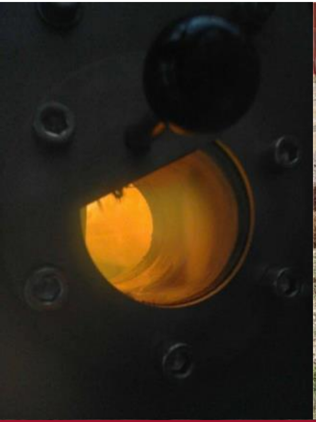
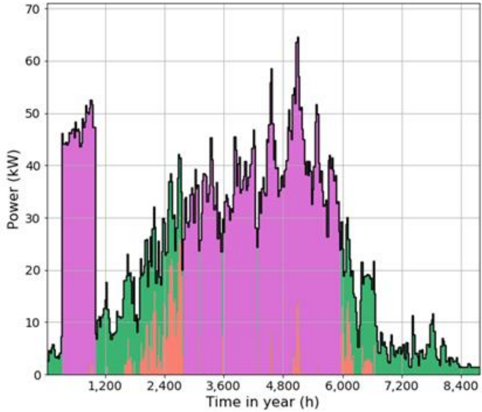
Small-scale biochar production on Swedish farms

Potential, variability & environmental performance







Elias Azzi, Erik Karltun & Cecilia Sundberg

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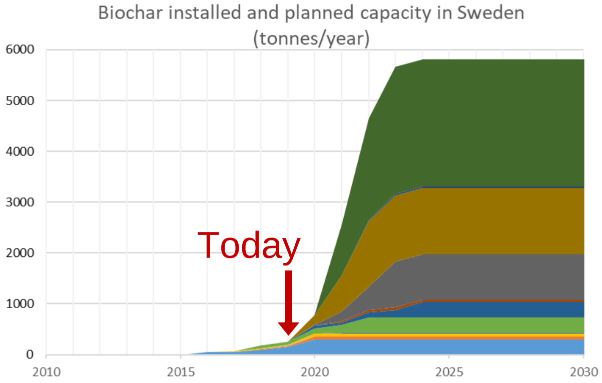
A PLEASANT JOURNEY

1 person Stockholm - Cetraro	Train (-85%)	Plane
kg CO_2-eq	66	450
kg biochar	**28**	191
GJ (CED)	1.8	7.2
€-offset	5.6 €	38 €

Ecoinvent 3.5 consequential system-model
Assumed: 80% C-content, 80% 100-year recalcitrance; 200 EUR/ton biochar
CED: Cumulative energy demand

CLIMATE-POSITIVE HEATING

- Governmental funding for local emission reduction investments
- 12 pyrolysis-biochar projects awarded (2016-2017) & more are expected
- 3 farmers that started operation > my object of study



CLIMATE-POSITIVE HEATING

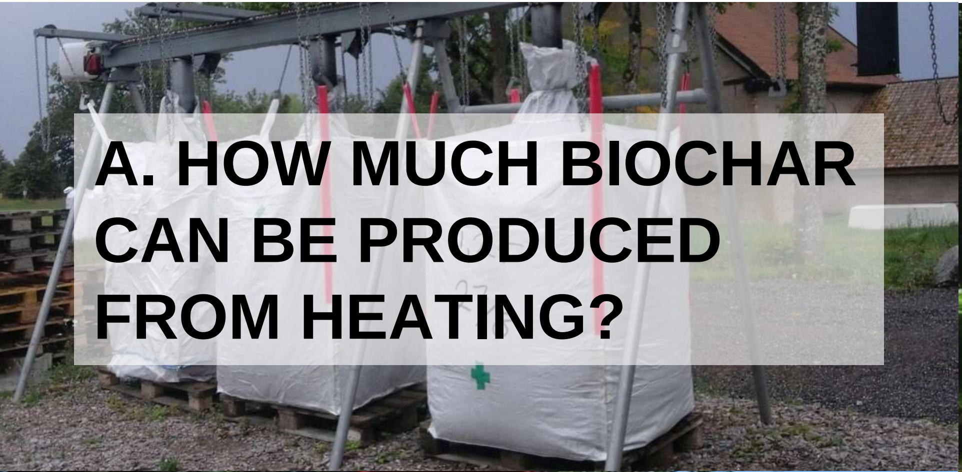
Lindeborgs 50 kW - 2017

Farm activities:
- Organic grain production (12 ha)
- Hotel, conference, and courses

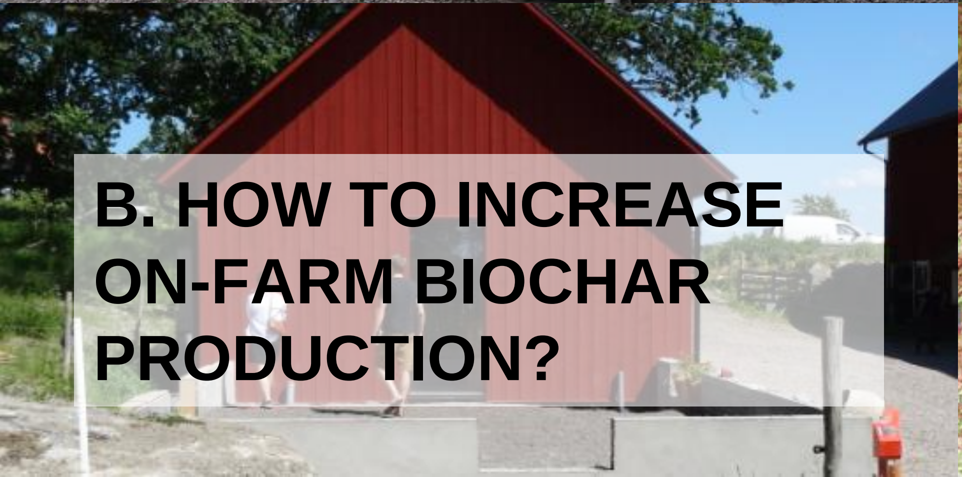
Heating equipment:
- 50 kW pyrolysis
- 16 kW heat pump
- Electrical heaters

Biochar as a co-product of heating

FOUR QUESTIONS

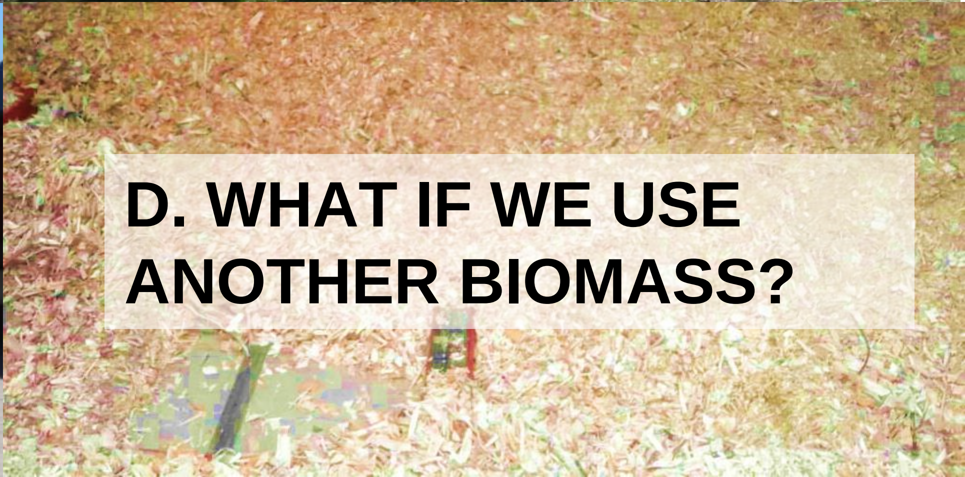


A. HOW MUCH BIOCHAR CAN BE PRODUCED FROM HEATING?



B. HOW TO INCREASE ON-FARM BIOCHAR PRODUCTION?

C. WHAT ENVIRONMENTAL IMPACTS?



D. WHAT IF WE USE ANOTHER BIOMASS?

A. HOW MUCH BIOCHAR FROM HEATING?

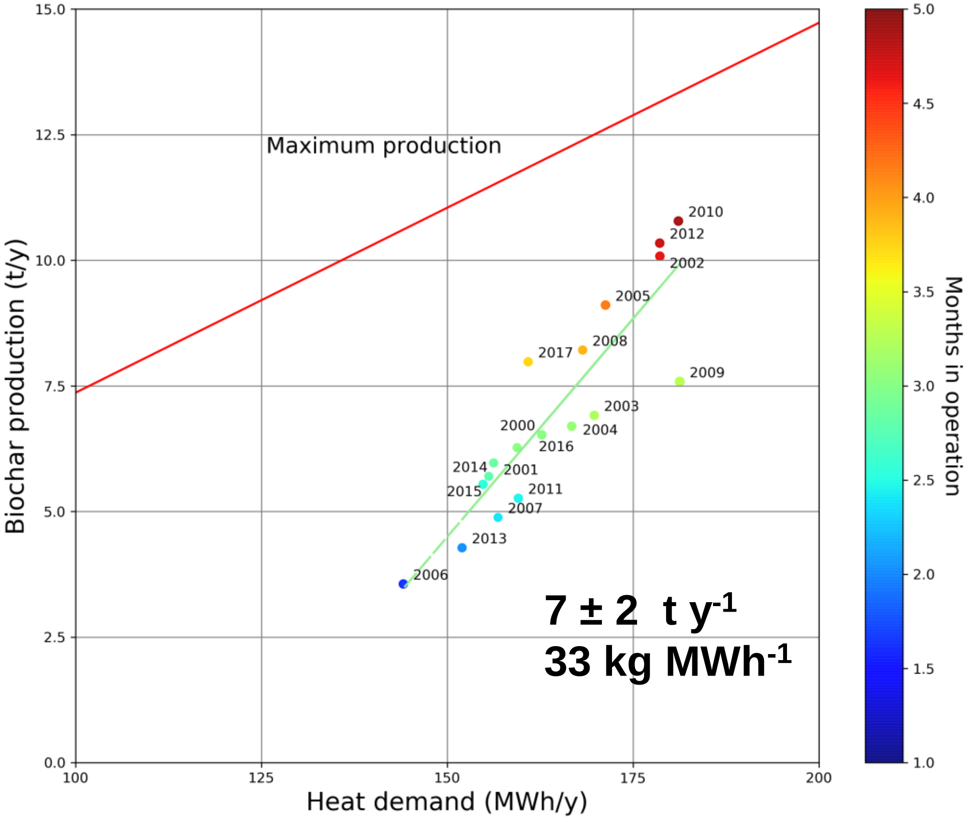
Method.
What did we do?

Input data:
- Daily temperature series
- Process description
- Management constraints

Model run for:
- Years 2000-2018 (past)
- Years 2020-2038 (future)
- Different management

Heated space
600 m²

Results.
What did we get?



7 ± 2 t y^{-1}
33 kg MWh^{-1}

Discussion.
What take-away?

A. HOW MUCH BIOCHAR FROM HEATING?

Method.
What did we do?

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600 m^2

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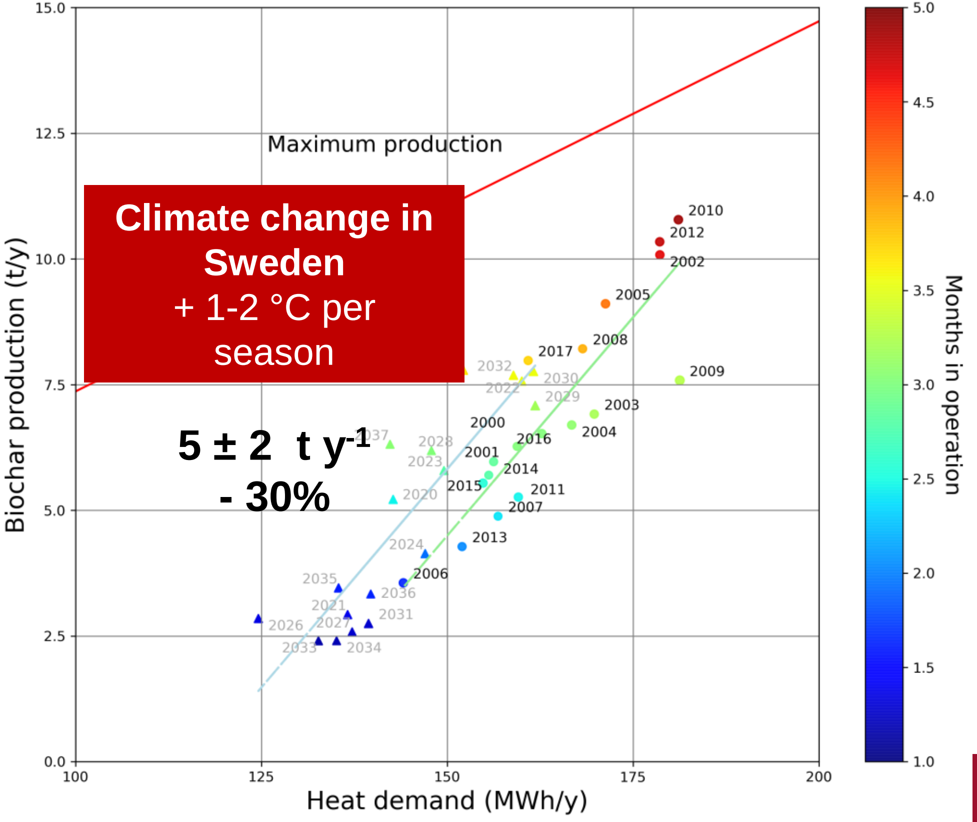


Discussion.
What take-away?

- Interannual variability
- Long term decreasing trend
- Plant sizing & flexibility matter!

B. WHAT OPTIONS TO GROW?

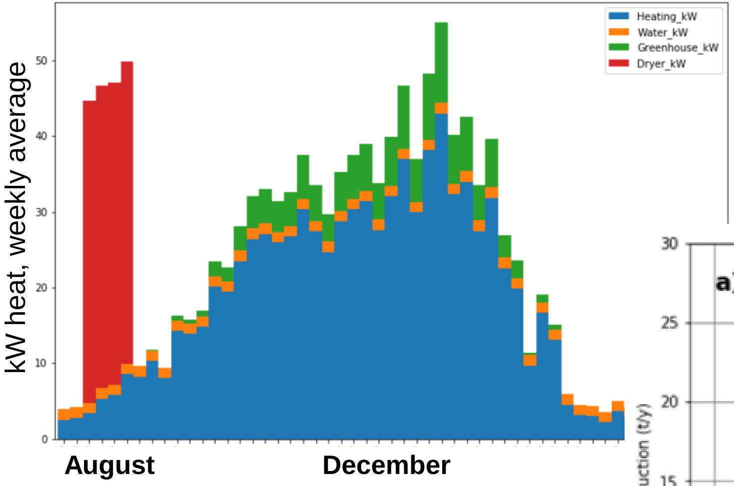
Method.
What did we do?

- **Space and water heating**
160 MWh yr^{-1}
600 m^{2}

- **Greenhouse**
+ 22 MWh yr^{-1},
+ 38 m^{2}, 153 m^{3}

- **Grain drying**
+ 25 MWh yr^{-1}
+ 7 t grain MWh^{-1}

Results.
What did we get?

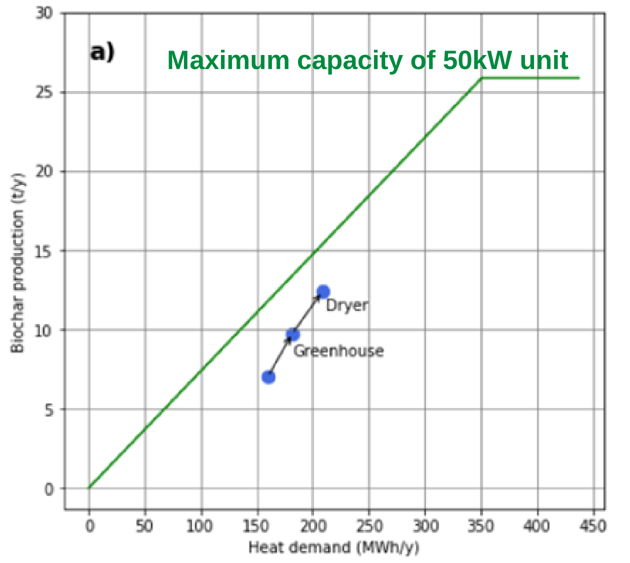


Greenhouse:
70 kg biochar m^{-2} , + 2.7 t biochar yr^{-1}

Grain drying:
15 kg biochar t^{-1} grain, + 2.7 t biochar yr^{-1}

Discussion.
What take-away?

- Future development scenarios can be explored at project start with farmers



C. WHAT ENVIRONMENTAL IMPACTS?

Method.
What did we do?

Unit of comparison
- 1 year of heating

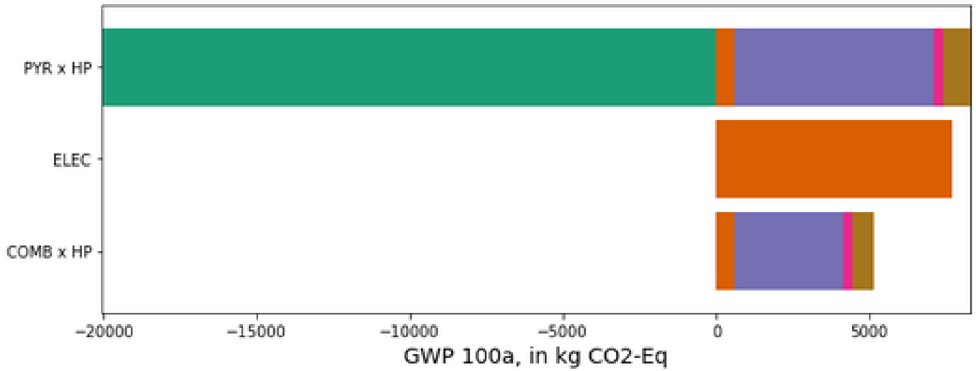
Scenarios
- PYR x HP
- ELEC
- COMB x HP

Scope
- Manufacturing
- Fuel production
- Plant emissions
- Electricity use
- Carbon sequestration

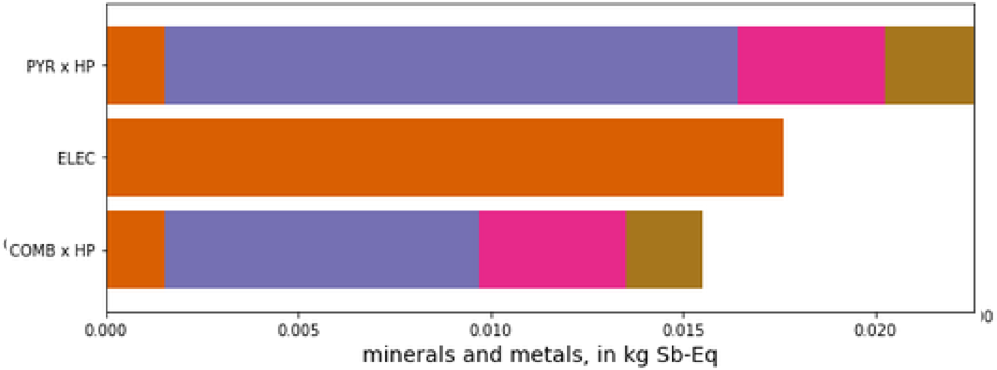
! Unspecified non-oxidative biochar use

Results.
What did we get?

C L I M A T E



O T H E R S



Discussion.
What take-away?

Not a surprise!
- Biochar carbon sequestration comes at an environmental cost.
- Biochar use phase is important.

C. WHAT ENVIRONMENTAL IMPACTS?

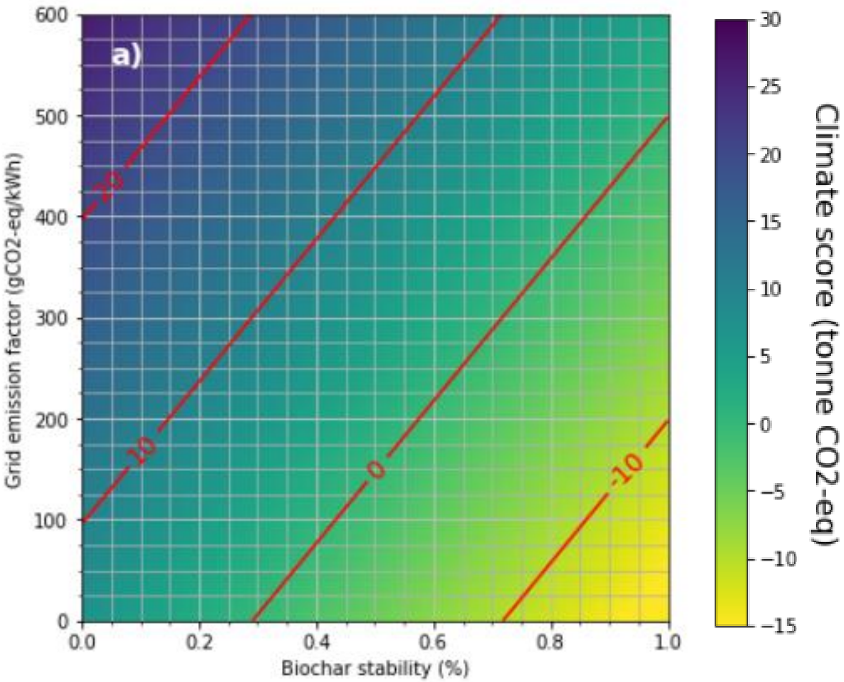
Method.
What did we do?

Sensitivity analysis on climate score
- PYR x HP

Factors
- Electricity emissions
  0 – 600 gCO_2-eq kWh^{-1}
- Biochar stability
  0 – 100%

Results.
What did we get?

PYR x HP



Discussion.
What take-away?

Climate positive heating if:
- Decarbonised electricity
- High biochar stability
- Importance of the overall system

D. WHAT IF WE USE ANOTHER BIOMASS?

Method.
What did we do?

Results.
What did we get?

Discussion.
What take-away?

Life cycle comparison
- Pellets
- Forest chips
- Plantation willow chips
- Agricultural waste

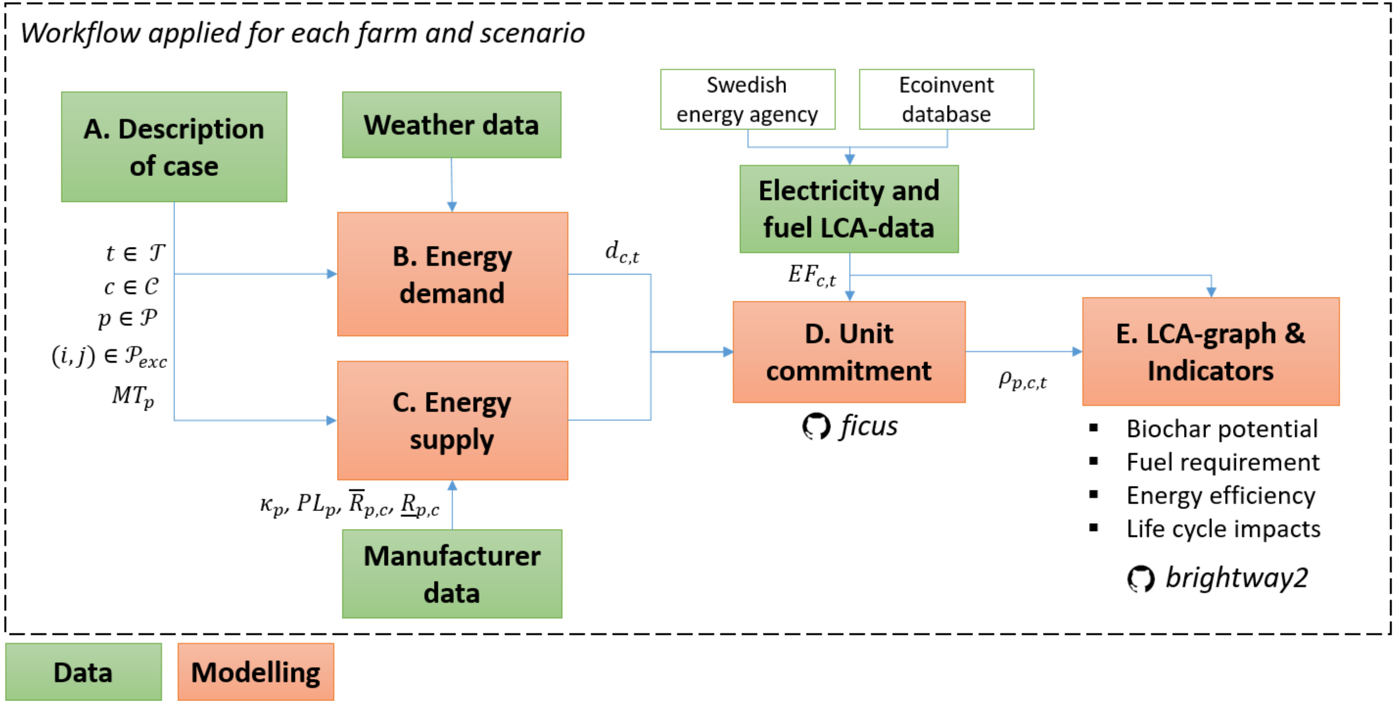
It changes:
- Process properties (moisture, energy, yield, C content, stability)
- Supply chain & land use changes (LUC)

With data available, only small changes in biochar production or carbon sequestration.

Biochar is a **bioenergy system**. Direct and indirect **land use changes** are important aspects.

"B3.1. If applied at scales necessary to remove CO_2 from the atmosphere at the level of several $GtCO_2$ yr^{-1}, afforestation, reforestation and **the use of land to provide feedstock for bioenergy with or without carbon capture and storage, or for biochar, could greatly increase demand for land conversion** (high confidence). **Integration into sustainably managed landscapes at appropriate scale can ameliorate adverse impacts** (medium confidence)."
IPCC SRCL

A WORD ABOUT THE *TOOL*



Written in Python

Will be available on GitHub

Reusable & extensible

- *biochar use phase*
- *benchmark reactors*

TAKE HOME MESSAGES

1. In small-scale biochar projects, do not produce biochar just to save the climate! Produce biochar because you need it for **some tangible effect**, whether climate-related or not.

2. Availability of biomass may not be a problem in Sweden currently, but globally, biomass is a limited resource. Biochar systems thrive most in future scenarios with low energy demand. Advocate for that future.

3. You have a biochar production project? Get in touch with us!

Keywords:
Industrial ecology
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Energy and agriculture

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Conference:
Biochar in the Nordics!
16th-17th October
Stockholm, Sweden

https://biochar.abe.kth.se

GENESIS OF FARMER PROJECTS

- Building an ecological hotel
- Looking for the ’best’ way to heat the hotel in winter
- Heard about biochar from a friend
- Applied for funding

- Bought a second farm in 2017
- Planning for an aquaponic farm in the new building
- Flexible plant: combustion mode or pyrolysis mode

- Heard about biochar online in 2014
- Wanted to try it out, but no fertiliser advisor could provide some
- Decided to produce himself