



# Generic Life Cycle Assessment of *proteins* from *insects*

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## RESEARCH TEAM



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## PROTEINS FROM INSECTS

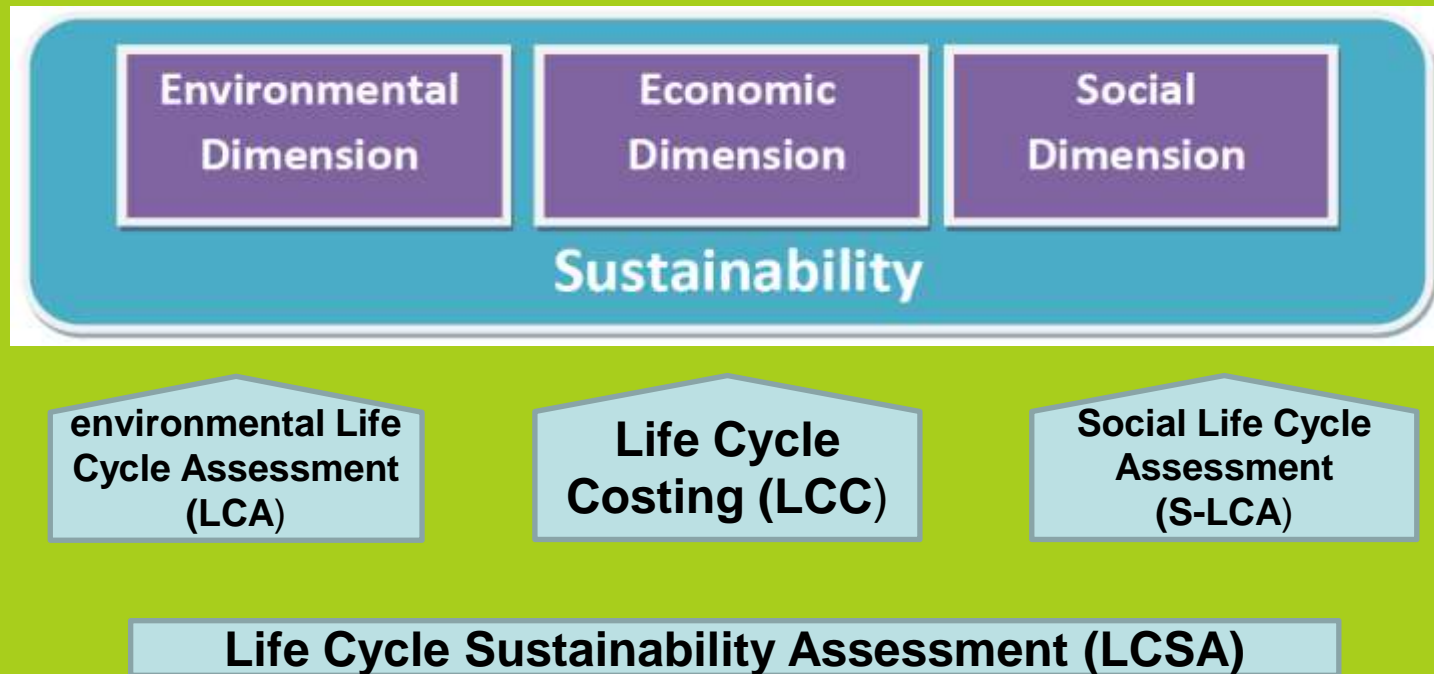
- ❑ Human population growth + dietary shifts → meat + fish consumption ↑↑↑
- ❑ Meat + fish production → high environmental impact (land and marine resources, GHG emissions)
- ❑ Insect protein = booming alternative for meat + fish OR as feed for meat + fish
- ❑ Is insect protein a sustainable substitute? Impact unexplored
- ❑ Insects = great application potential, but success will largely depend on **proven sustainability**
- Consider sustainability issues **from the design phase**





## HOW TO ASSESS SUSTAINABILITY?

- Consider **all aspects** of sustainability

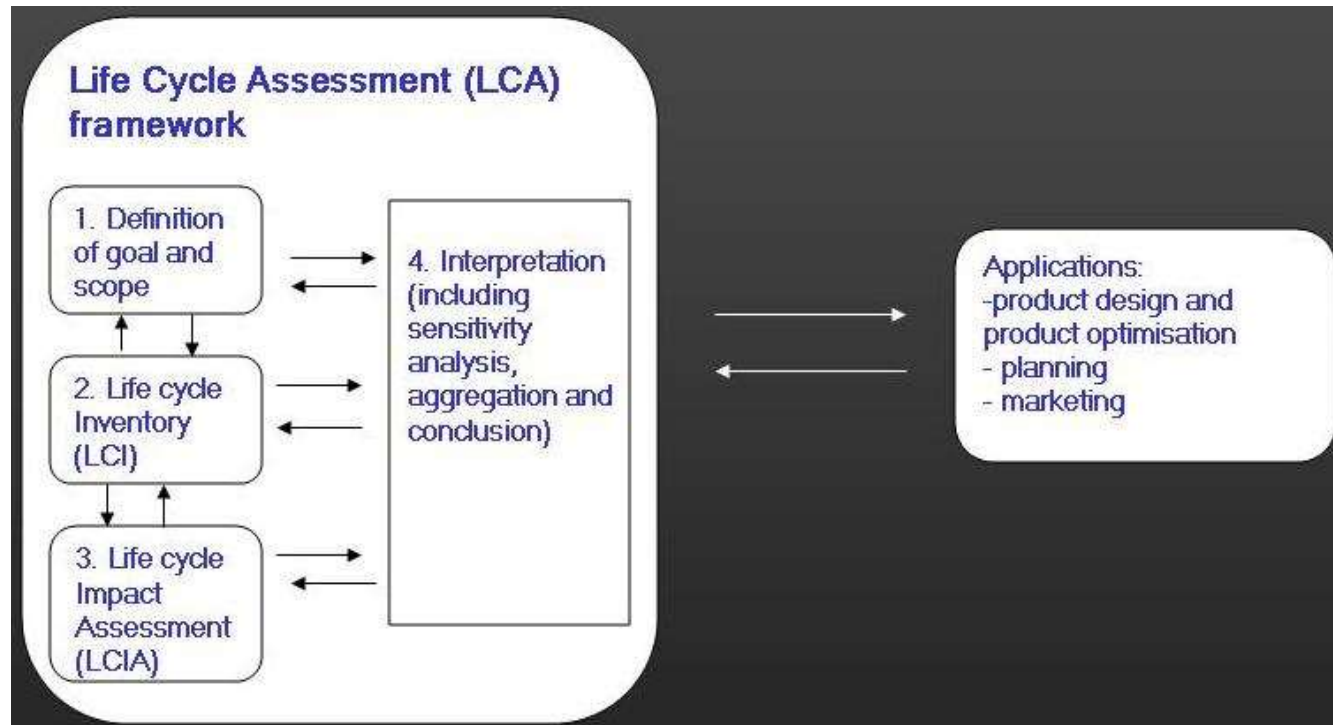


- Use outcomes in a **learning process** of **continuous improvement**





# WHAT IS LIFE CYCLE ASSESSMENT?

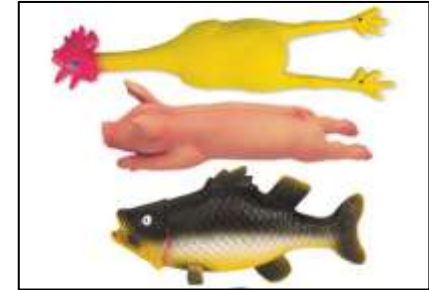


- ❑ ISO 14040 standardised procedure to quantify the environmental impact of a product
- ❑ Including all input (resource use) and output (emissions) related impacts along the complete life cycle from cradle to grave





# PROTEINSECT PROJECT: INSECT PROTEINS FOR FEED



- ❑ GOAL & SCOPE: develop sustainable production systems of insect protein for animal feed
- ❑ INPUT: Insects reared on organic waste streams
- ❑ OUTPUT: valuable proteins suitable for fish and monogastric livestock production.
- ❑ CONDITION: Integrate LCSA





Generic LCAs for small scale industrial units  
Functional unit (FU): depends on the system

4 production systems:

Main Purpose	By-products	Species	Substrate	Scenario	Code
<b>Pig manure reduction</b> (FU: 1kg of waste reduction)	Residue Substrate + Insect Protein	Housefly ( <i>Musca domestica</i> )	Pig manure	Fresh manure	HF fm
				Dewatered manure	HF dm
<b>Insect Protein</b> (FU: 1 kg of insect product)	Residue Substrate	Black Soldier fly ( <i>Hermetia illuscens</i> )	Brewery waste	Manual harvest	BSF mh
				Automated harvest	BSF ah





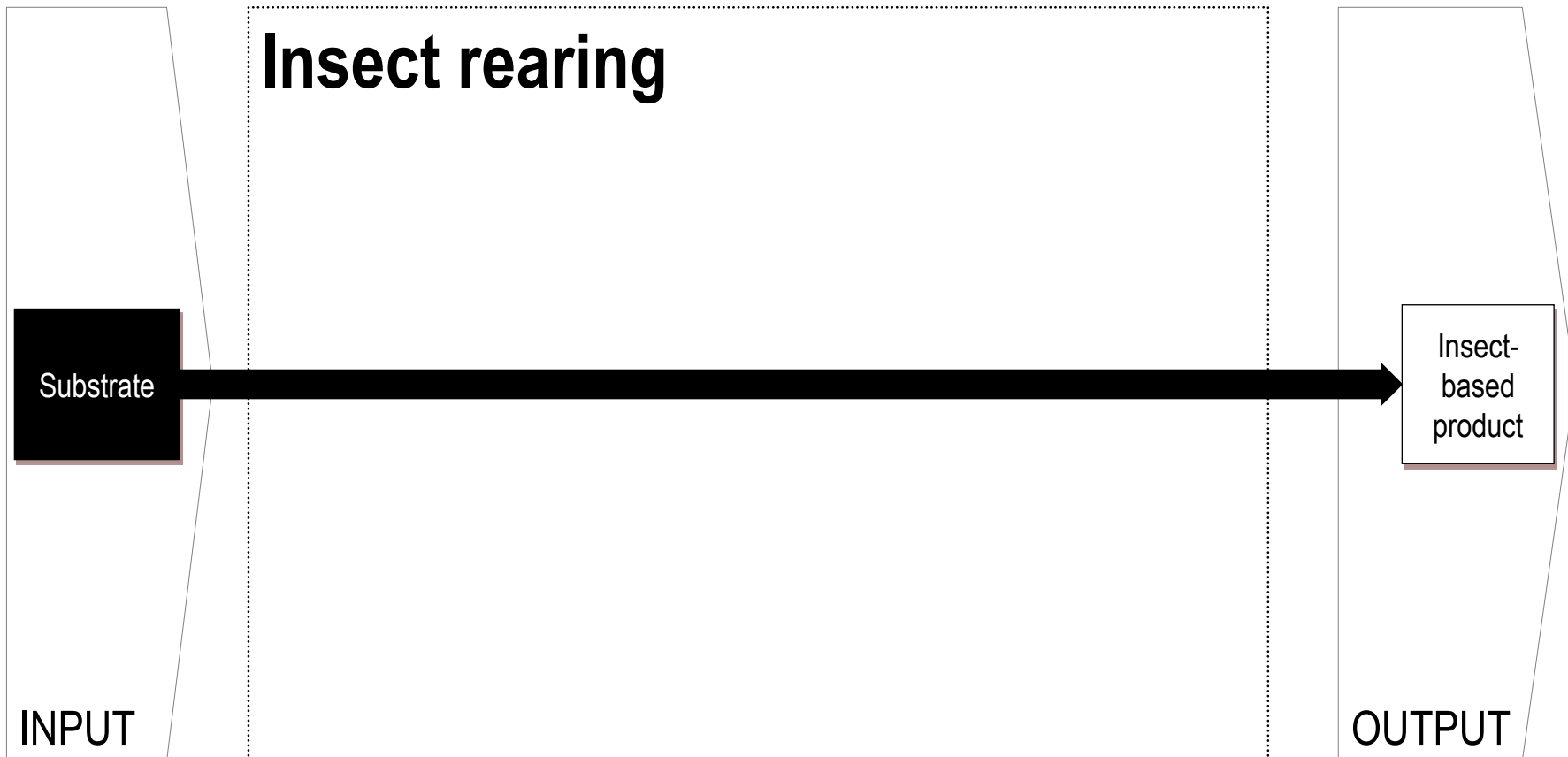
1. Building a material flow chart: example for **HF fm**
2. Finalized material flow charts for all **4 case studies**
3. Descriptive analysis based on inventory analysis for all **4 case studies**
4. Impact assessment (land occupation and fossil fuel depletion) for all **4 case studies**





## Example: HOUSE FLY - FRESH MANURE – MANUAL HARVEST

### 1. Simple basic scheme

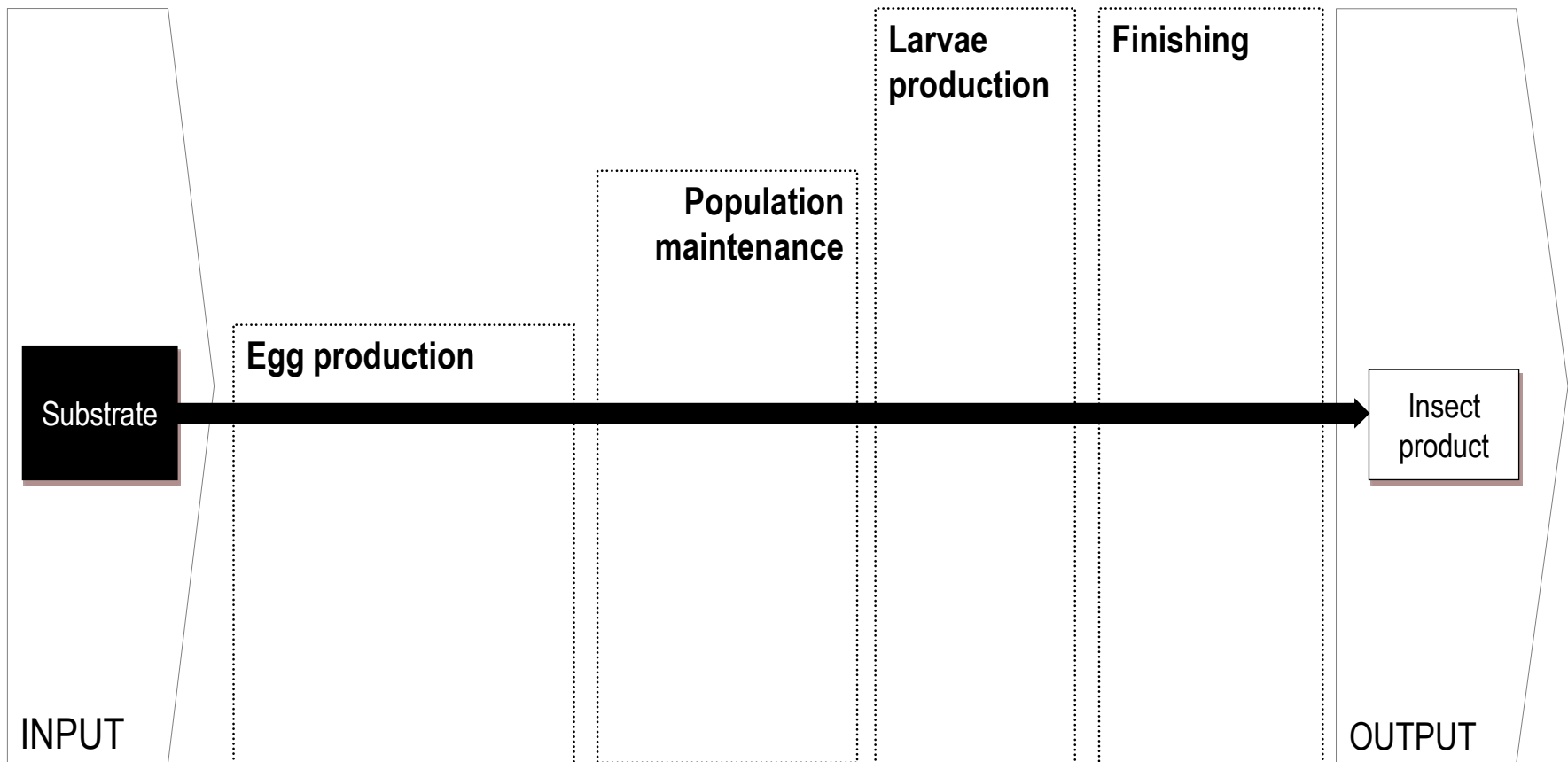






## Example: HOUSE FLY - FRESH MANURE – MANUAL HARVEST

### 2. Discerning the unit processes ( $\neq$ operating conditions)

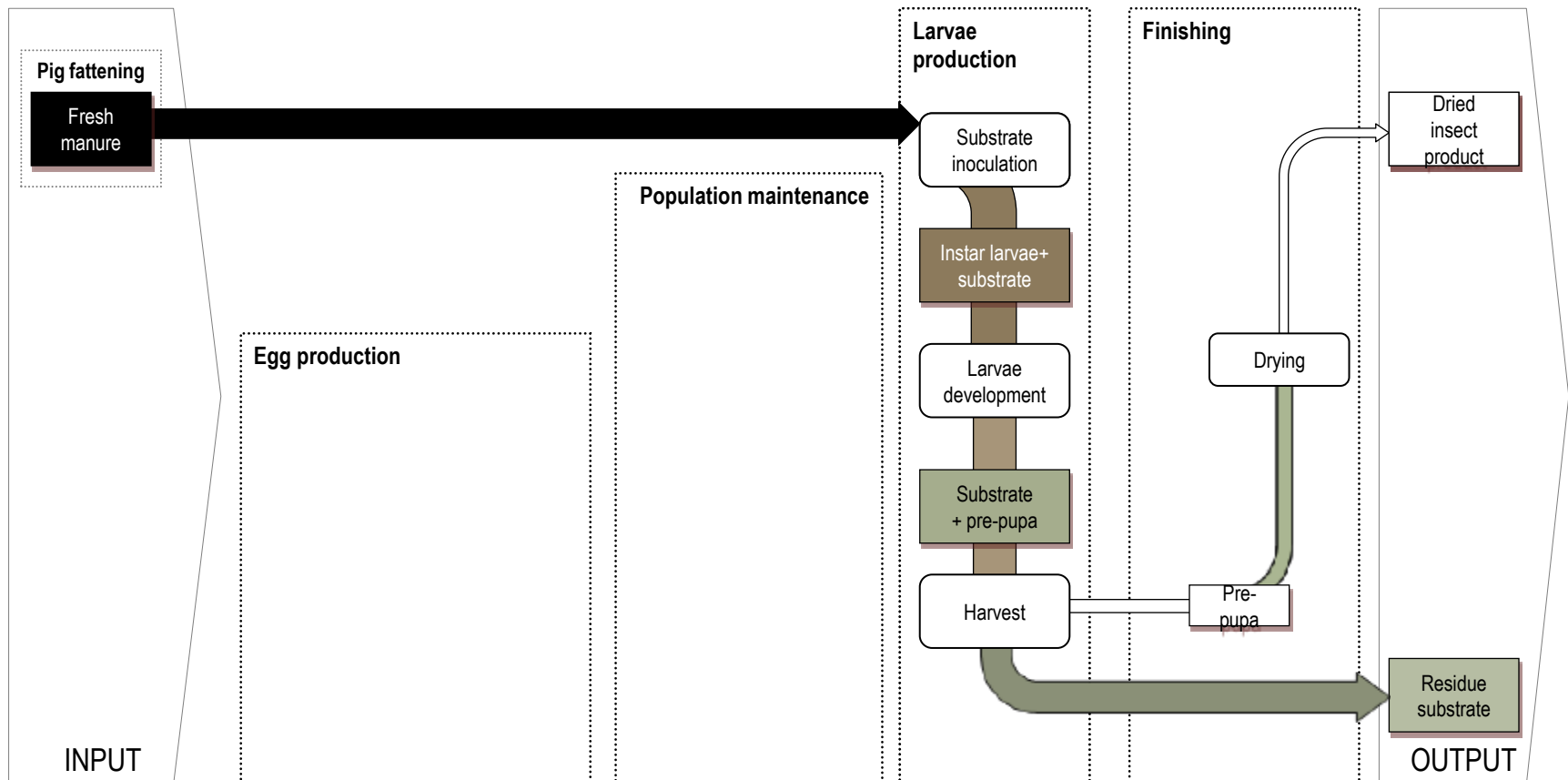






## Example: HOUSE FLY - FRESH MANURE – MANUAL HARVEST

### 3. Focusing on the manure reduction (larvae + finishing)



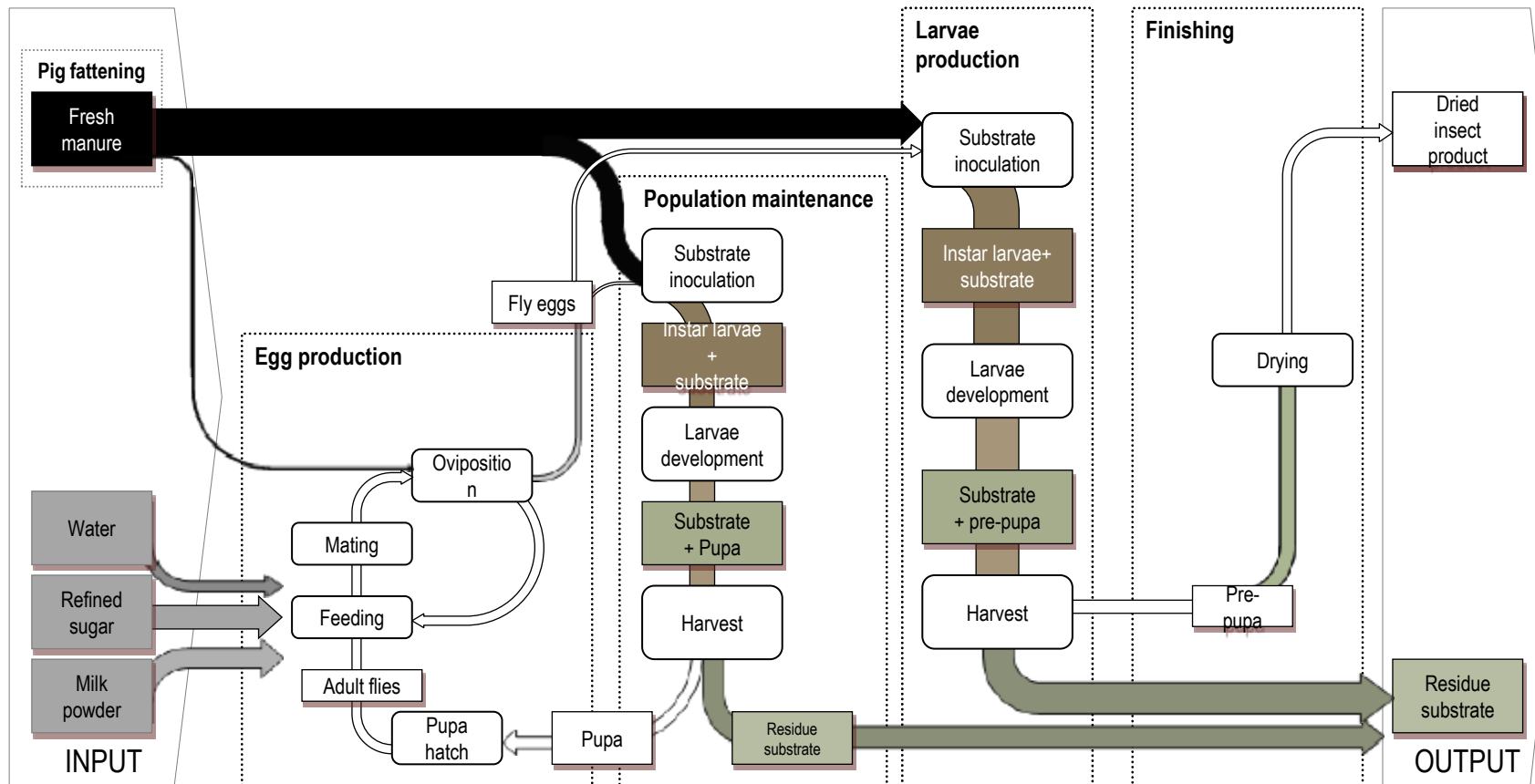




# BUILDING THE MATERIAL FLOW CHART

## Example: HOUSE FLY - FRESH MANURE – MANUAL HARVEST

4. Focusing on egg production and adult population maintenance (= similar to larvae production, but  $\neq$  conditions +  $\neq$  output)

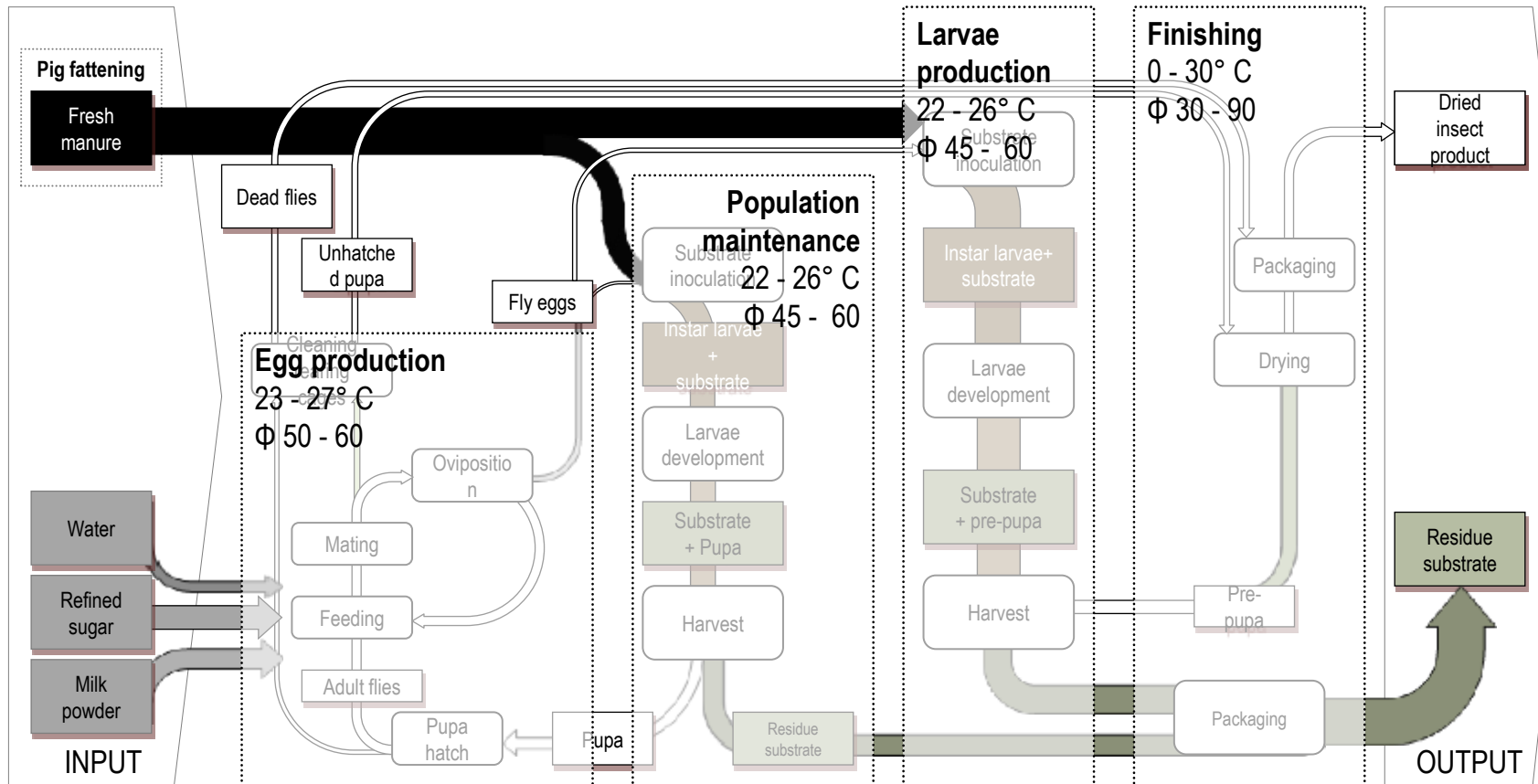






## Example: HOUSE FLY - FRESH MANURE – MANUAL HARVEST

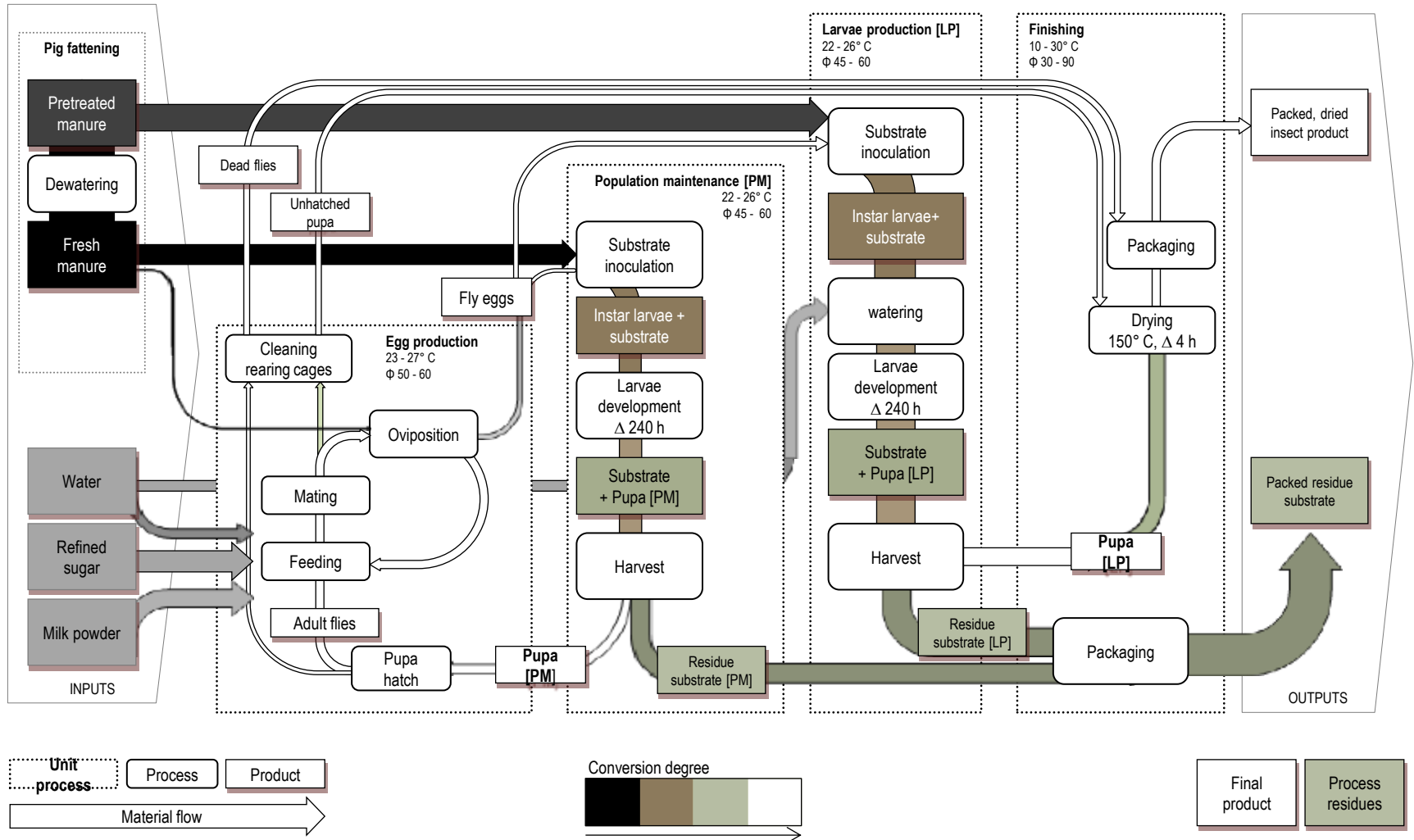
### 5. Adding remaining flows + determining optimal conditions of unit processes





# Insect rearing system - Unit processes and fundamental material flows

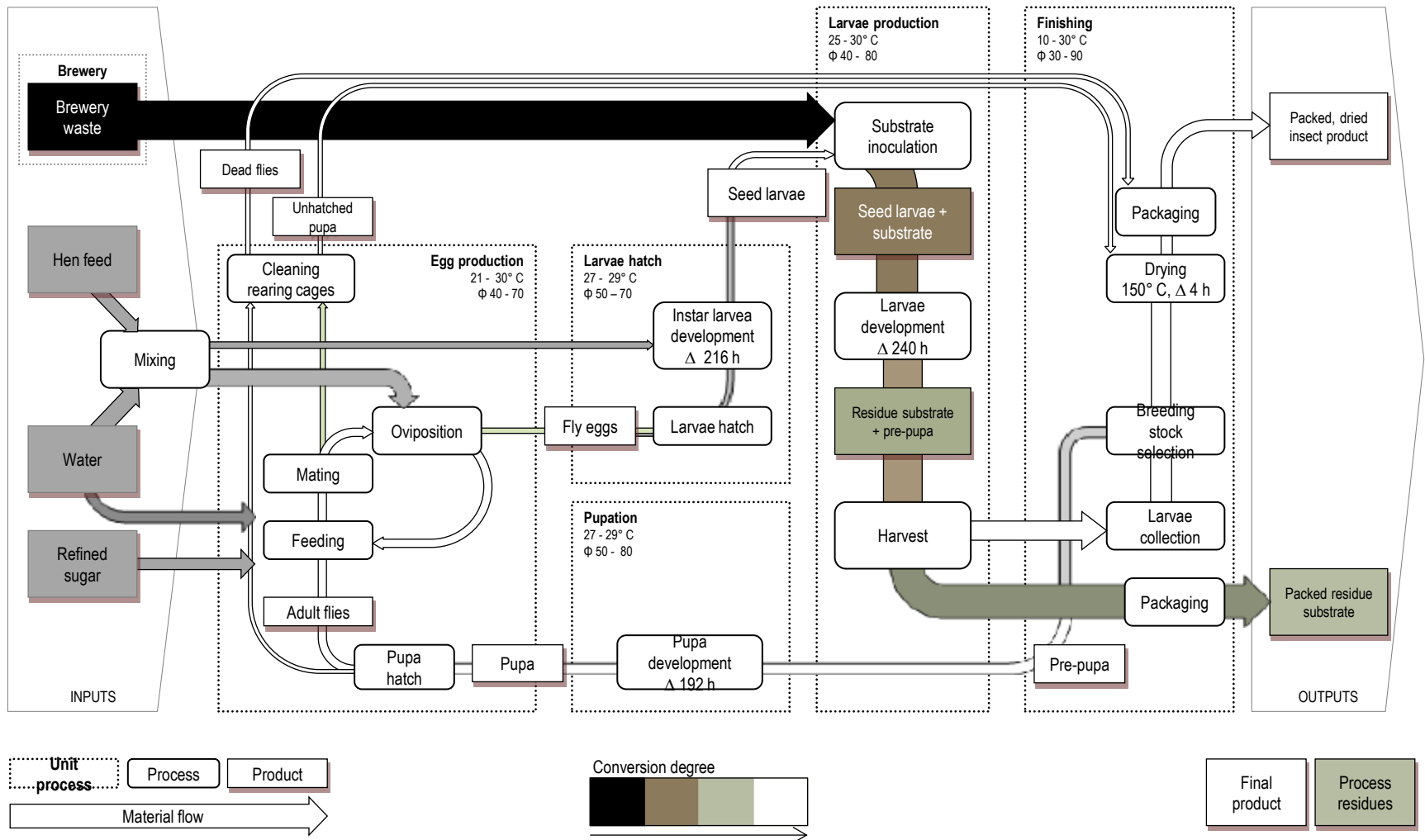
Pretreated pig manure, manual harvest, dried insect product [HFdm] (Alicante, Spain)  
House fly [*Musca domestica*]





# Insect rearing system - Unit processes and fundamental material flows

Brewery waste, manual harvest, dried insect product [BSFmh] (Alicante, Spain)  
Black Soldier Fly [*Hermetia illuscens*]

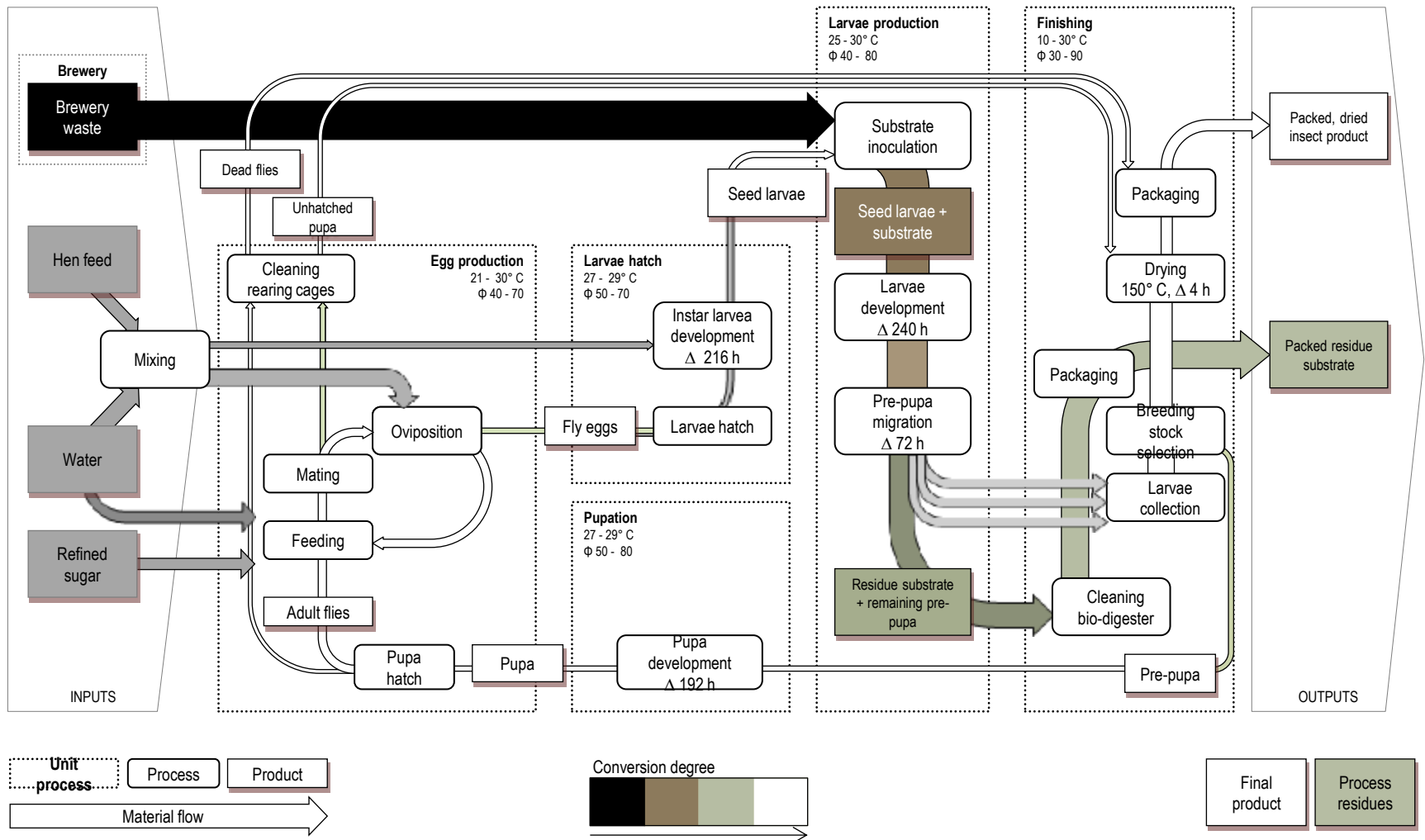




# Insect rearing system - Unit processes and fundamental material flows

Brewery waste, semi-automated harvest, dried insect product [BSFah] (Alicante, Spain)

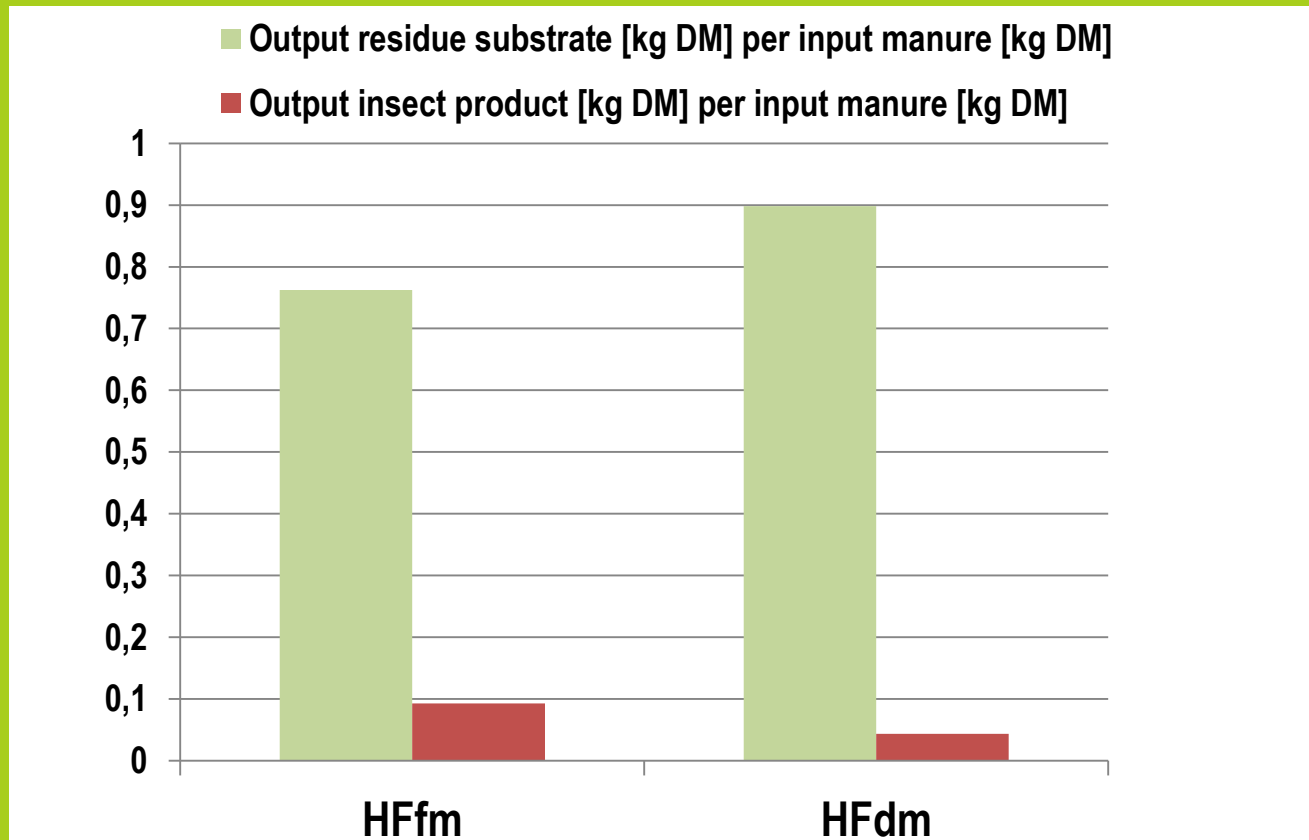
Black Soldier Fly [*Hermetia illuscens*]







## Material flow: outputs per 1 kg pig manure reduction

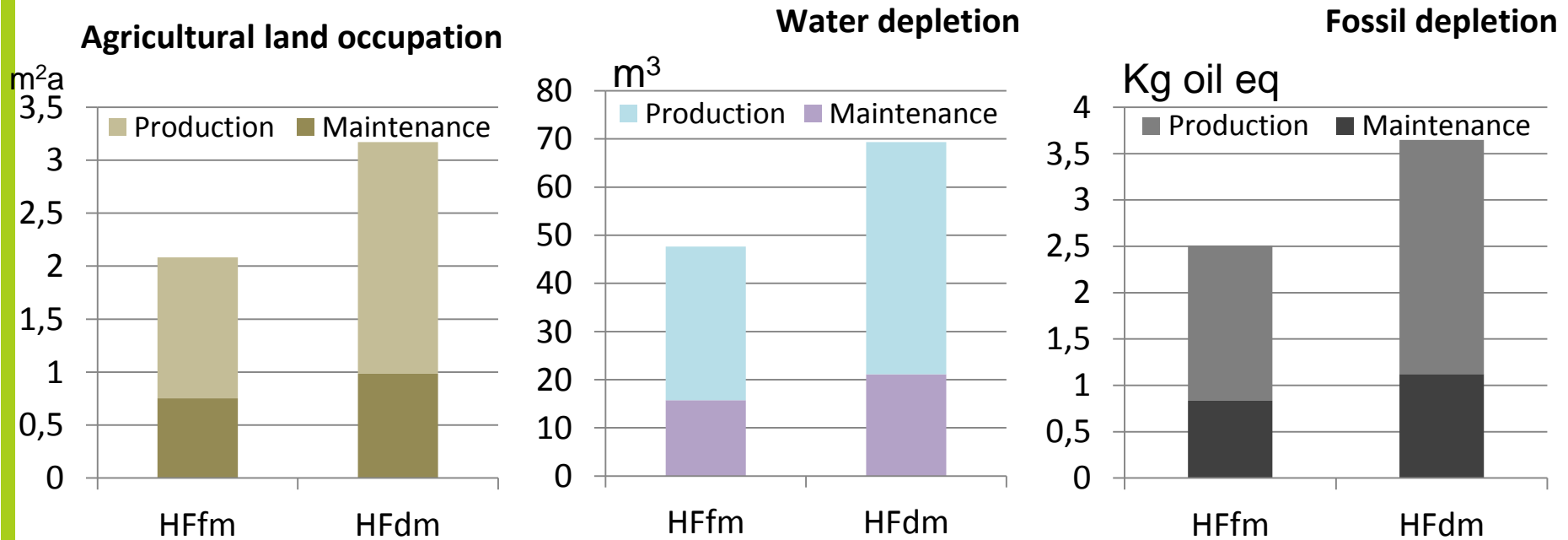


- ❑ High conversion rate into valuable products
- ❑ Manure dewatering useful if residue substrate is valuable





Life Cycle impacts (ReCIPe midpoint categories) per kg of manure reduction [DM]

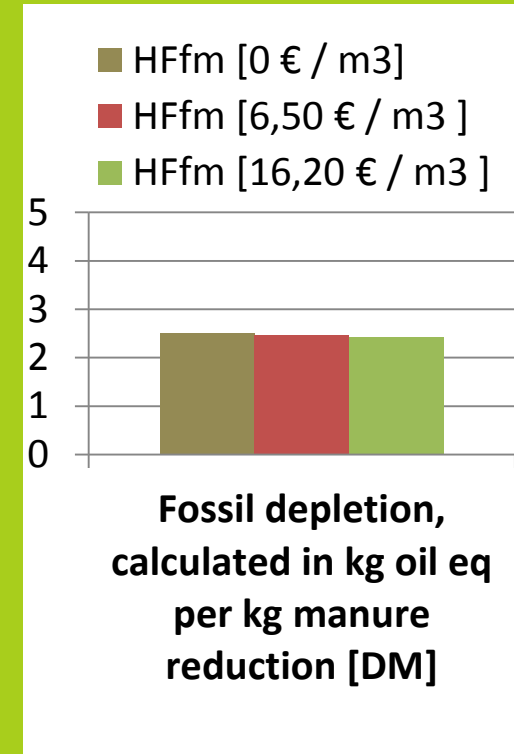
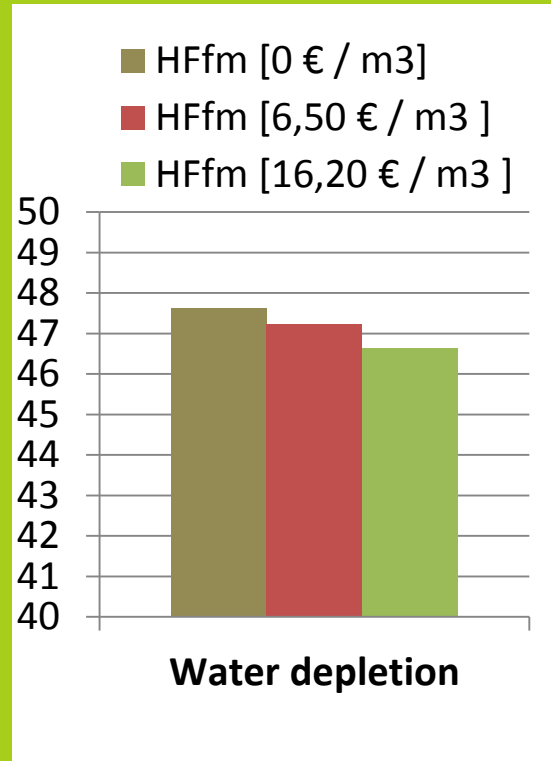
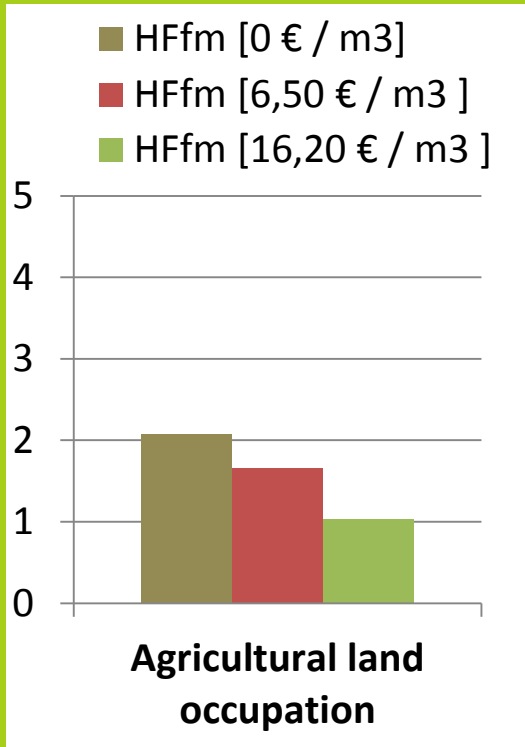


- ❑ Dewatering has substantial impact by lower system efficiency
- ❑ Large contribution of unit processes dedicated to maintenance





## Life Cycle impacts (ReCIPe midpoint categories) per kg of manure reduction [DM]

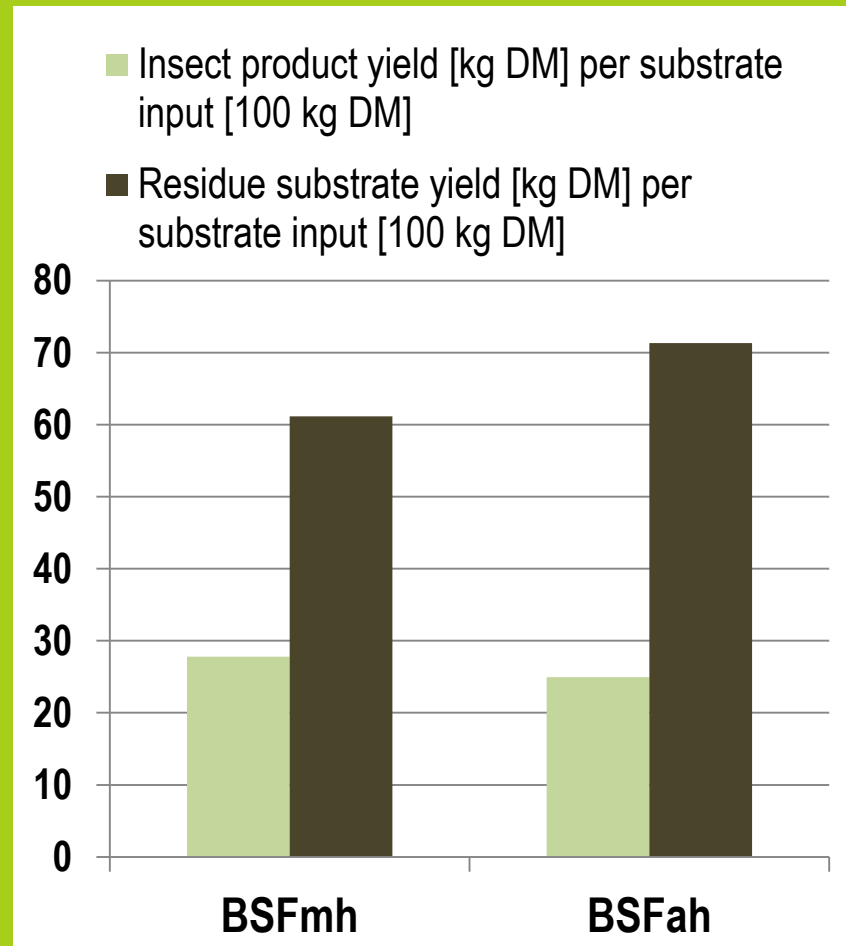


- Value of manure reduction lowers impact dramatically (economic allocation to pig rearing)





## Material flow: yield per 100 kg input substrate

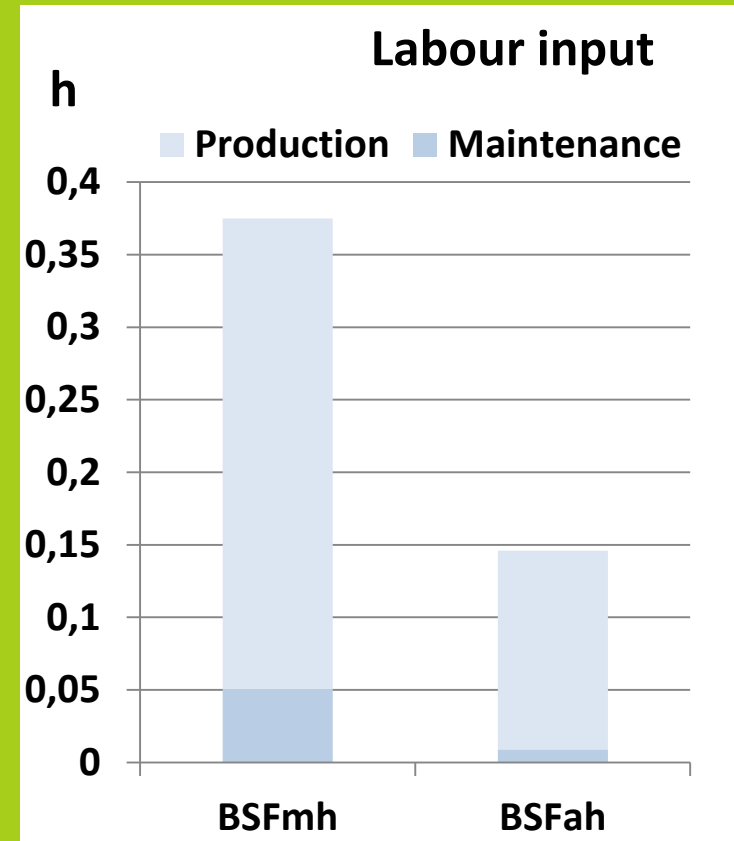
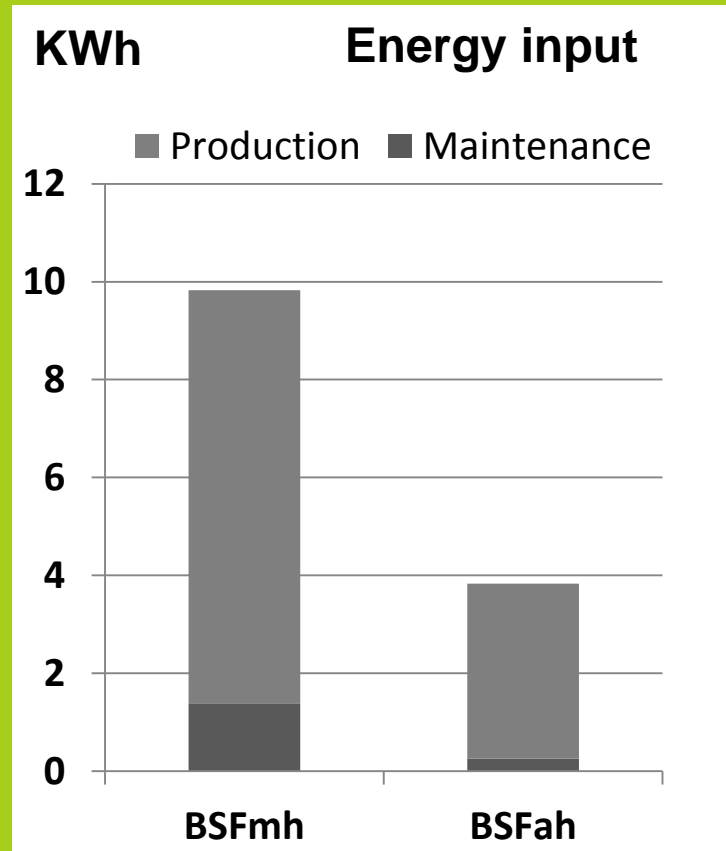


Good conversion rate, a little affected by automation





## Energy and labour input per kg insect product

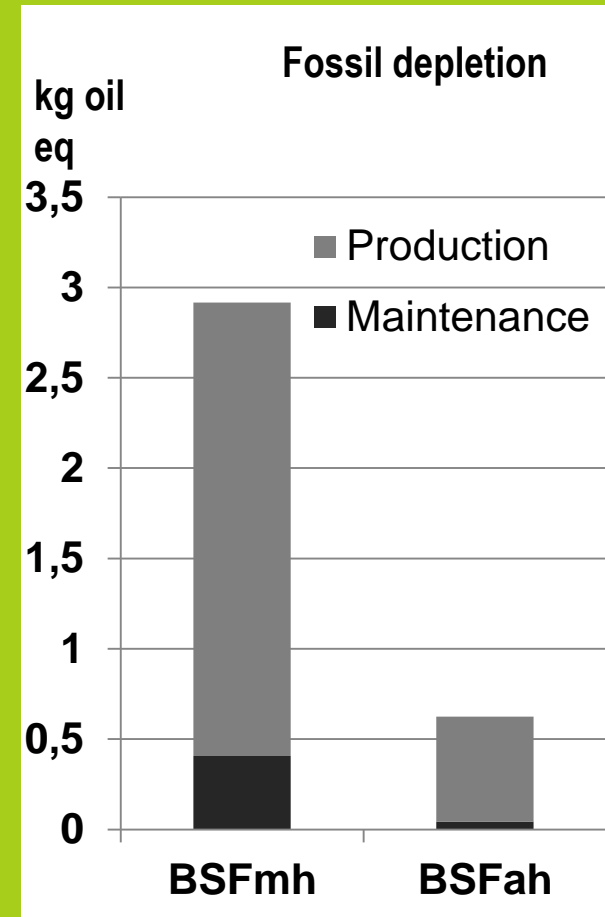
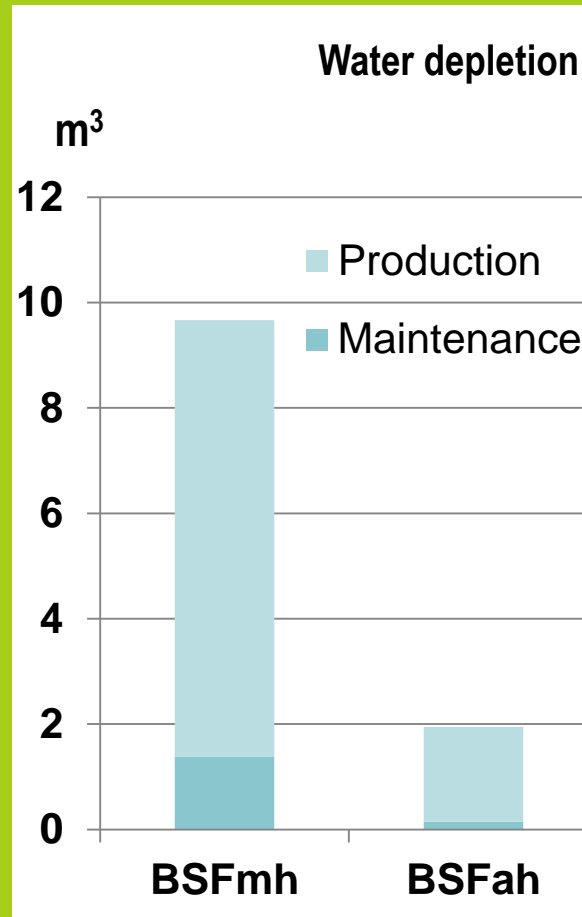
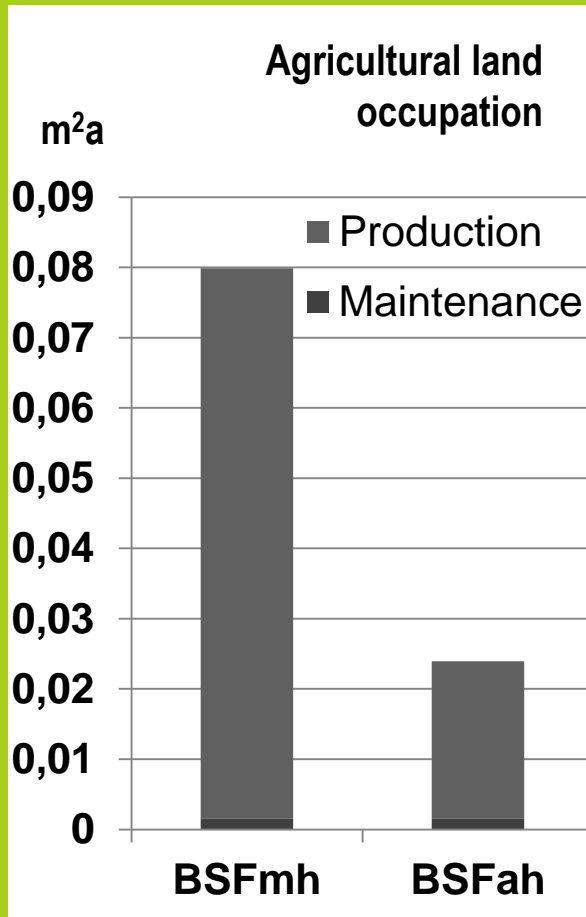


- Large efficiency improvement by automation
- Minor impact due to maintenance





## Life Cycle impacts (ReCIPe midpoint categories) per 1kg of insect product [DM]

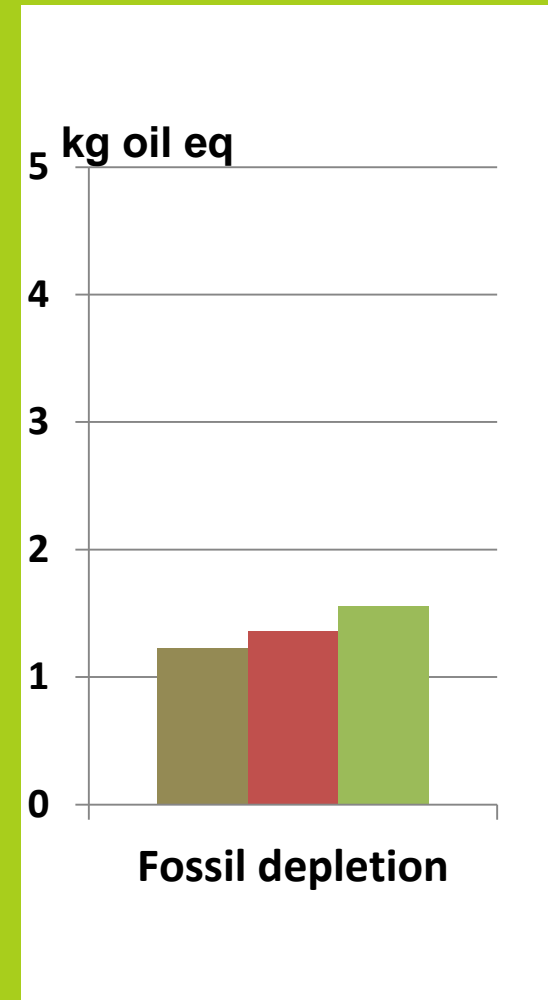
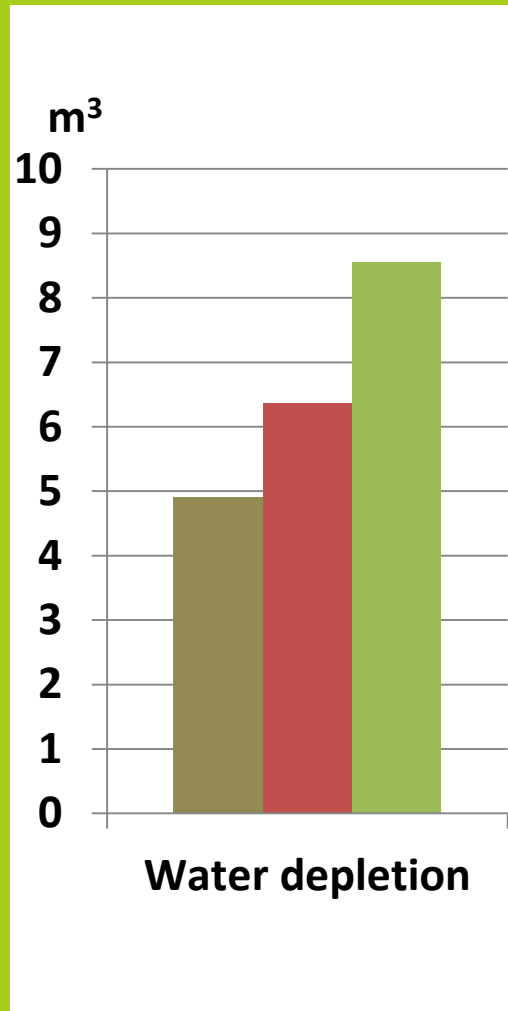
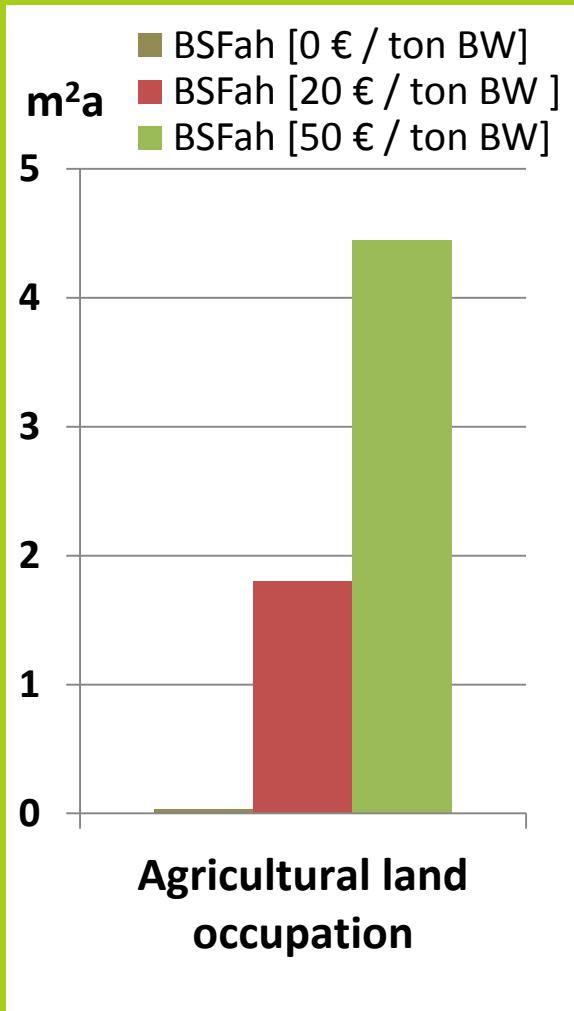


- Large efficiency increase by automation
- Minor environmental cost of population maintenance





Life Cycle impacts (ReCIPe midpoint categories) per 1kg of insect product [DM]

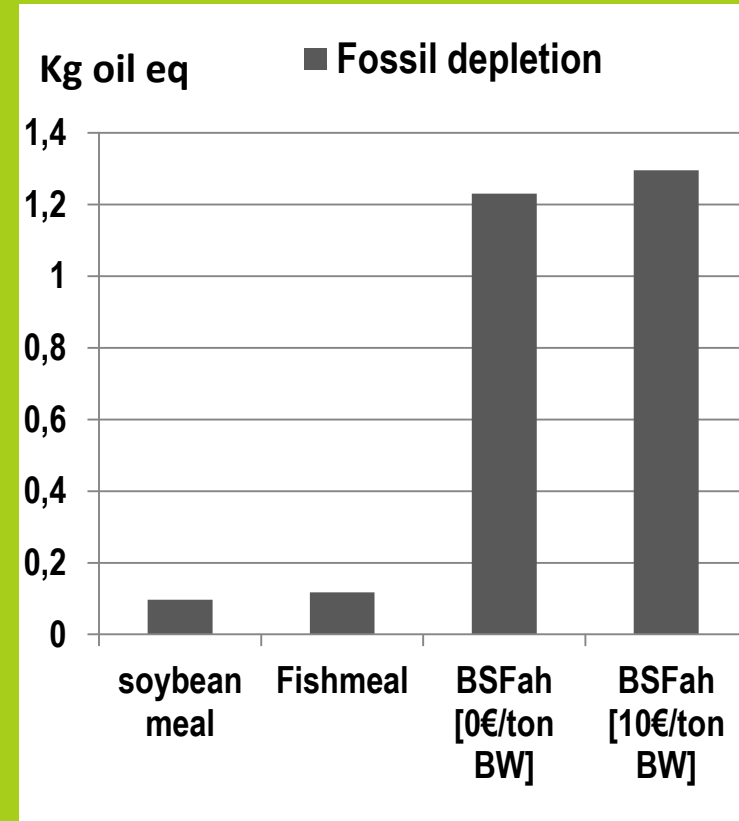
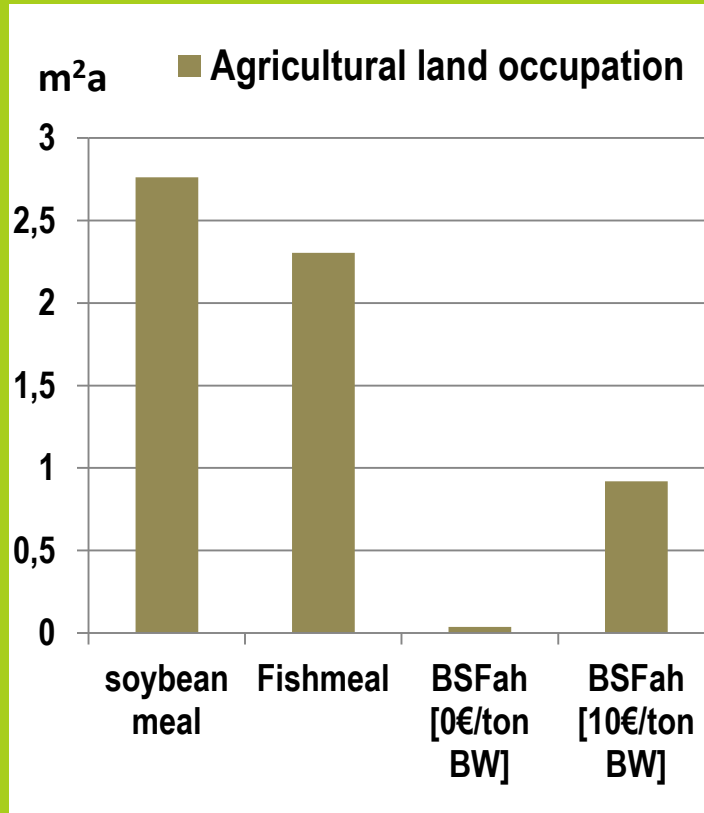


Higher value of brewery waste leads to higher impacts





## Life Cycle impacts (ReCIPe midpoint categories) per 1kg of insect product [DM]



□ Benchmarking against related products reveals strengths and improvement challenges





- 1) Insect production is a versatile system to make agriculture more efficient (adding value, waste reduction)
- 2) Systems are difficult to compare (different goals, different species, different technological equipment)
- 3) Alternative production scenarios result in different system performances and efficiencies = room for improvement
- 4) A large part of the impacts is due to non-productive processes (maintenance of the population)
- 5) Value of substrates and products affects environmental performance (economic allocation)





- 6) Benchmarking of this novel technology with highly optimized related products (e.g. soya) shows potential and challenges for improvement (e.g. in energy requirements)
- 7) LCA helps to identify the crucial steps for improvement
- 8) Life cycle approach will also contribute to improving social cost and economic profit
- 9) Golden rule of innovation for transition: do not CLAIM before you KNOW (cf. the self-destruction of the Jatropha tropical biofuel hype)
- 10) Sustainability is an issue of the START, not of the END





**THANK YOU FOR YOUR ATTENTION**

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