TNO innovation for life

HORTI BLUE-C

WP3 – LIFE CYCLE ASSESSMENT

BACKGROUND

- Intensive greenhouse horticulture poses a heavy environmental burden: natural gas for heating, electricity for lighting, peat and stone wool substrates
- Greenhouses of the future must reduce their environmental impact
- This can be achieved with alternatives for substrates and energy for heating and lighting

LCA GOAL

A life cycle assessment (LCA) was conducted to evaluate the environmental impacts of conventional (peat, stone wool) and proposed alternative substrates (biochar, wood fiber) and substrate blends.

- Highlight options towards more sustainable greenhouse systems.

NOTE: Only gives information about the environmental impacts; does not consider economics

Accuracy is only as good as the data you put into the LCA (ISO Standards and EU-approved databases are used)

Impact of biochar on soil quality/plant growth beyond C storage is not considered (no data available)

LIFE CYCLE ASSESSMENT

APPROACH

- Focus on greenhouse production of tomatoes and strawberries
- Use data from growers & check with partners (ADAS, Proefcentrum Hoogstraten)
- Assess global warming impact (CO_{2eq}) and damage (human health, ecosystems, resources)

FUNCTIONAL UNIT FOR THE LCA

1 kg of tomato or strawberry growth in a greenhouse

METHODS

- SimaPro software, EcoInvent database and data from growers

OVERVIEW OF SUBSTRATES CONSIDERED

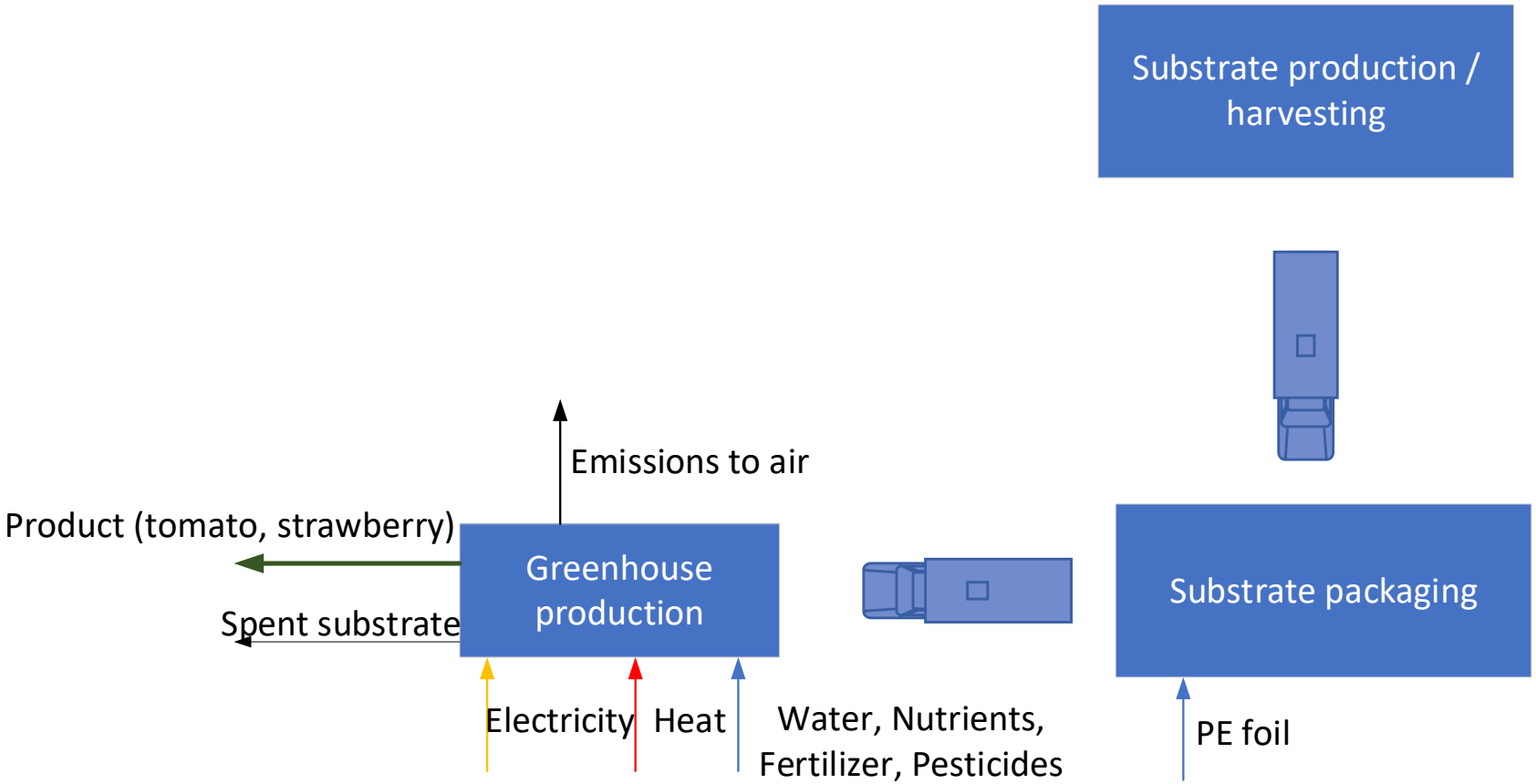
PURE SUBSTRATES

1. Peat
2. Biochar – from *Miscanthus* or park residues (two different methods of preparation)
3. Wood fiber – from forest residues
4. Stone wool

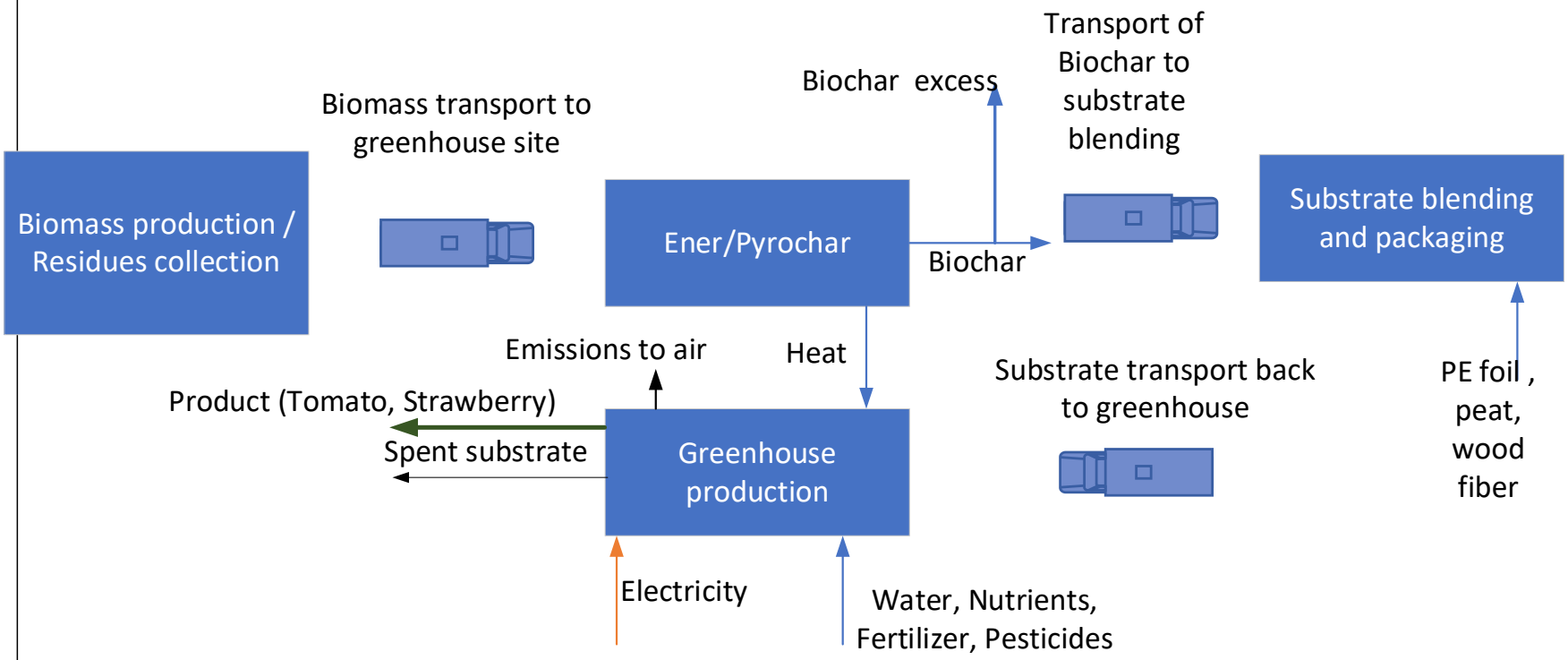
SUBSTRATE BLENDS

- Peat and biochar
- Peat and wood fiber
- Peat, biochar and wood fiber
- Stone wool was not considered in substrate blends
- Maximum 50% biochar in a blend, based on previous research

SYSTEM BOUNDARIES
STONE WOOL, PEAT, WOOD RESIDUES



SYSTEM BOUNDARIES
BIOCHAR FROM MISCANTHUS, PARK RESIDUES



BIOCHAR PRODUCTION METHODS

PYROCHAR AND ENERCHAR

	ENERCHAR	PYROCHAR
Feed (kg)	3000	3000
Total efficiency to energy (syngas)	0.80	0.31
Thermal output (MWh)	12.2	3.5
Biochar (m^3)	4.5	9
Biochar (kg)	450	900
CO_2 sequestration (kg CO_2/kg biochar)	-2.78	-1.38
Price (€/ton)	250 - 350	350 - 1000

SUBSTRATE BLENDS

	PEAT	STONE WOOL	BIOCHAR*	WOOD FIBER
1	100%			
2		100%		
3			100%	
4				
5	90, 75, 50%			10, 25, 50%
6	90, 75, 50%		10, 25, 50%	
7	90, 75, 50%			
8	90, 75, 50%		25%	25%

*Biochar from park residues or *Miscanthus*, produced via Enerchar or Pyrochar (best case scenario)

DATA FROM GROWERS

per m^2/year	Cherry Tomato	Cherry Tomato	Strawberry
	Heated, lighted greenhouse	Polytunnel (unheated, unlighted)	Heated, unlighted greenhouse
Yield (kg)	28	16	13
Substrate volume (L/cultivation cycle)	25	25	20
Cultivation cycles/year	1	1	3
Substrate volume (L/year)	25	25	60
Heat use (MJ)	1980	0	630
Electricity (kWh)	333	0	0
Water (kg)	1200	800	840
Total fertilizers* (g)	1112	742	981

*Detailed fertilizer inputs provided and used in the model, as well as pesticides and data on emissions to air (not shown)

POLL QUESTION
STRAWBERRY PRODUCTION

Reference case: 100% peat substrate

Which input do you think has the highest environmental impact on strawberry production?

- Heat
- Peat Substrate
- Fertilizers
- Pesticides
- Water

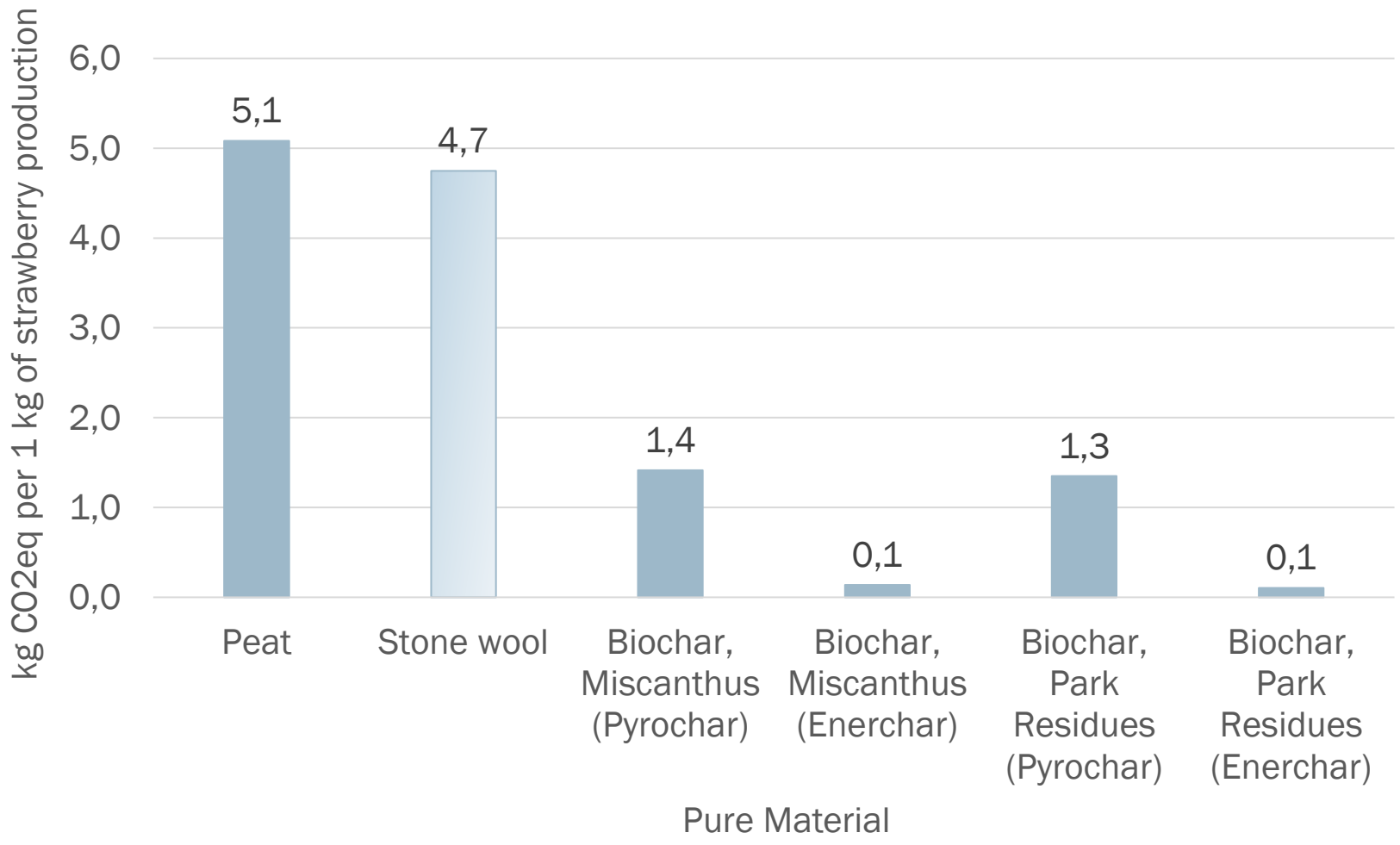
RESULTS
STRAWBERRY PRODUCTION

Reference case: 100% peat substrate

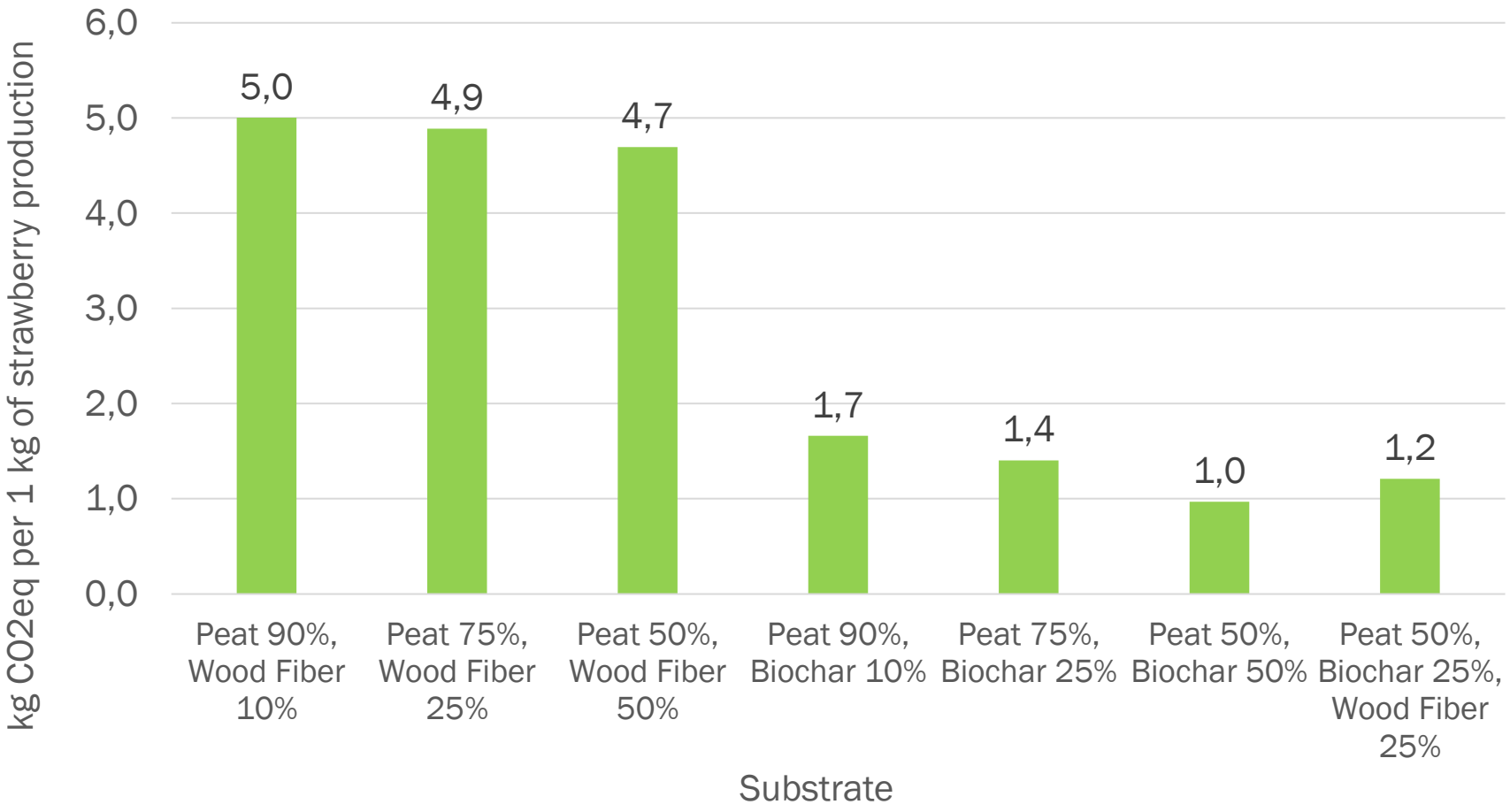
Impact Category	Global warming impact ($kg\ CO_{2eq}$/kg strawberries)
Heat	3.61
Electricity	0
Peat	0.78
Fertilizers	0.63
Water and Pesticides	0.06
Total	5.08

- Most impact from heat (71%)
- Peat substrate contributes 15% of impact

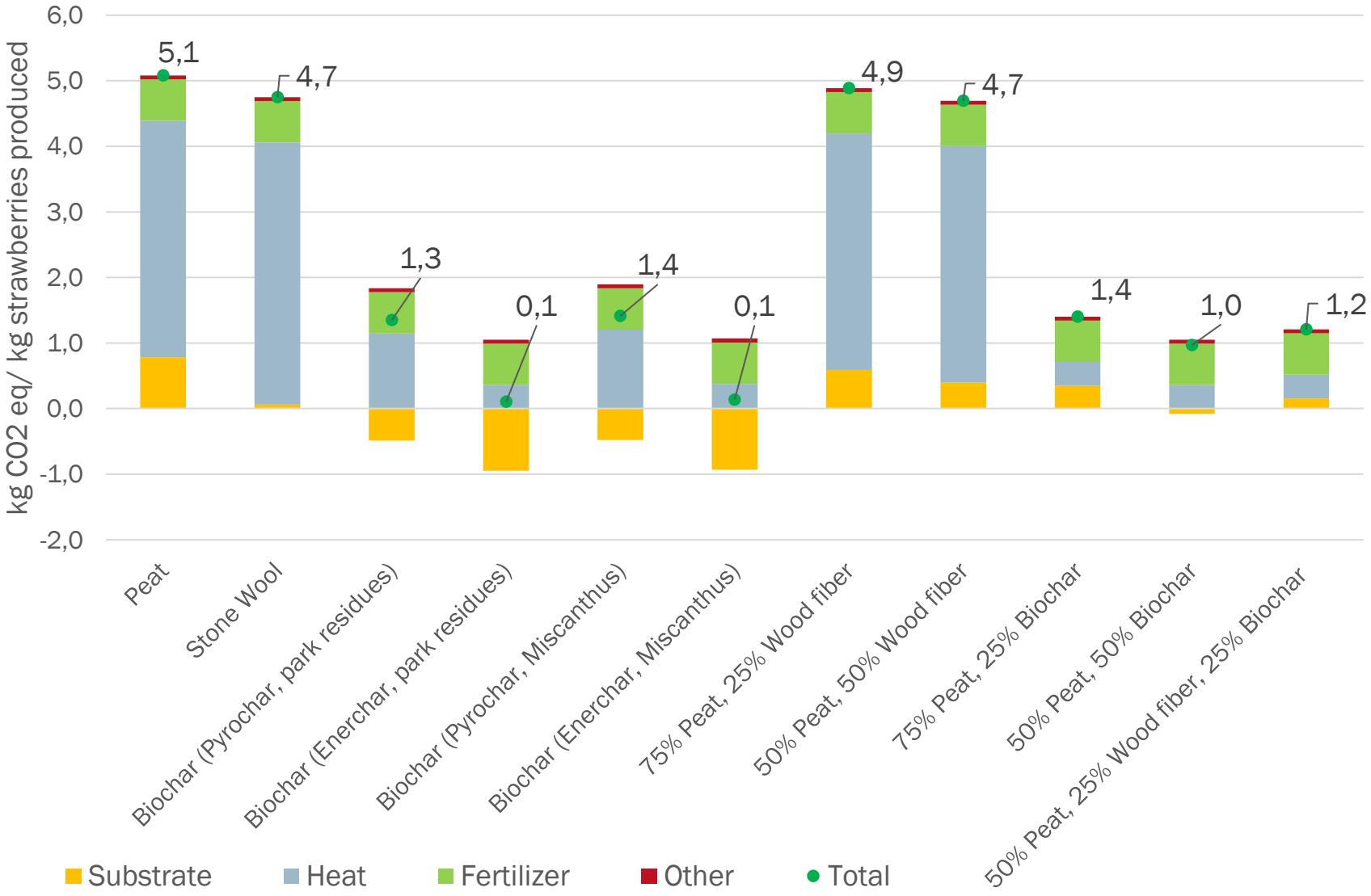
STRAWBERRY PRODUCTION
PURE MATERIAL



STRAWBERRY PRODUCTION
SUBSTRATE BLENDS

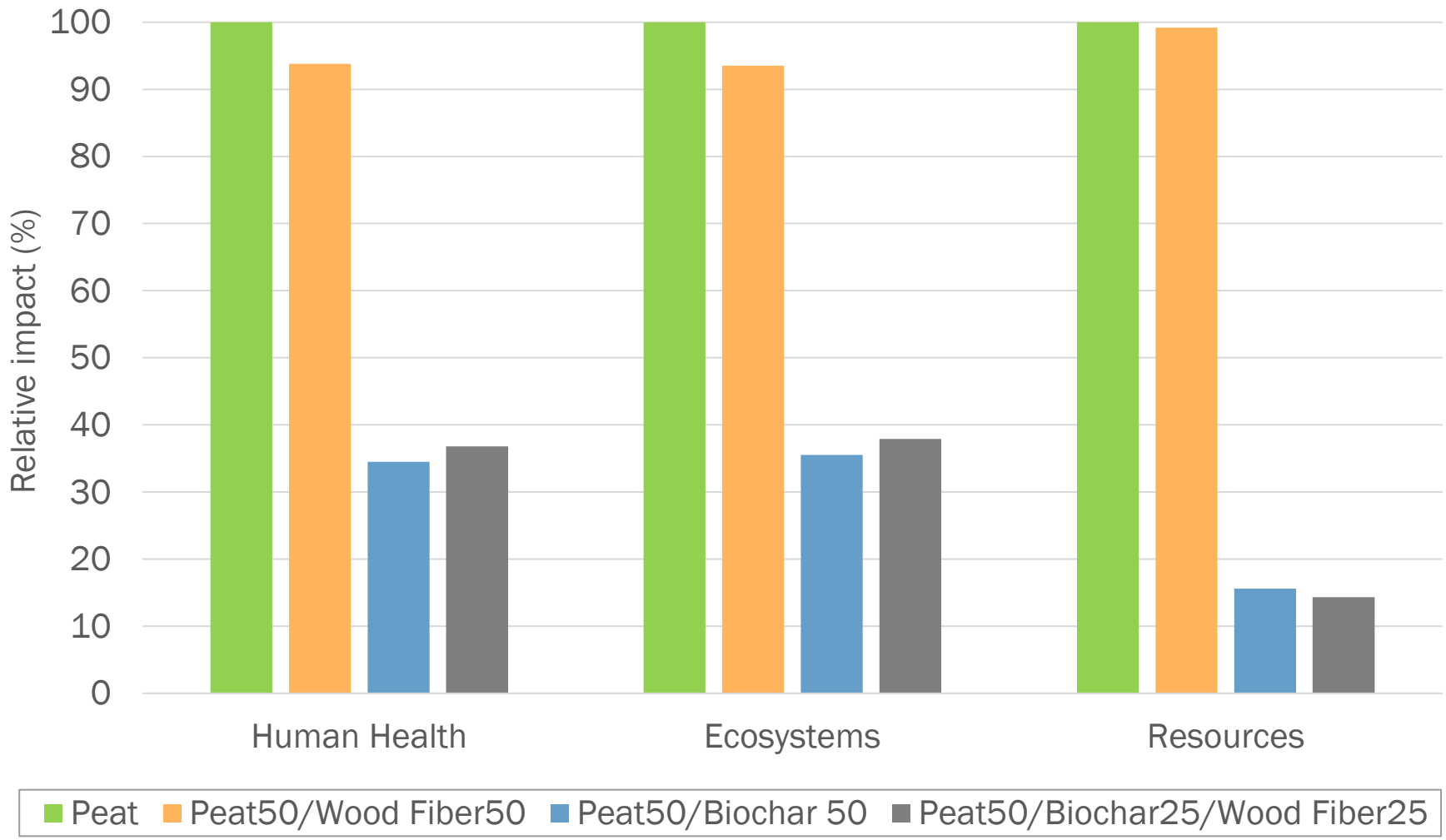


STRAWBERRY PRODUCTION – SUBSTRATE IMPACT



STRAWBERRY PRODUCTION – DAMAGE ASSESSMENT

RELATIVE IMPACTS



POLL QUESTION
CHERRY TOMATO PRODUCTION

Reference case: 100% stone wool substrate

Which input do you think has the highest environmental impact on tomato production?

- Heat
- Electricity (for lighting)
- Stone Wool Substrate
- Fertilizers
- Pesticides
- Water

RESULTS

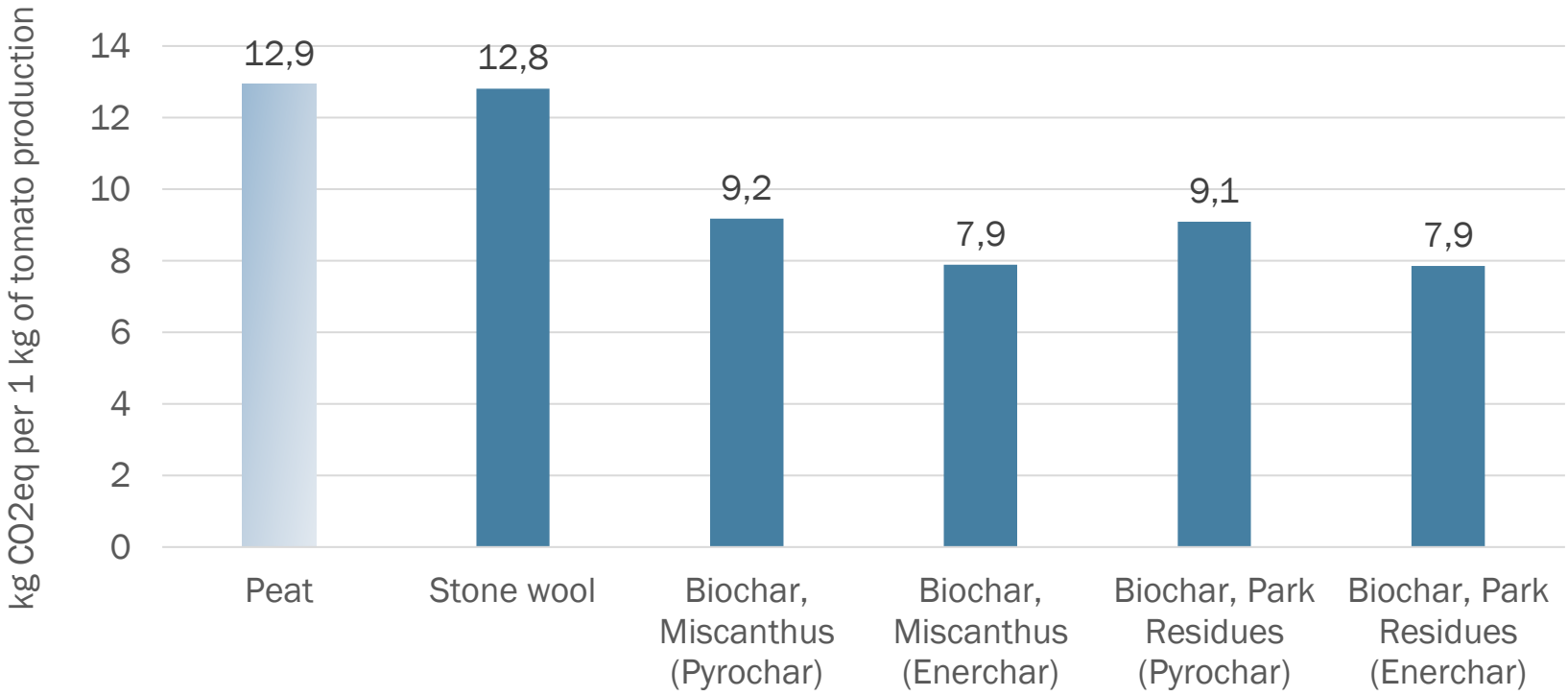
CHERRY TOMATO PRODUCTION IN A HEATED, LIGHTED GREENHOUSE

Reference case: 100% stone wool substrate

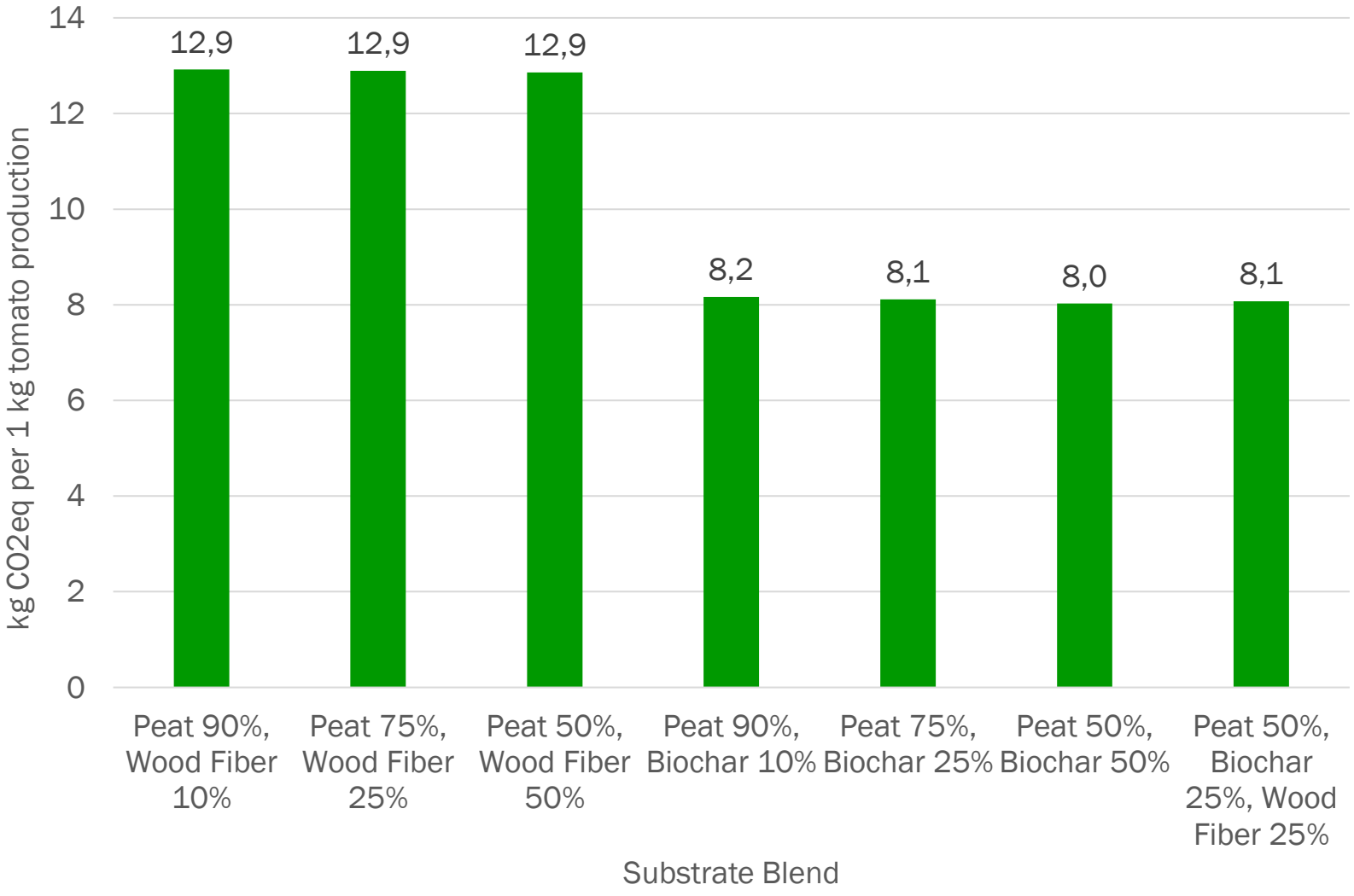
Impact Category	Global warming impact (kg CO_{2eq}/kg tomatoes)
Electricity	7.39
Heat	5.26
Stone wool	0.03
Fertilizers, Water and Pesticides	0.1
Total	**12.81**

- Most impact from electricity (57%) and heat (41%)
- Substrate has a relatively minor impact (<1%)

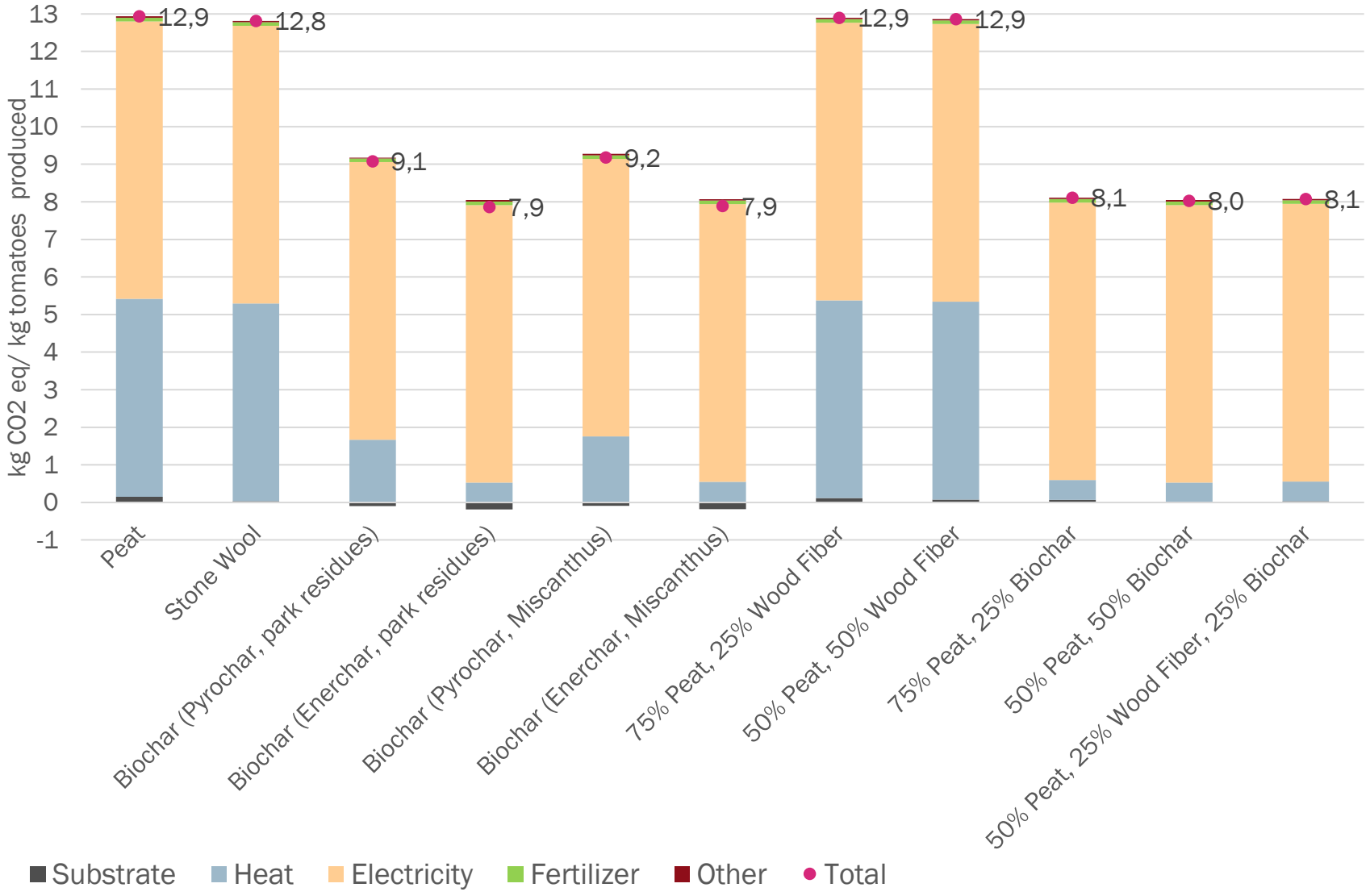
TOMATO PRODUCTION - PURE MATERIAL



TOMATO PRODUCTION – SUBSTRATE BLENDS

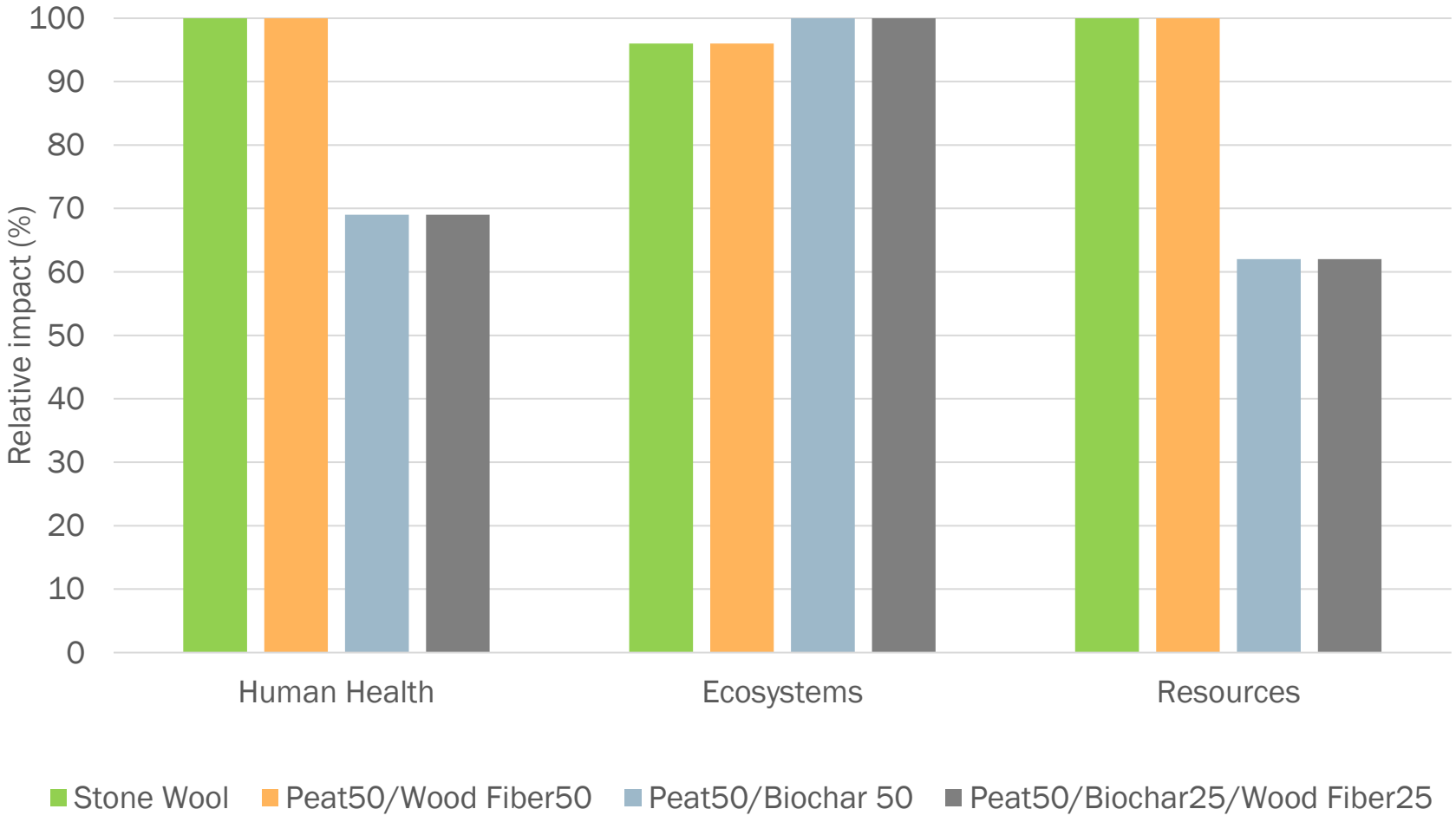


TOMATO PRODUCTION – SUBSTRATE IMPACT



TOMATO PRODUCTION – DAMAGE ASSESSMENT

RELATIVE IMPACTS



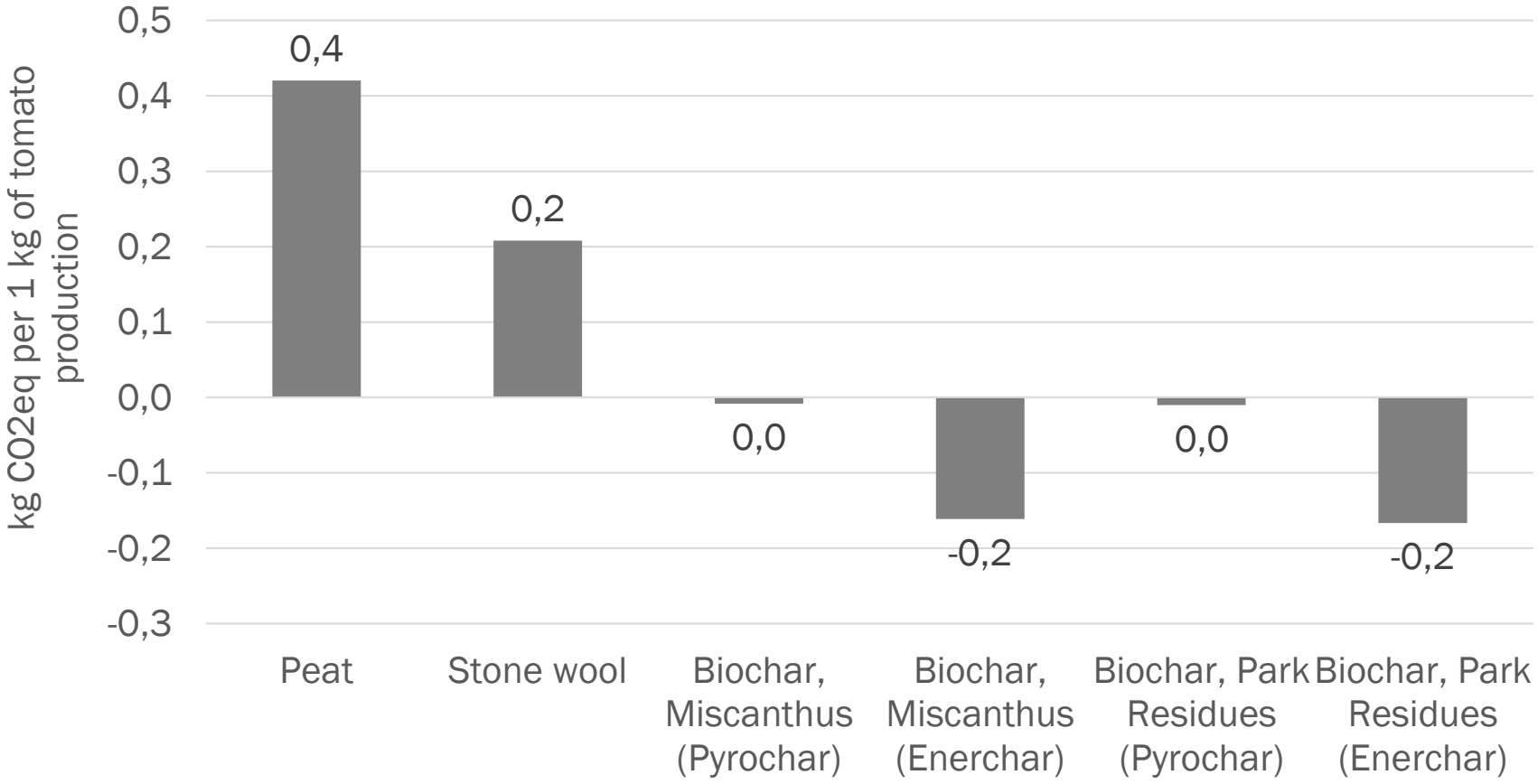
RESULTS
CHERRY TOMATO PRODUCTION IN A POLYTUNNEL

Reference case: 100% stone wool substrate

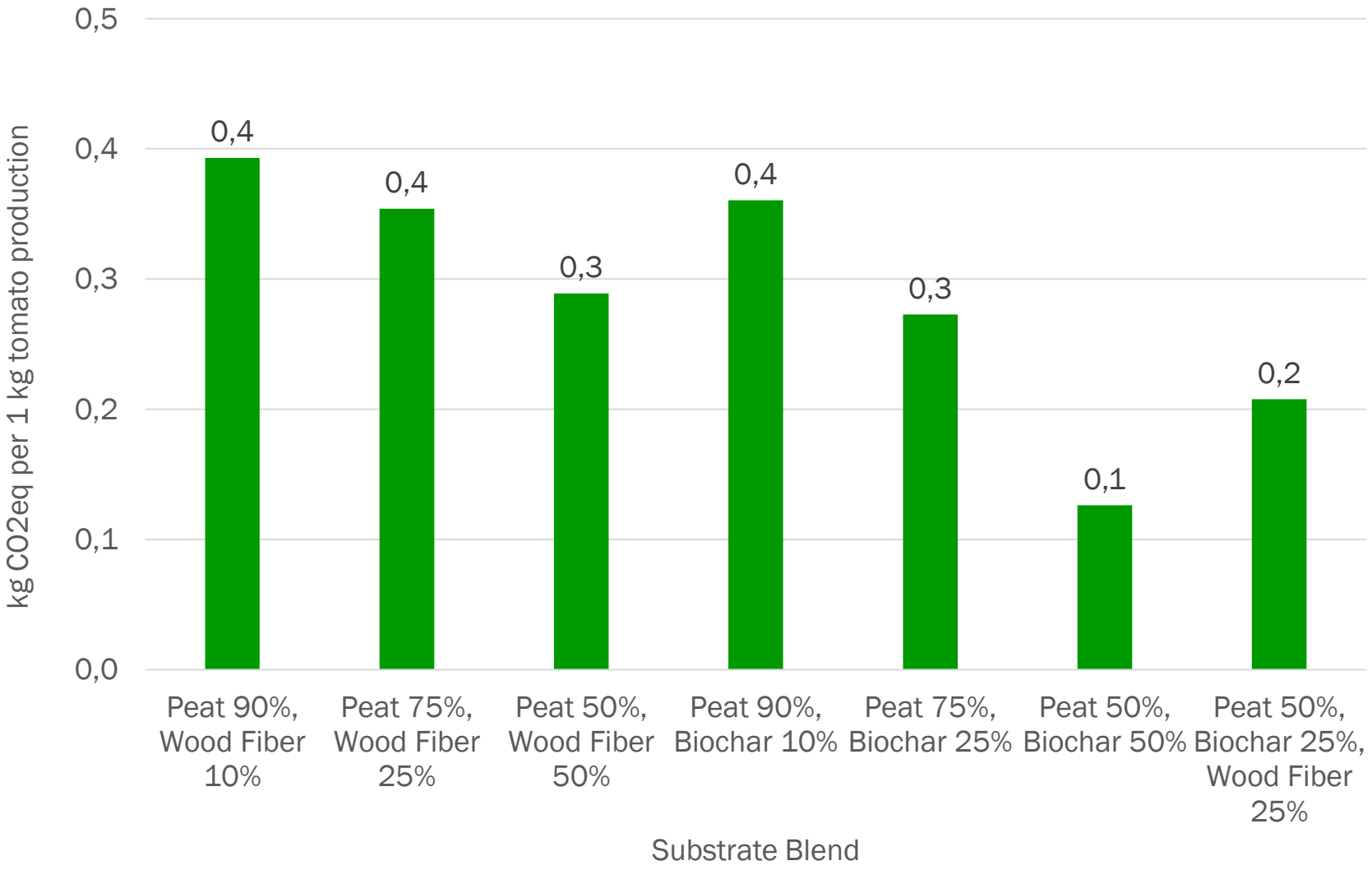
Impact Category	Global warming impact ($kg\ CO_{2eq}$/kg tomatoes)
Stone wool	0.05
Fertilizers and Pesticides	0.11
Water	0.02
Total	0.21

- Most impact from fertilizer (54%) , substrate (25%), water (10%)

TOMATO PRODUCTION POLYTUNNEL- PURE SUBSTRATES

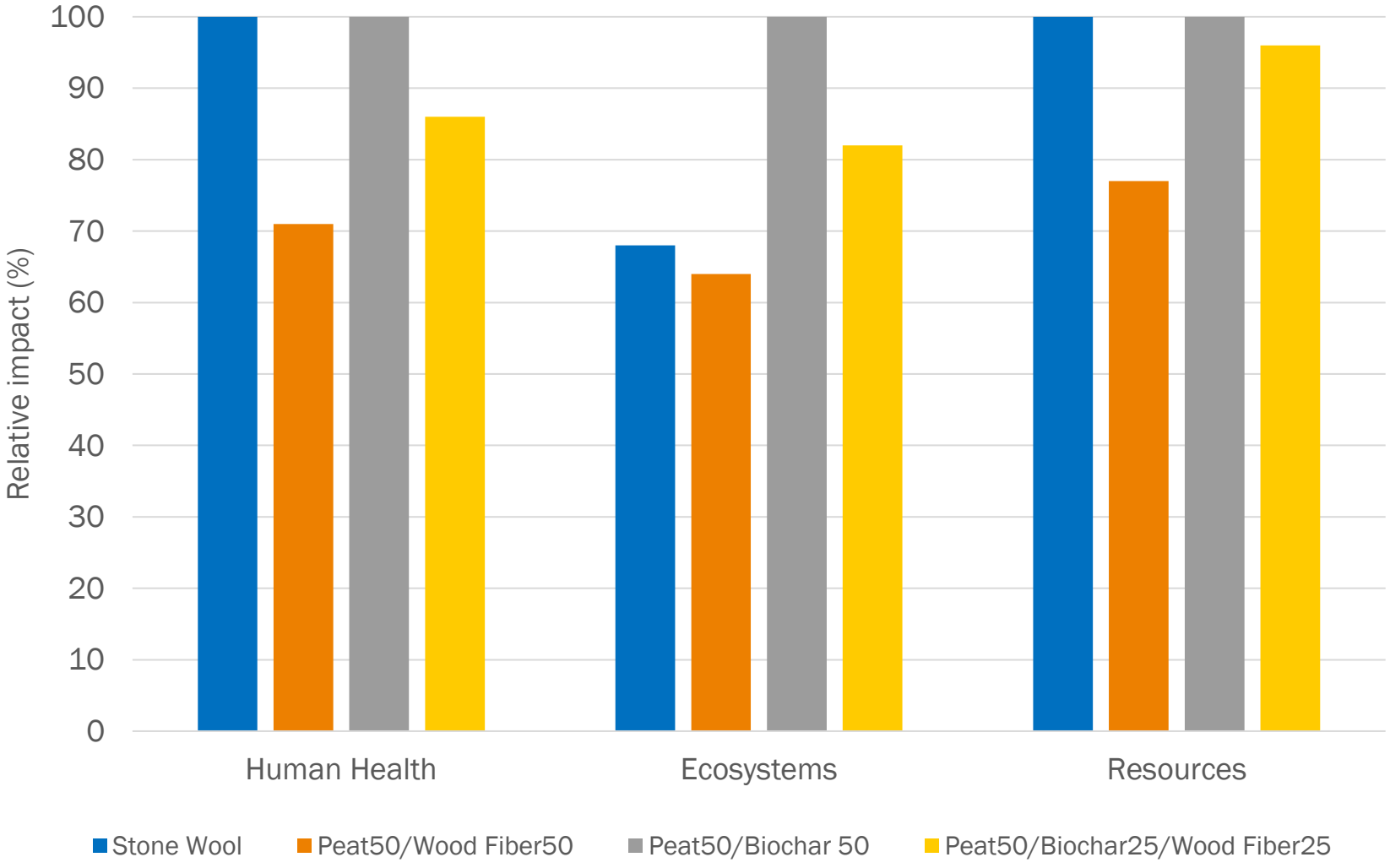


TOMATO PRODUCTION POLYTUNNEL–SUBSTRATE BLENDS



TOMATO PRODUCTION POLYTUNNEL – SUBSTRATE IMPACT

TOMATO PRODUCTION POLYTUNNEL DAMAGE ASSESSMENT



CONCLUSIONS

REFERENCE SCENARIOS

- For conventional scenarios, most impact is from greenhouse heating and electricity for lighting
- Large difference in environmental impact between greenhouse and polytunnel production of tomatoes
- Conventional substrates (stone wool, peat) have a relatively minor impact compared to heat and electricity
- For growing conditions without electricity and/or heat, the use of alternative substrates can reduce the impact to almost zero or even result in negative CO_2 emissions

ALTERNATIVE SUBSTRATES

- Use of biochar as a substrate or in a substrate blend significantly reduces the environmental impact and associated ecosystem damage of tomato/strawberry production due to:
  - the use of co-produced energy to heat the greenhouse
  - addition of used biochar substrate to soil for carbon sequestration (negative emissions)
- The lowest impact is associated with biochar substrate, produced with Enerchar technology using park residues as a feedstock:
  - 98% reduction of reference case impact for strawberry production
  - 39% reduction of reference case impact for tomato production

NEXT STEPS

Many opportunities for future research

BIOCHAR

- Biochar could play a role in future carbon credit schemes
- Linking the LCA results to economics
- Future testing:
  - Biochar on soil fungi (see fact sheet)
  - Phytotoxicity and criteria for testing
- We are open for cooperation on biochar-related topics!

THANK YOU FOR
YOUR TIME
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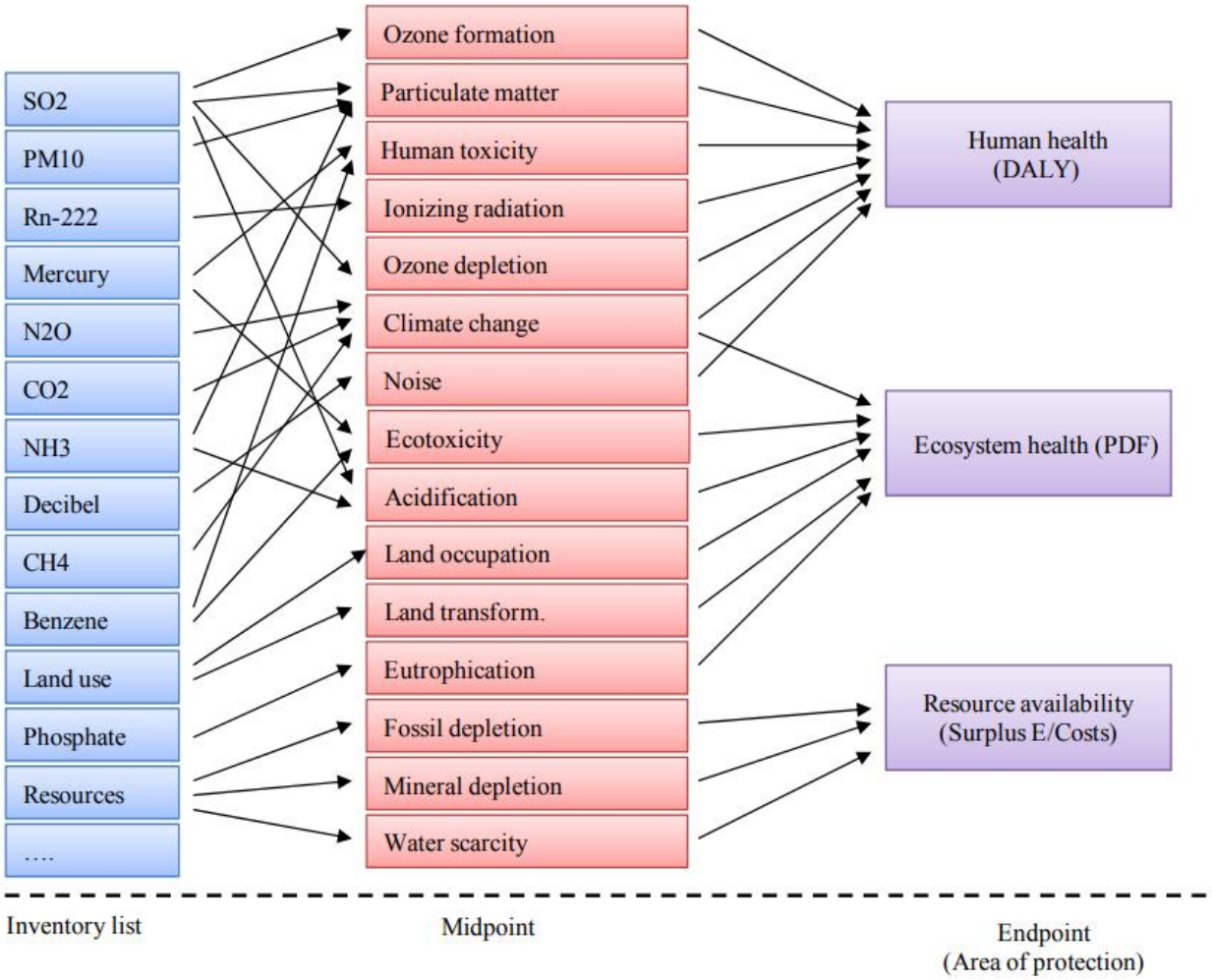
IMPACT CATEGORIES TO ENDPOINT EVALUATION