NEGATIVE EMISSIONS VIA (BIO)PLASTICS

Impacts on pathways to net-zero/negative emissions in Sweden

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Agenda

- Aim
- Background
  - Sweden's net-zero target
  - Where does plastic fit?
- Method and scenario assumptions for material stock assessment and related emissions
- Results
- Concluding remarks

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Aim

Investigate how accounting for carbon stored in (bio)plastic products impacts Sweden's pathways to net zero greenhouse gas emissions.

Accomplished using TIMES-Sweden, which includes detailed representation of biorefineries and olefin/polymer (plastic) production

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Sweden's net-zero target

- Net zero by 2045
- 85% reduction of territorial emissions
- ≈ -10Mt CO_2 equivalents required

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Complementary measures

- Direct air capture and storage (DACCS)
- Bioenergy with CCS (BECCS)
- CCU
- “Verified emission reductions abroad”

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Estimating emissions from plastic

Material stock change

- First order decay
- Recycling rates
- Service life of materials

Three approaches for assessing emissions

- National borders (cross border trade)
- Timing of emissions

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Material/carbon stocks

$$C_{(i+1)} = e^{-k} * C_{(i)} + \left[\frac{(1-e^{-k})}{k}\right] * In_{(i)} \quad (1)^*$$

$$C_{(i+1)} = e^{-k} * C_{(i)} + \left[\frac{(1-e^{-k})}{k}\right] * In_{(i)} + \boldsymbol{Rr_{(i)} * Disc_{(i)}} \quad (2)$$

$$\boldsymbol{Disc_{(i)} = (1 - e^{-k}) * C_{(i)} + (1 - \left[\frac{(1-e^{-k})}{k}\right]) * In_{(i)}} \quad (3)$$

$C_{(i)}$ = material stock in year i, k = decay constant (derived from service life of materials),
$Disc_{(i)}$= discarded material available for recycling, $Rr_{(i)}$= recycling rate, $In_{(i)}$= input of new materials

*Folows IPCC guidelines for harvested wood products.

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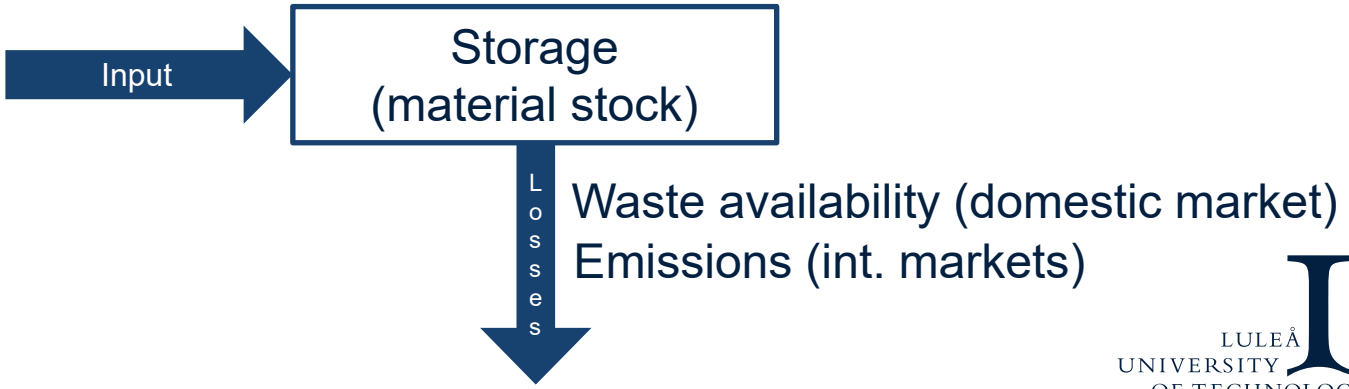
Implementation in TIMES-Sweden

- Storage process
- Parameterised loss profile
  - Material specific service life
  - Scenario specific recycling rates



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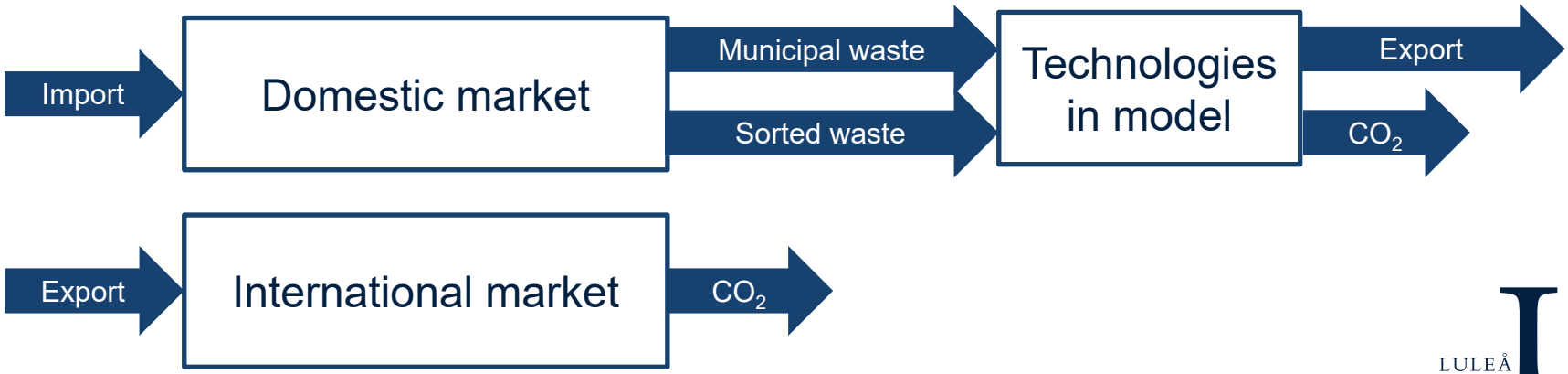
Applying material stock estimations for Sweden

- All domestic use is imported
  - Fossil origin
- All produced material is exported



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Service life of materials

End-use	Mean service life [Years]	All plastic [Mt]	HDPE [Mt]	LDPE [Mt]	PVC [Mt]
Packaging	0.5	19.8	3.6	6.0	0.5
Building and construction	35	9.8	1.3	0.5	3.6
Automotive	13	5.0	0.3	0.2	0.2
Electronics	8	3.1	0.2	0.3	0.1
Agriculture	3	1.6	0.0	0.5	0.1
Household, leisure, and sports	5	2.1	0.2	0.0	0.2
Others	7	8.4	0.5	1.3	0.3
Material equivalent service life [Years/ton]		10.4	9.3	4.1	26.8

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Recycling rates

Market specific

– Follows technology representation (mechanical and chemical recycling)

Domestic

Year	Low	Mid	High
2020	10%	10%	10%
2030	10%	50%	50%
2050	10%	50%	50%

International

Year	Low	Mid	High
2020	10%	10%	10%
2030	10%	50%	50%
2050	10%	50%	85%

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Emission accounting

SCA-tier1 (cradle-to-gate equivalent, optimistic)

- Exported carbon, and CO_2, accounted to importing party

PA-tier1 (cradle-to-grave equivalent, conservative)

- Exported carbon accounted to exporting party
- CO_2 emission accounted immediately when exported

PA-tier2 (approximation of actual emissions)

- Exported carbon accounted to exporting party
- CO_2 emission accounted when material is discarded from stock (delayed emissions)

Based on IPCC guidelines on land use, land use change and forestry (IPCC, 2006)

SCA = Stock change approach, PA = Production approach

Carbon from renewable feedstocks always accounts negative when stored in material

Carbon from fossil feedstocks always accounts net-zero when stored in material

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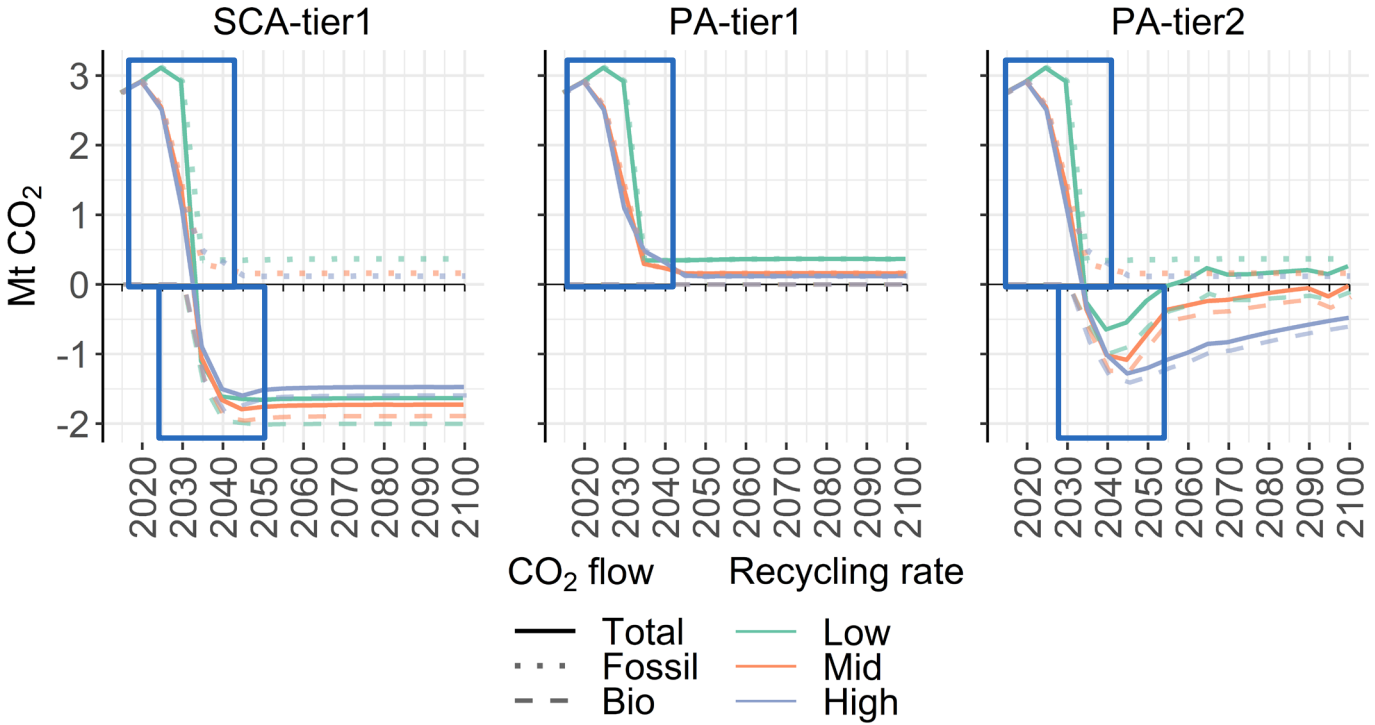
Resulting emissions from plastic



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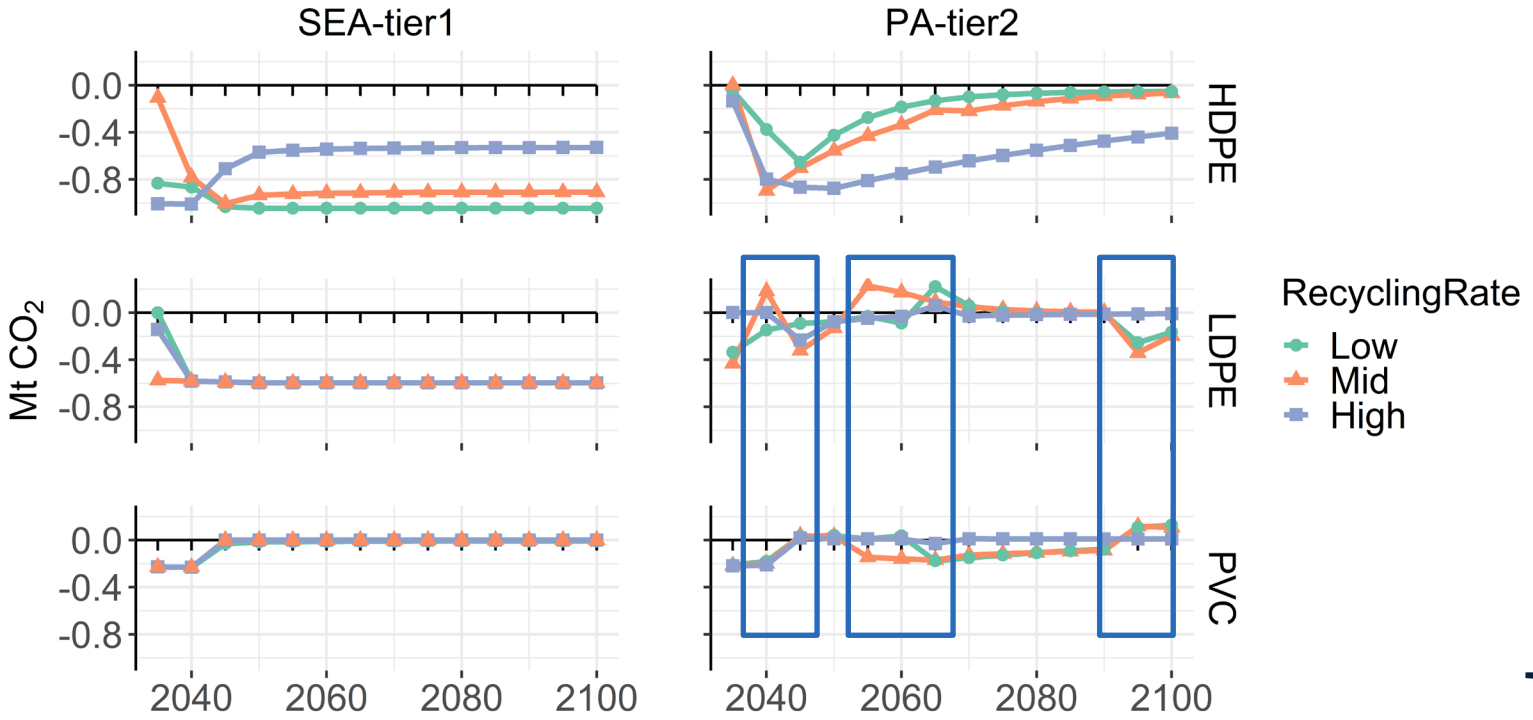
Material specific contribution



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Future improvements

- PA-tier2 is a good approximation **BUT…**
- Vulnerable to overestimations of recycling rates
- For further improvement
  - Material specific recycling rates
  - Better understanding of quality limitations of chemical recycling

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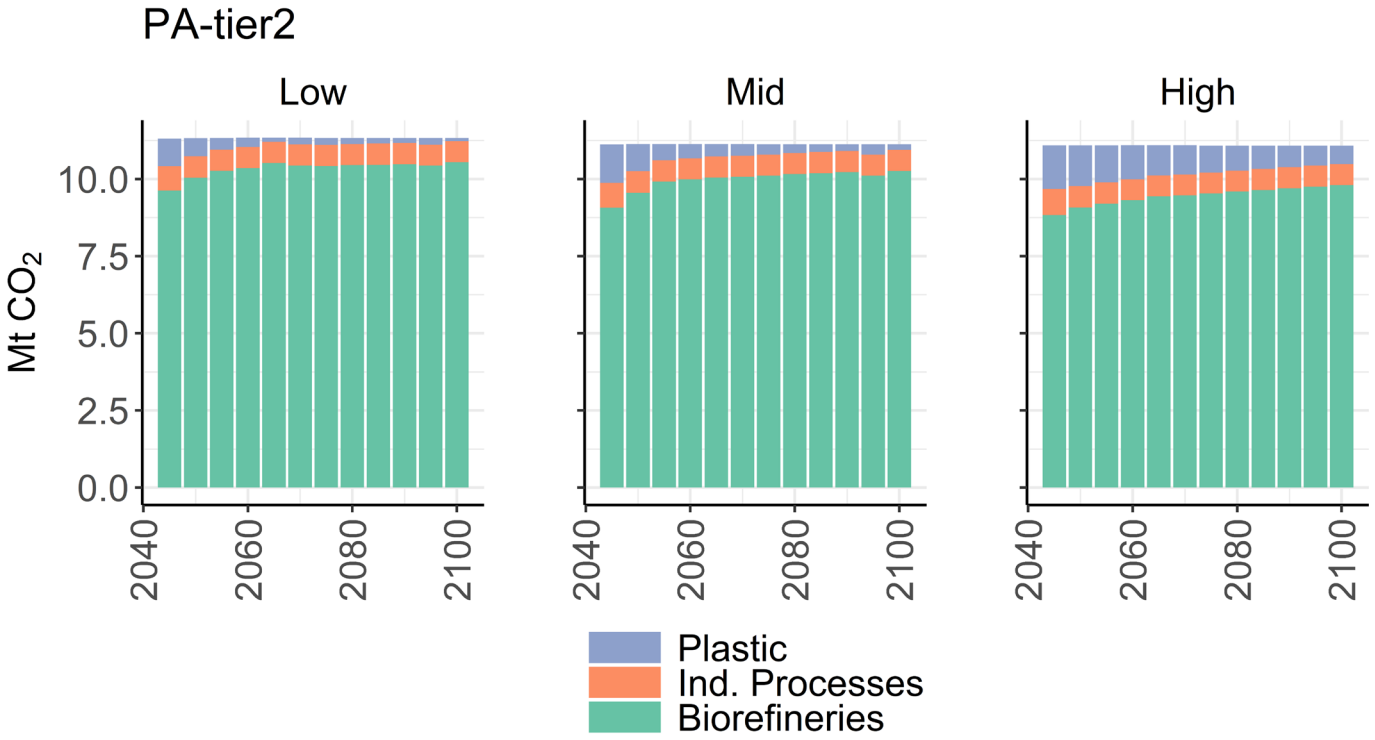
Contribution to Sweden's net-zero target



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Concluding remarks

- Neither SCA-tier1 nor PA-tier1 offers good approximations for PA-tier2
  - Tracking carbon in plastic requires dedicated modelling
- Added incentives for renewable plastic in models
  - Direct competition with carbon removal technologies
- Can contribute to Sweden's net zero targets but is not game-changing with current production and consumption levels
  - Low impact on energy system due to high availability of biomass and high deployment of biorefineries in 2045
  - Increasingly important if increased export of plastic materials

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Databases

- TIMES-Sweden Industry Database (1.0) DOI: 10.5281/ZENODO.5702722
- TIMES-Sweden Fuel production technologies database (1.0) DOI: 10.5281/zenodo.6372927
- TIMES-Sweden (Industrial) Heat generation technologies database (1.0) DOI: 10.5281/zenodo.6372931

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