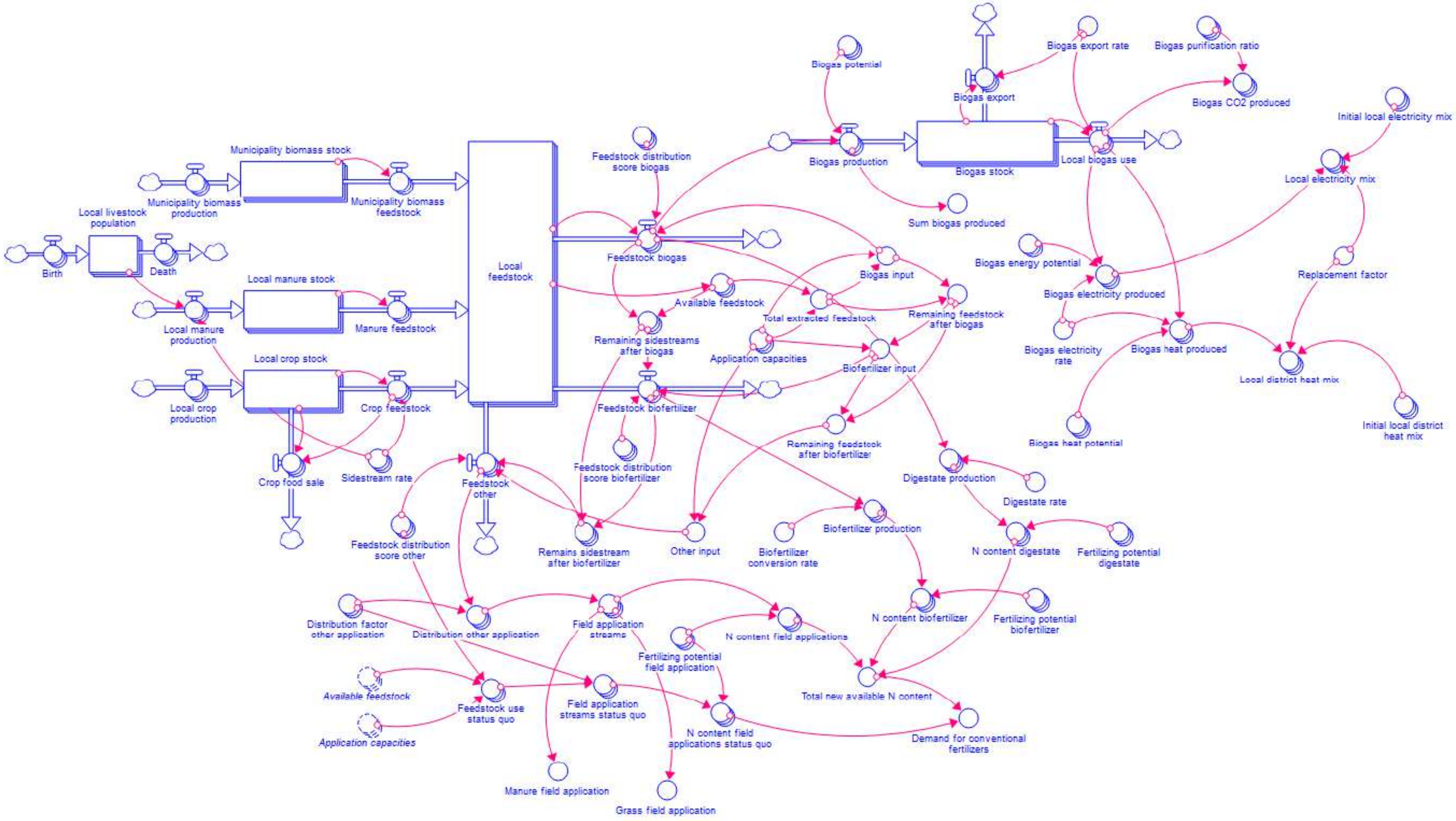
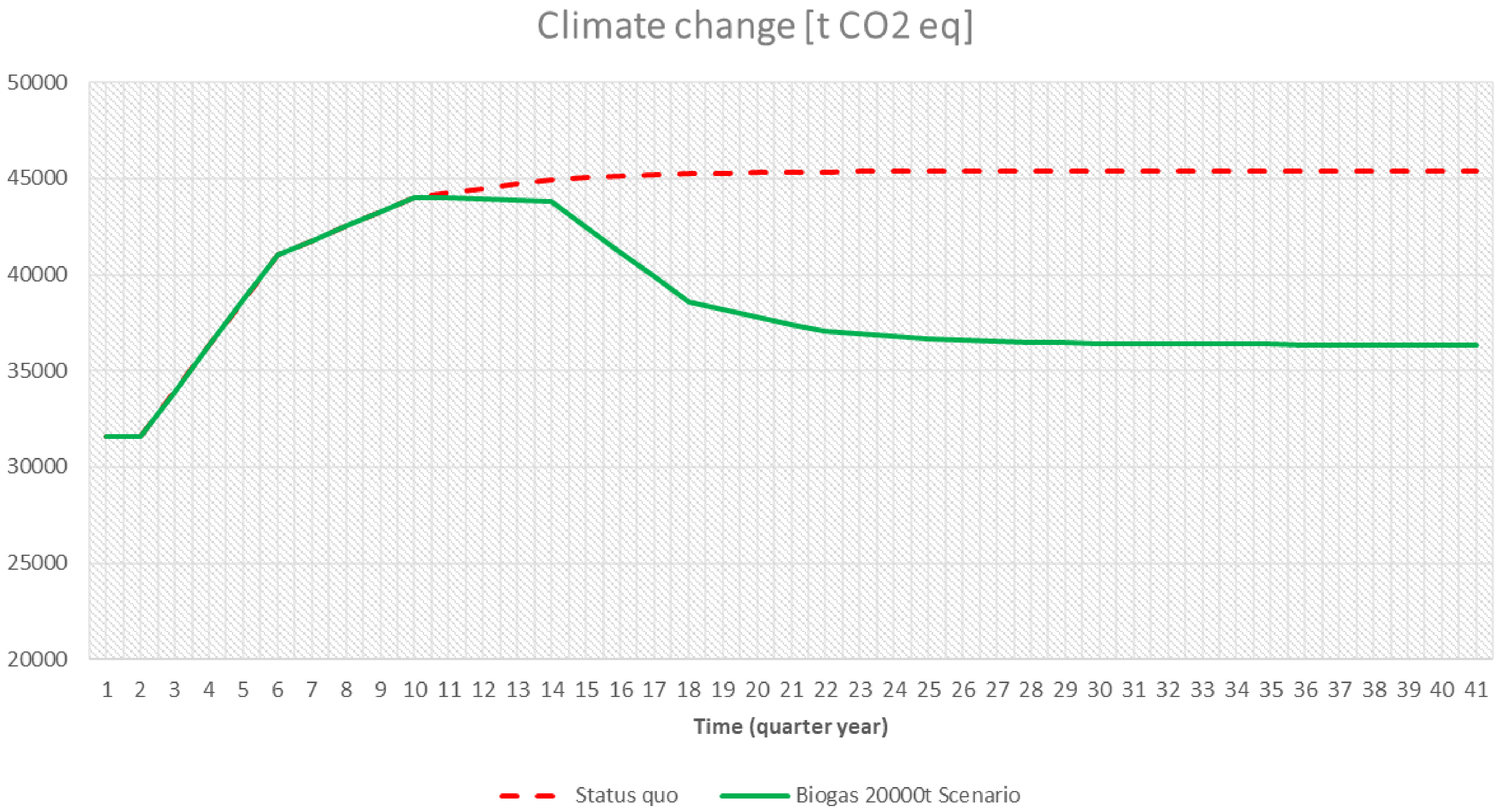
Mono-AD: Mono-anaerobic digestions ; FW-CoAD: Food waste co-anaerobic digestion
Grass-CoAD: Grass co-anaerobic digestion; Grass Gasf: Grass gasificition

# Biomass – System dynamics model



# Biomass – Regional impacts over time

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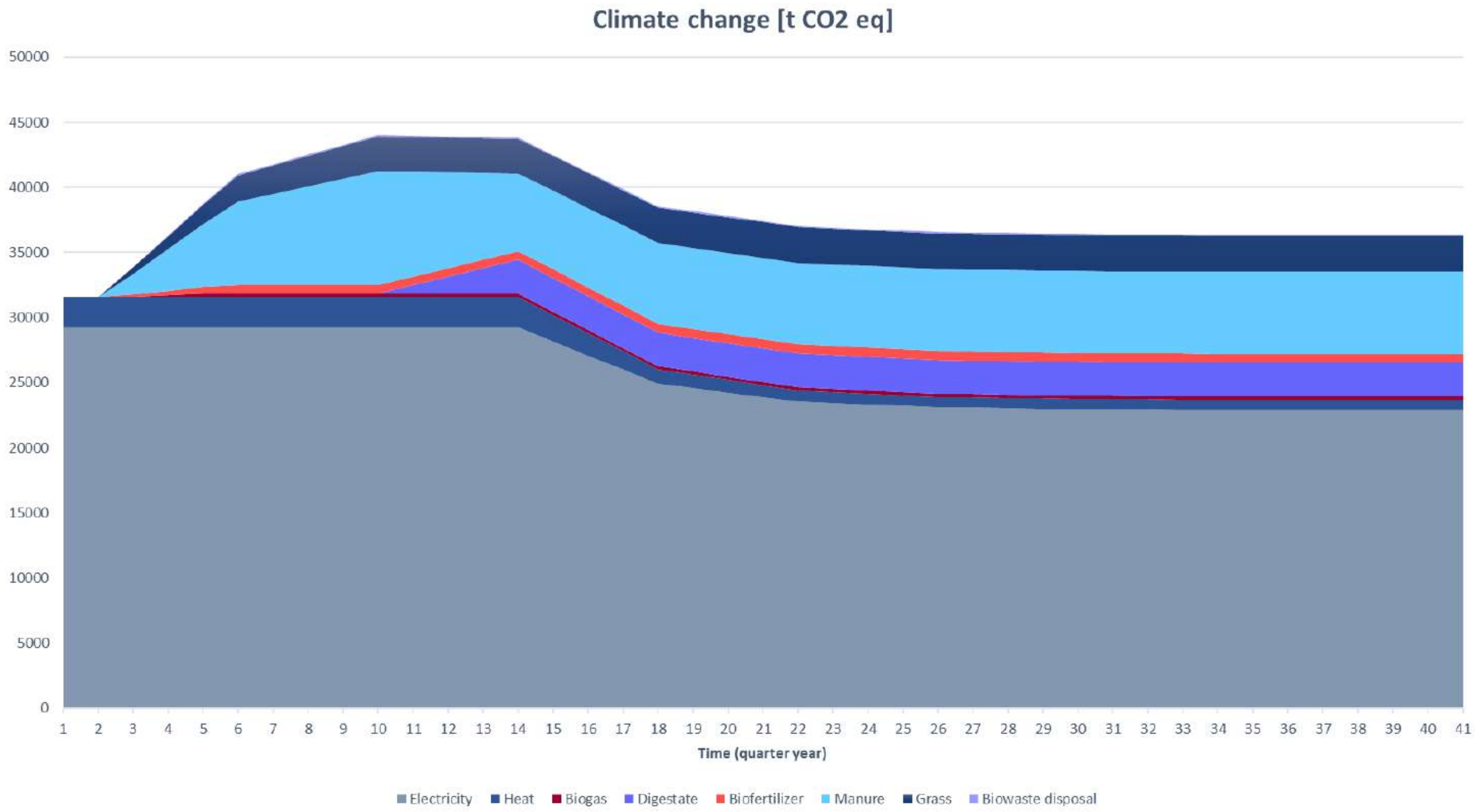
# Biomass – Regional impacts over time

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# T7.5.3 – Summary

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- Introducing a biogas plant can significantly reduce regional environmental impacts in several impact categories
- The induced change in heat and electricity mix is the main reason for reduced impacts
- Change in current application of bio-based side and waste streams (field or disposal) contribute to the reduction but is countered by additional use of compost and digestate

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# Conclusion

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# Conclusion

- System dynamics proved to be a valuable extension of LCAs for 3 different cases
- In 2 cases, regional impacts were higher than product-level LCA results
- In all 3 cases it becomes clear that enabling conditions need to be in place for CE solutions to perform well
- Data gaps lead to several assumptions and system boundary adjustments
- But when matching this with a defined decision-making scope, results still might be suitable
- Model validation or scoring can help improve trustworthiness of results

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# Thank you!

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