Kompendium från HåBiMet-seminarium den 31/1 – 2025

HåBiMet består av tre projekt inom det strategiska innovationsprogrammet Impact Innovation. HåBiMet syftar till att utreda vad som hindrar en hållbar marknad för metallurgiskt biokol från att växa fram i Sverige, samt vilken sorts insatser som skulle kunna främja den. De tre projekten adresserar utmaningar från olika perspektiv; tekniskt, socialt, och policymässigt. Detta stödjer Sveriges övergång till fossilfria produktionsmetoder och främjar samverkan mellan olika industrier för att minska klimatpåverkan.

HåBiMet utförs inom Impact Innovation-programmet Swedish Metals & Minerals, en gemensam satsning av Energimyndigheten, Formas och Vinnova

Detta kompendium innehåller presentationer från det Nulägesseminarium som anordnades i projektet den 30/1 – 2025. Seminariet syftade till att ge en överblick av kunskapsläget kring användning och produktion av biokol för metallurgisk användning, samt för vissa andra tillämpningar. Kunskapsutbytet fungerade som grund för det fortsatta samarbetet i projektet. Seminariet och kompendiet är indelat i tre block:

Seminarieblock 1 – Överblick, biomassa och metallurgi

I. **Planetens gränser och systemtransformationen** – *Anna Steorn och Louise Hård af Segerstad (Albaeco)*
II. **Biomassa och produktionsarealer, olika produktionsprocesser för biokol, samt försörjning från jordbruksbiomassa** – *Elisabeth Wetterlund (LTU), Erland Nylund (Swerim)*
III. **Outlook biomassa i energisektorn** – *Johnny Kjellström (Svebio)*
IV. **Tekniska försök biokol i metallurgi** – *Chuan Wang, (Swerim)*

Seminarieblock 2 – Användning av biokol och tekniska erfarenheter

V. **Typiska fällor, fel, krav och önskemål biokol i metallindustrin** – *Gunnar Ruist (GRu konsult)*
VI. **Biokol i marken – en introduktion** – *Cecilia Sundberg (SLU)*
VII. **Upparbetning av HTC** – *Yu-Chiao Lu (KTH)*
VIII. **Användning av biokol i metallindustrin och dess tekniska specifikationer**– *Konstantinos Rigas*
IX. **Höganäs erfarenheter med biokol** – *Ryan Robinson*
X. **Biokol för ferrokrom** – *Ludvig Ånnhagen*

Seminarieblock 3 – Möjligheter och policy

XI. **Samproduktion biokol-fjärrvärme** – *Mikael Karlsson, (Energiforsk)*
XII. **Hur policys och marknadseffekter påverkar priser** –*Robert Lundmark (LTU)*

Compendium from HåBiMet seminar on 31/1 – 2025

HåBiMet consists of three projects within the strategic innovation program Impact Innovation. HåBiMet aims to investigate what prevents a sustainable market for metallurgical biochar from emerging in Sweden, and what kind of initiatives could promote it. The three projects address challenges from different perspectives; technically, socially, and policy-wise. This supports Sweden's transition to fossil-free production methods and promotes collaboration between different industries to reduce climate impact.

HåBiMet is carried out within the Impact Innovation programme Swedish Metals & Minerals, a joint initiative by the Swedish Energy Agency, Formas and Vinnova

This compendium contains presentations from the Current Situation Seminar that was organized in the project on 30/1 – 2025. The seminar aimed to provide an overview of the state of knowledge regarding the use and production of biochar for metallurgical use, as well as for certain other applications. The exchange of knowledge served as a basis for the continued collaboration in the project. The seminar and compendium are divided into three blocks:

Block 1 – Överblick, biomassa och metallurgi

Planetary boundaries and system transformation

30 January 2025

Louise Hård af Segerstad and Anna Steorn
Albaeco

Albaeco

Independent organization with broad expertise in sustainable development

Co-founder of Stockholm Resilience Centre

Experts in social ecological systems, transformation and resilience thinking

Research communication and strategic advice on environment, climate and sustainability

albaeco


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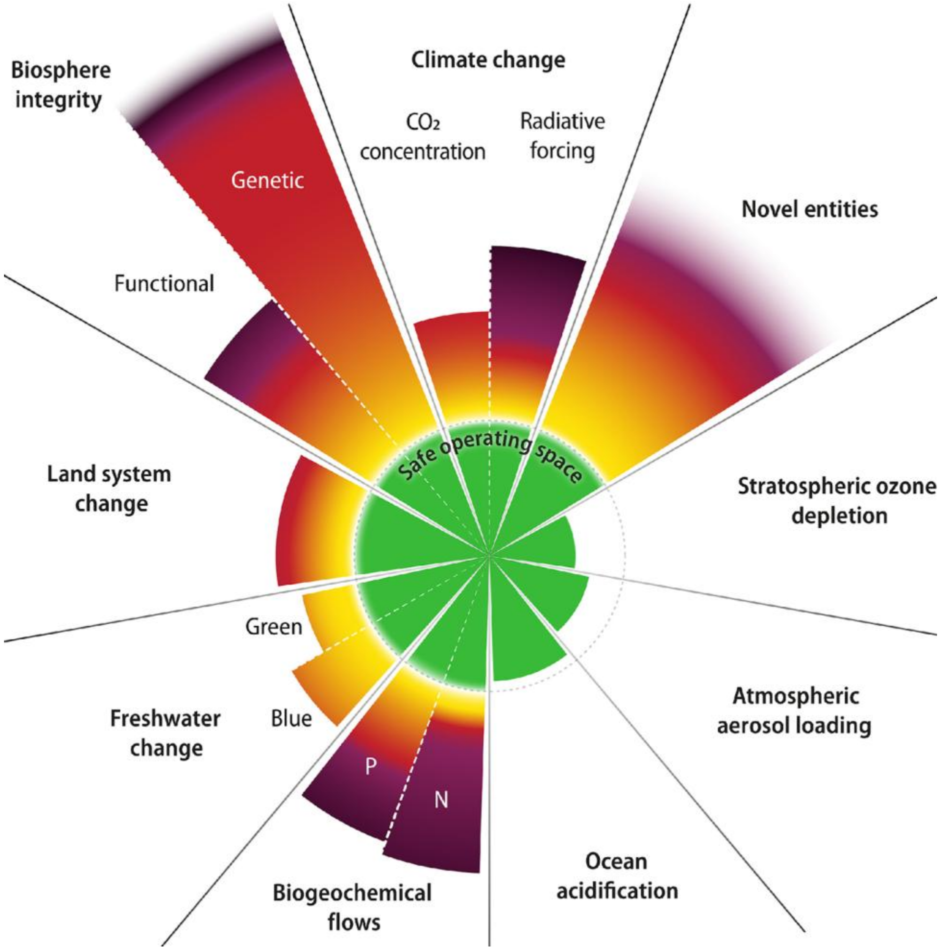


A safe operating space for humanity

2023

- All 9 areas quantified
- 6 out of 9 outside safe operating space
- New indicator for functional biodiversity

2015

- Biodiversity and climate defined as core boundaries
- 4 out of 9 outside safe operating space

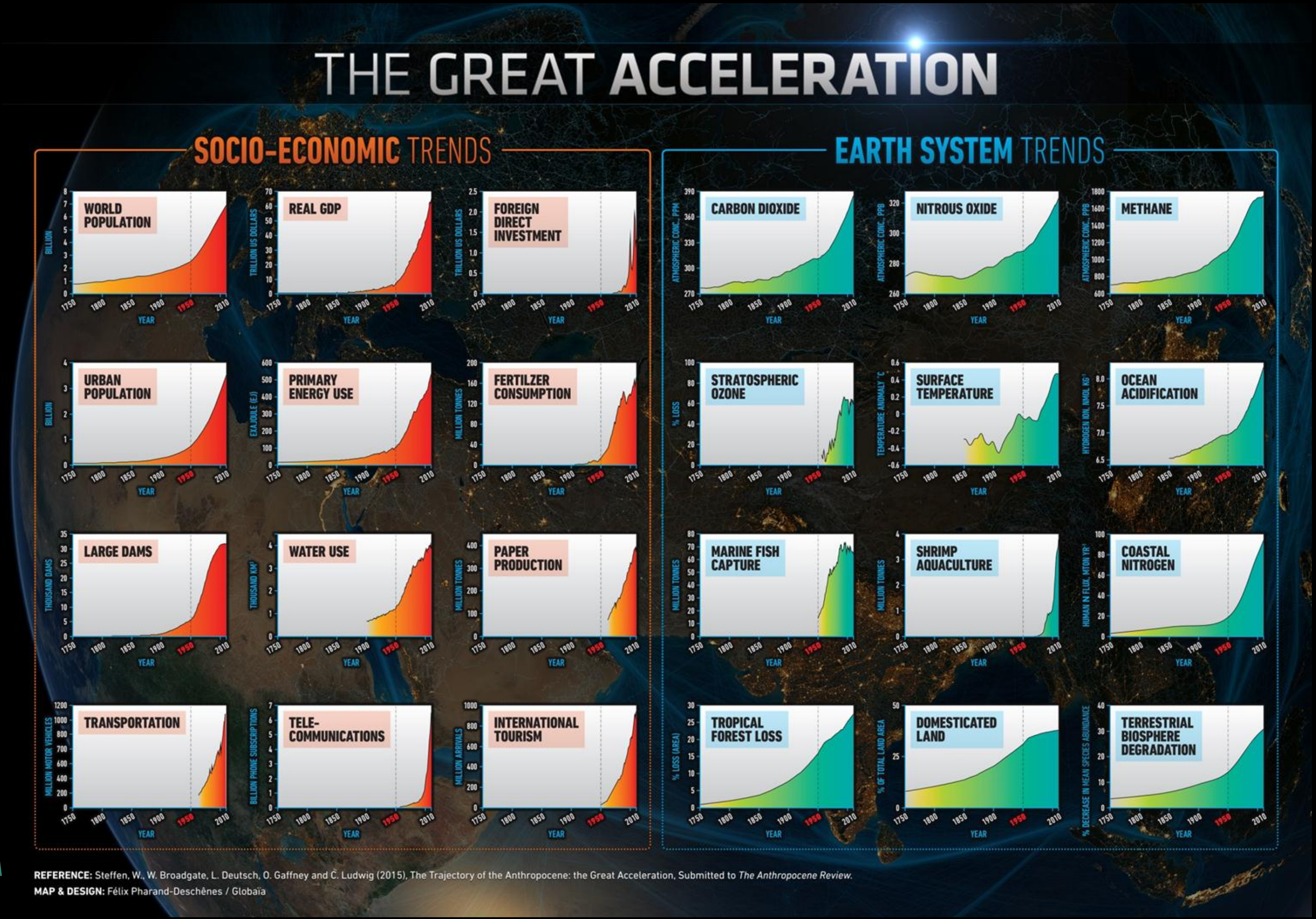
2009

- First article on the PB framework
- 3 out of 9 outside safe operating space

***Source**: Richardson et al 2023. Science Advances. Illustration av Azote.*

Tipping points

Scheffer et al. 2001. *Nature;* Folke et al. 2004. *AREES*
Threshold database www.resalliance.org


THE GREAT ACCELERATION
SOCIO-ECONOMIC TRENDS
EARTH SYSTEM TRENDS
WORLD POPULATION
BILLION
REAL GDP
TRILLION US DOLLARS
FOREIGN DIRECT INVESTMENT
TRILLION US DOLLARS
CARBON DIOXIDE
ATMOSPHERIC CONC., PPM
NITROUS OXIDE
ATMOSPHERIC CONC., PPB
METHANE
ATMOSPHERIC CONC., PPB
URBAN POPULATION
BILLION
PRIMARY ENERGY USE
EXAJOULE (EJ)
FERTILZER CONSUMPTION
MILLION TONNES
STRATOSPHERIC OZONE
% LOSS
SURFACE TEMPERATURE
TEMPERATURE ANOMALY °C
OCEAN ACIDIFICATION
HYDROGEN ION, NMOL KG⁻¹
LARGE DAMS
THOUSAND DAMS
WATER USE
THOUSAND KM³
PAPER PRODUCTION
MILLION TONNES
MARINE FISH CAPTURE
MILLION TONNES
SHRIMP AQUACULTURE
MILLION TONNES
COASTAL NITROGEN
HUMAN N FLUX, MTON YR⁻¹
TRANSPORTATION
MILLION MOTOR VEHICLES
TELE-COMMUNICATIONS
BILLION PHONE SUBSCRIPTIONS
INTERNATIONAL TOURISM
MILLION ARRIVALS
TROPICAL FOREST LOSS
% LOSS (AREA)
DOMESTICATED LAND
% OF TOTAL LAND AREA
TERRESTRIAL BIOSPHERE DEGRADATION
% DECREASE IN MEAN SPECIES ABUNDANCE
YEAR
1750 1800 1850 1900 1950 2010
REFERENCE: Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney and C. Ludwig (2015), The Trajectory of the Anthropocene: the Great Acceleration, Submitted to The Anthropocene Review.
MAP & DESIGN: Félix Pharand-Deschênes / Globaïa


THE IGBP SERIES
Global Change and the Earth System
Springer

Holocene –10 000 stabila år

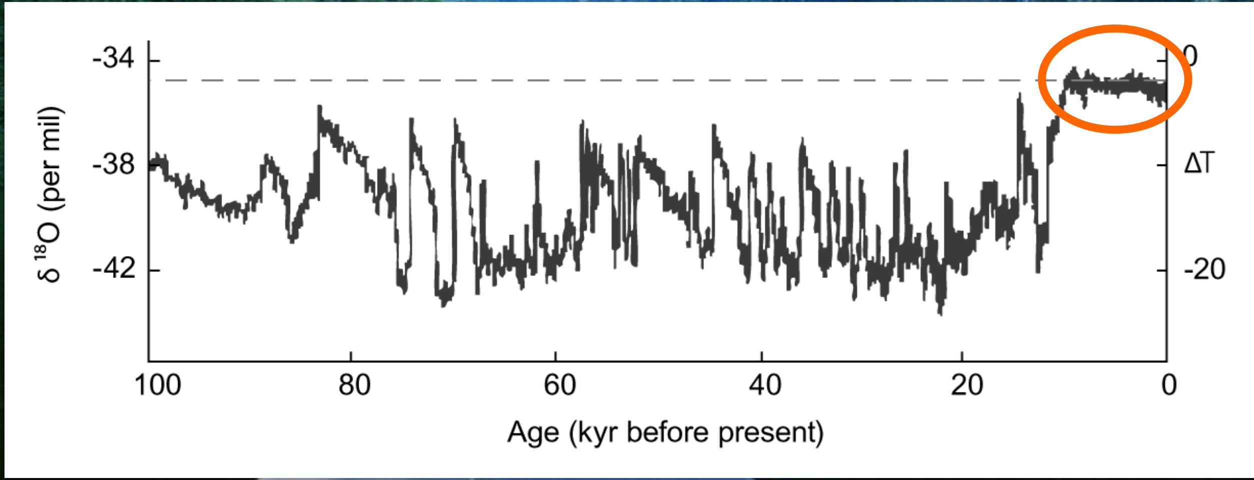
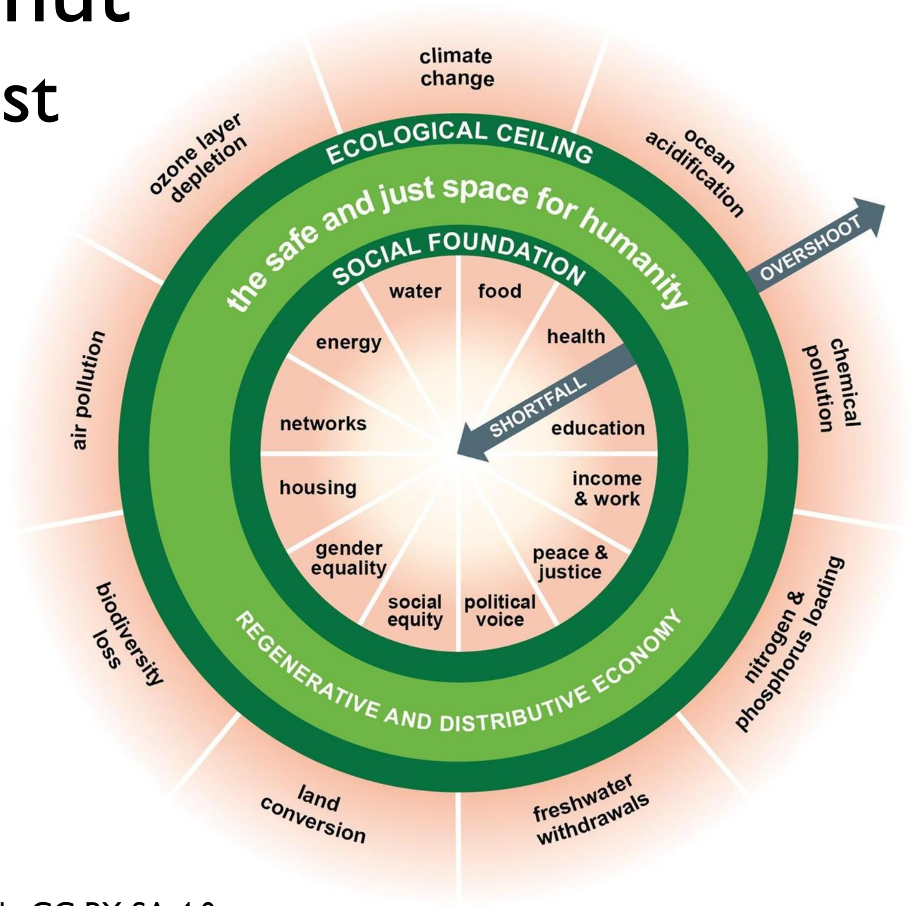


Photo: Michael A. Stecker

”The Doughnut” – a safe and just development



Kate Raworth, Oxford University

What is a system?

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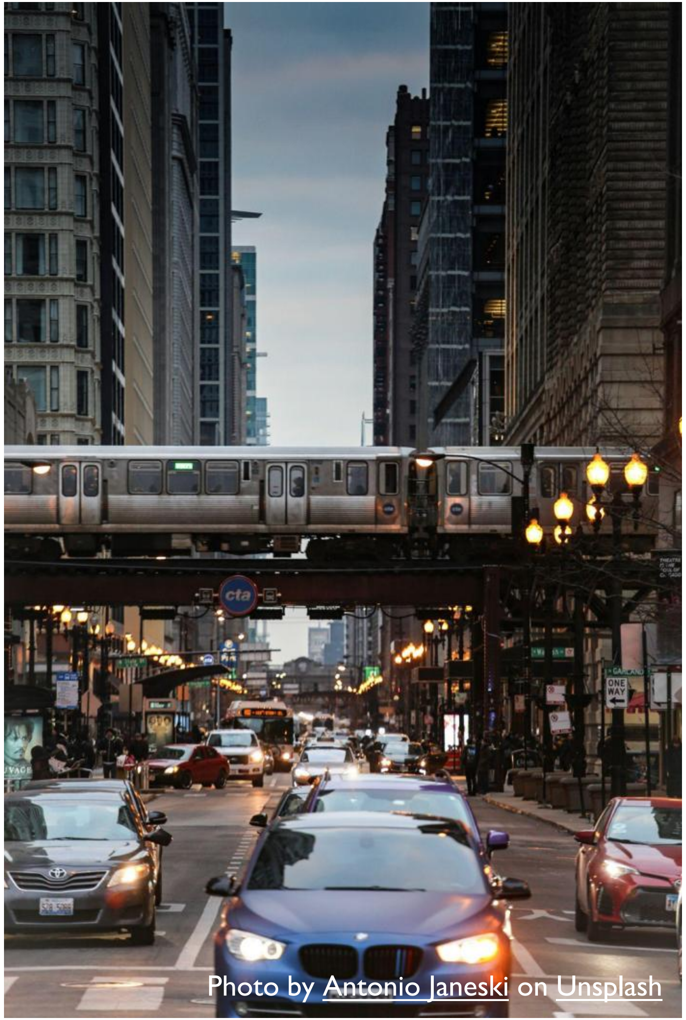
Photo by Guillermo Ferla on Unsplash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ONE WAY
Photo by Antonio Janeski on Unsplash

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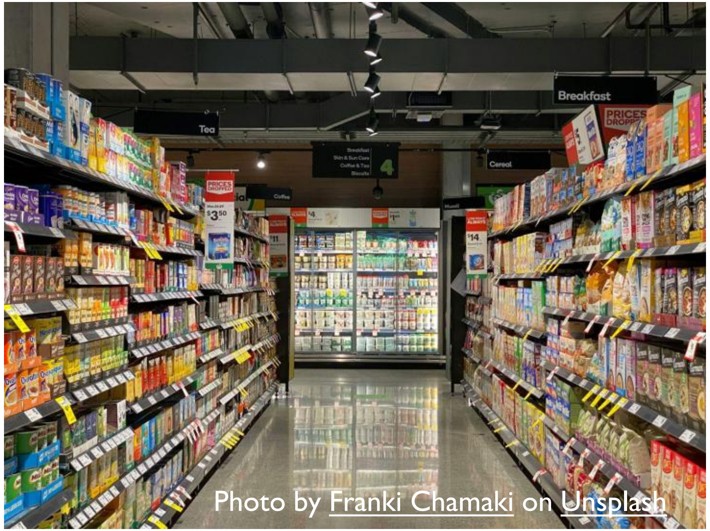

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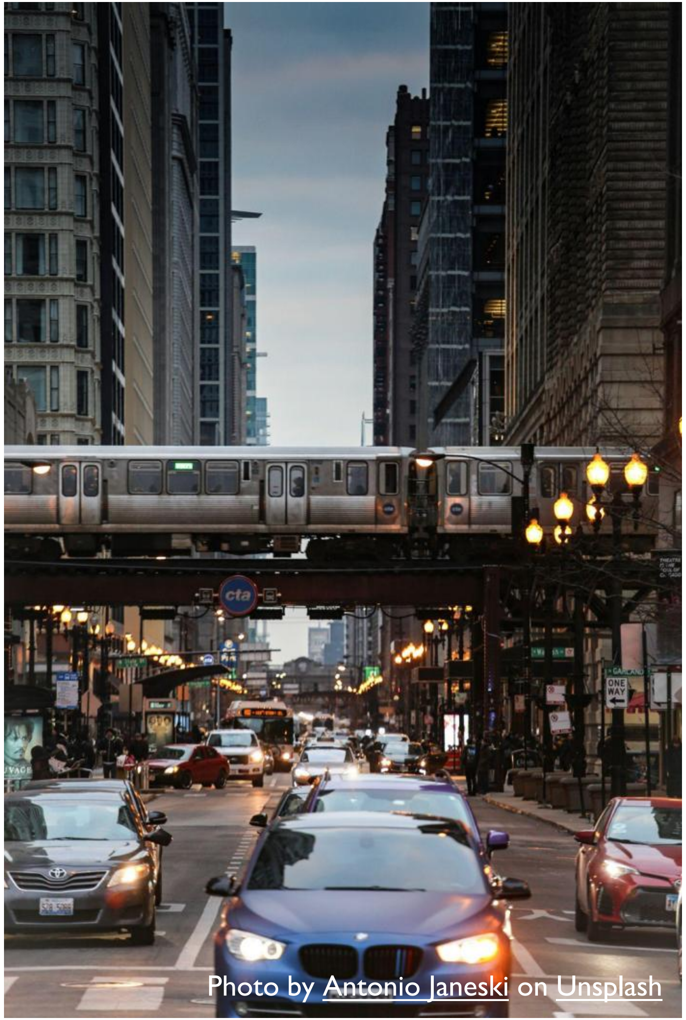

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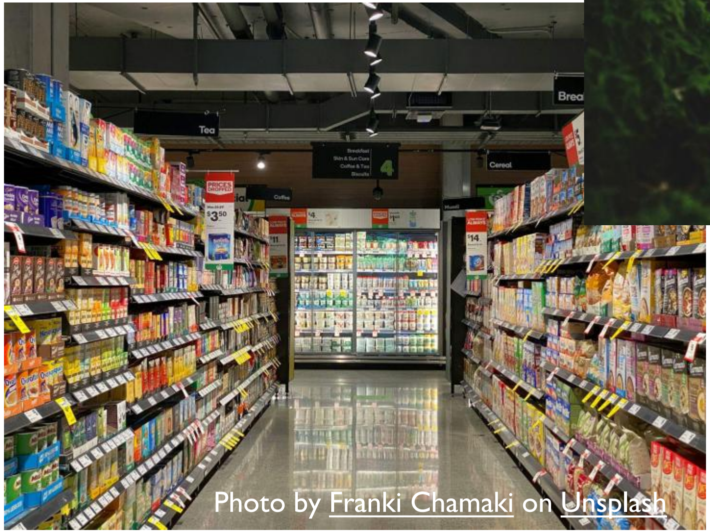


Photo by Franki Chamaki on Unsplash

Photo by Vinit Srivastava on Unsplash

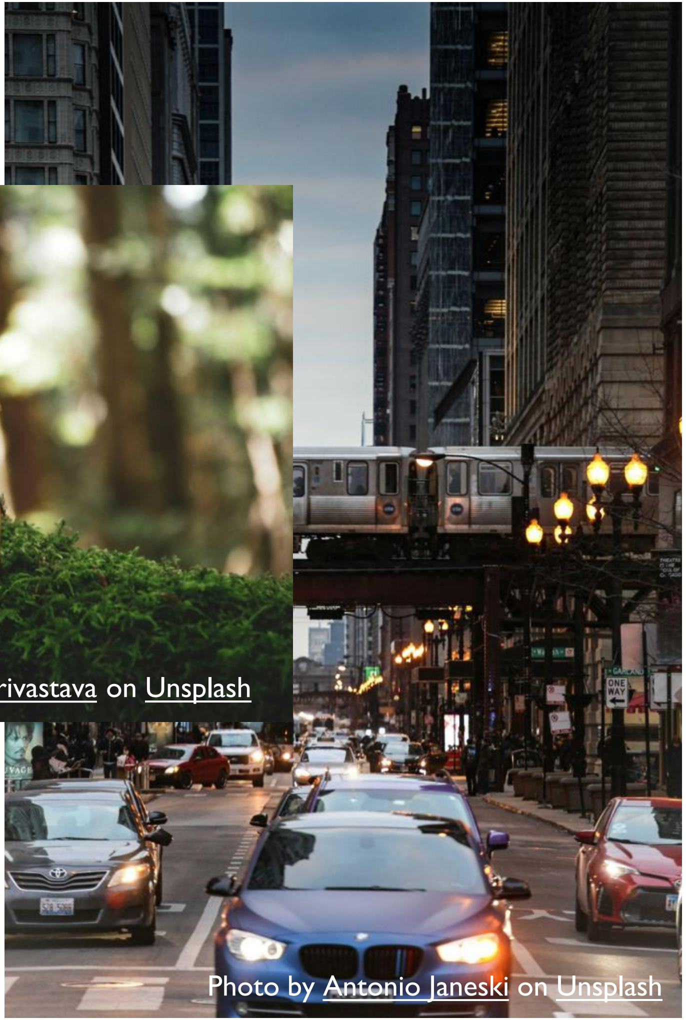
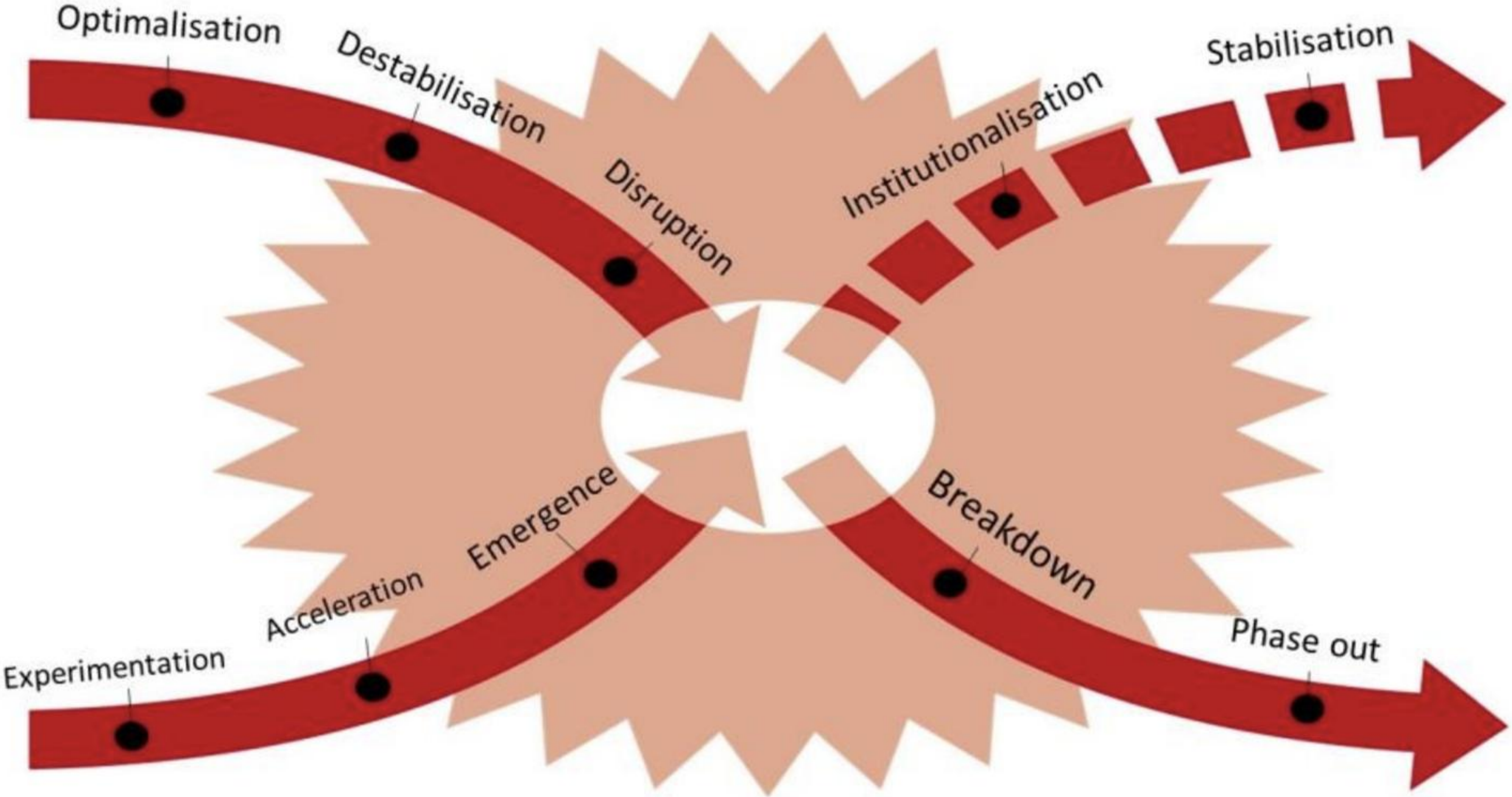
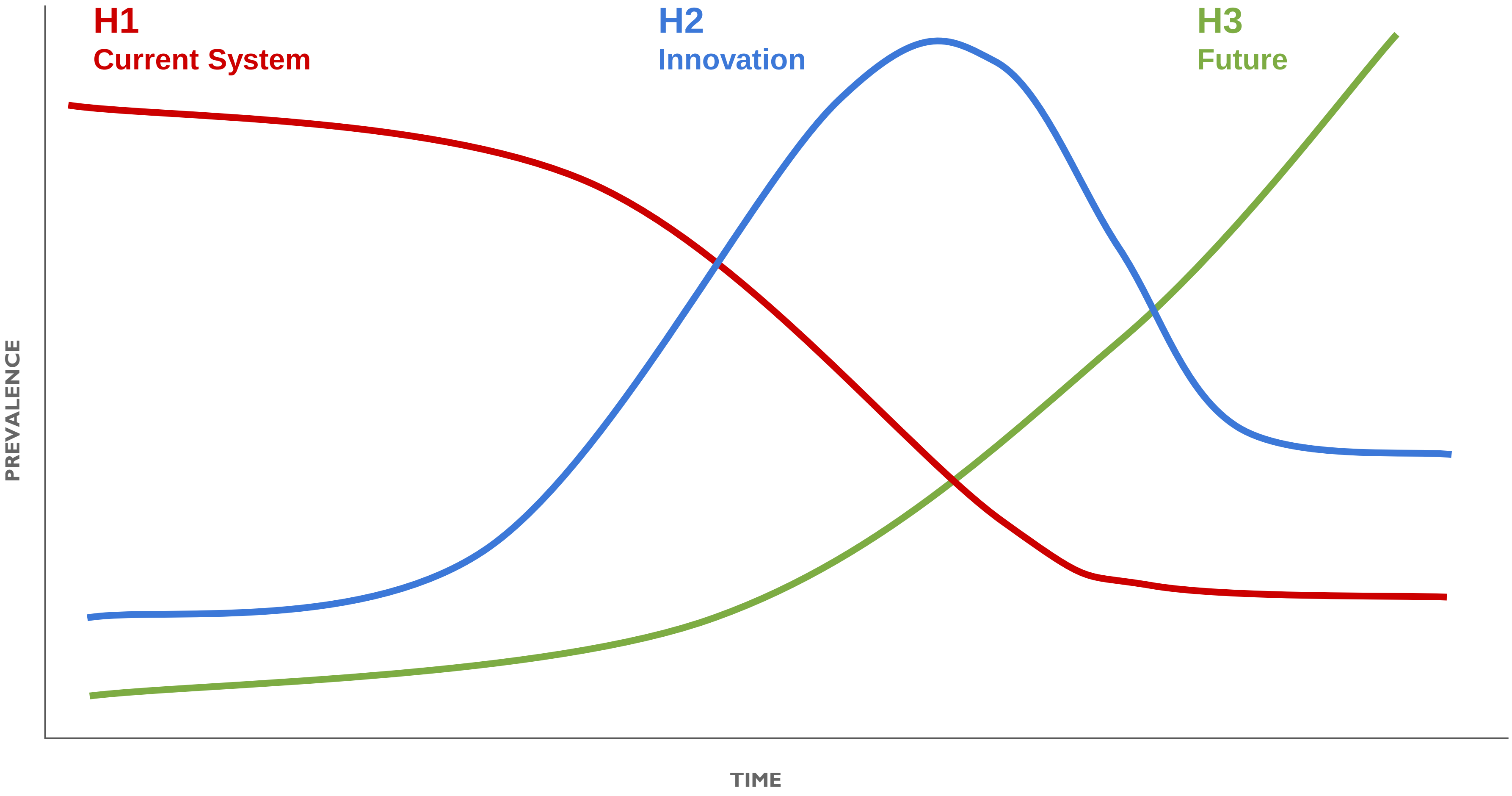


Photo by Antonio Janeski on Unsplash

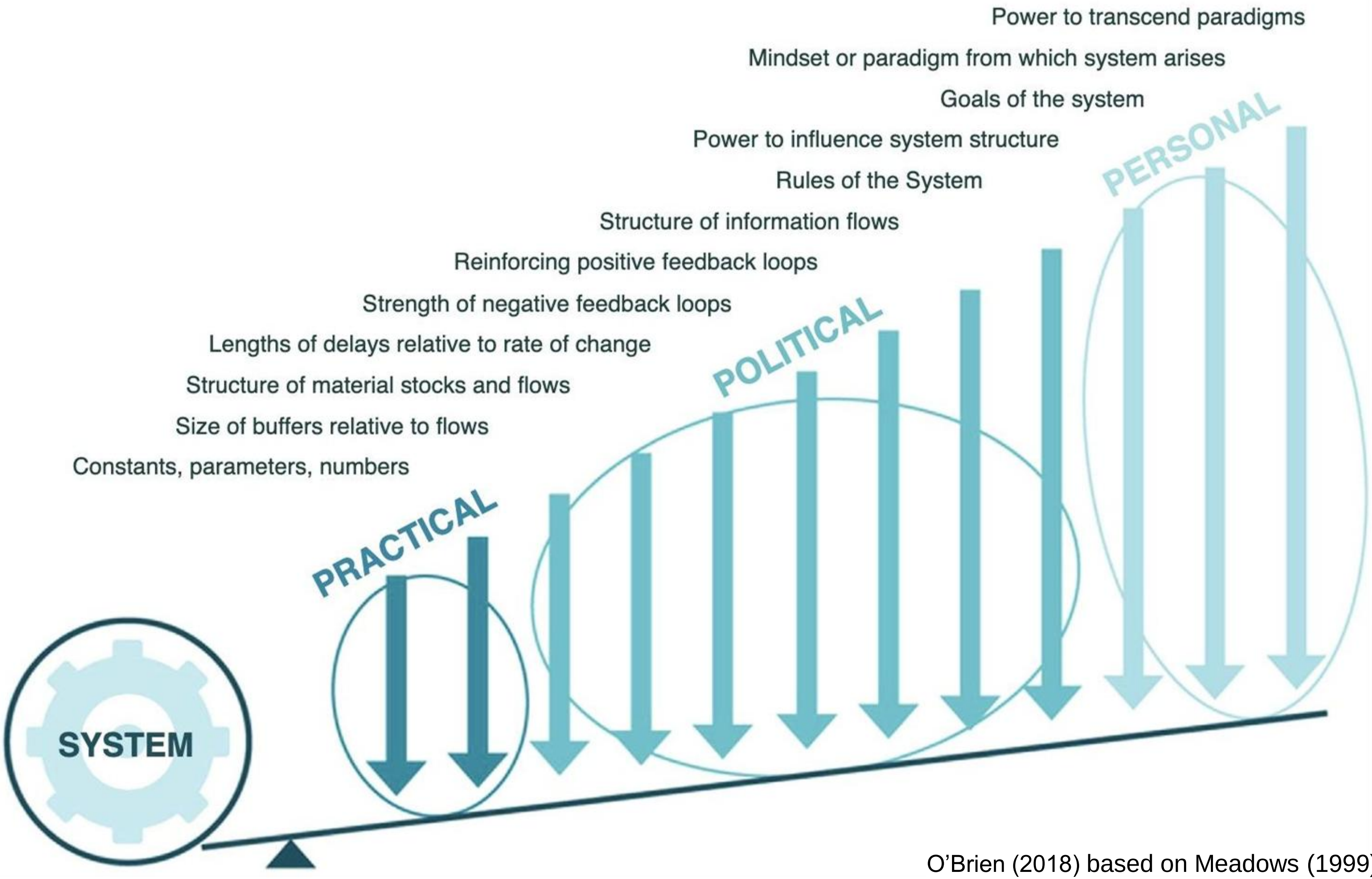
What is transformation?



Loorbach et al. (2017)



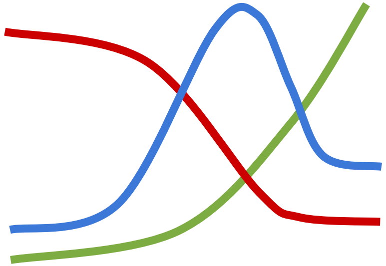
Sharpe (2013)



O’Brien (2018) based on Meadows (1999)

What is the goal of the system?

How do we get there?



How can we achieve this within the safe and just operating space?

TACK

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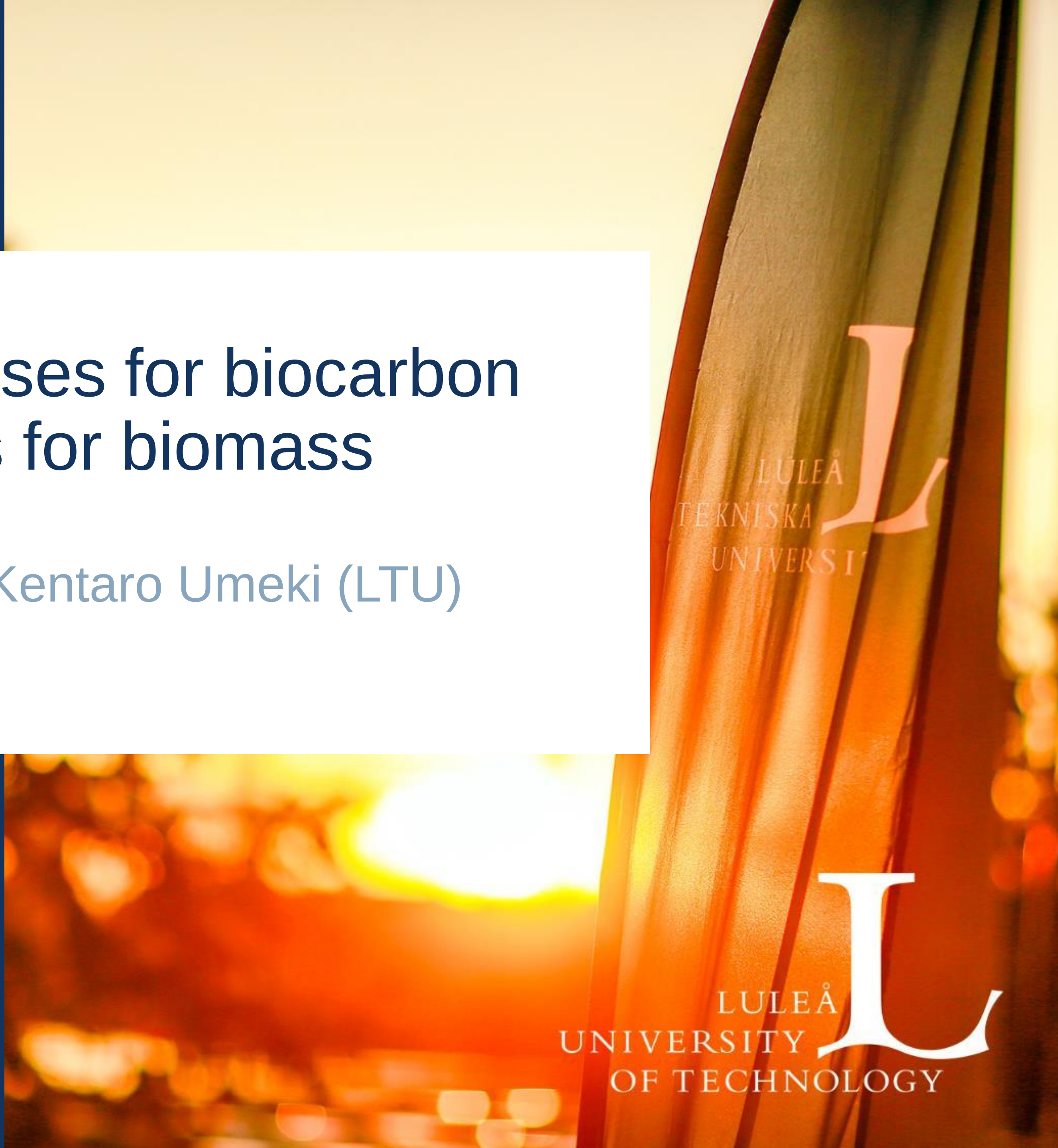
anna.steorn@albaeco.com

Production processes for biocarbon & producing areas for biomass

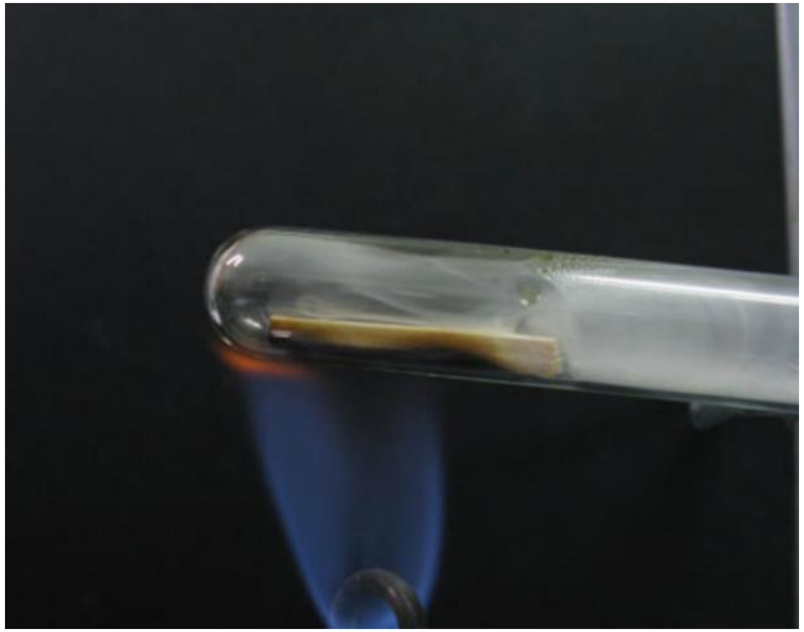
Elisabeth Wetterlund & Kentaro Umeki (LTU)
Erland Nylund (Swerim)



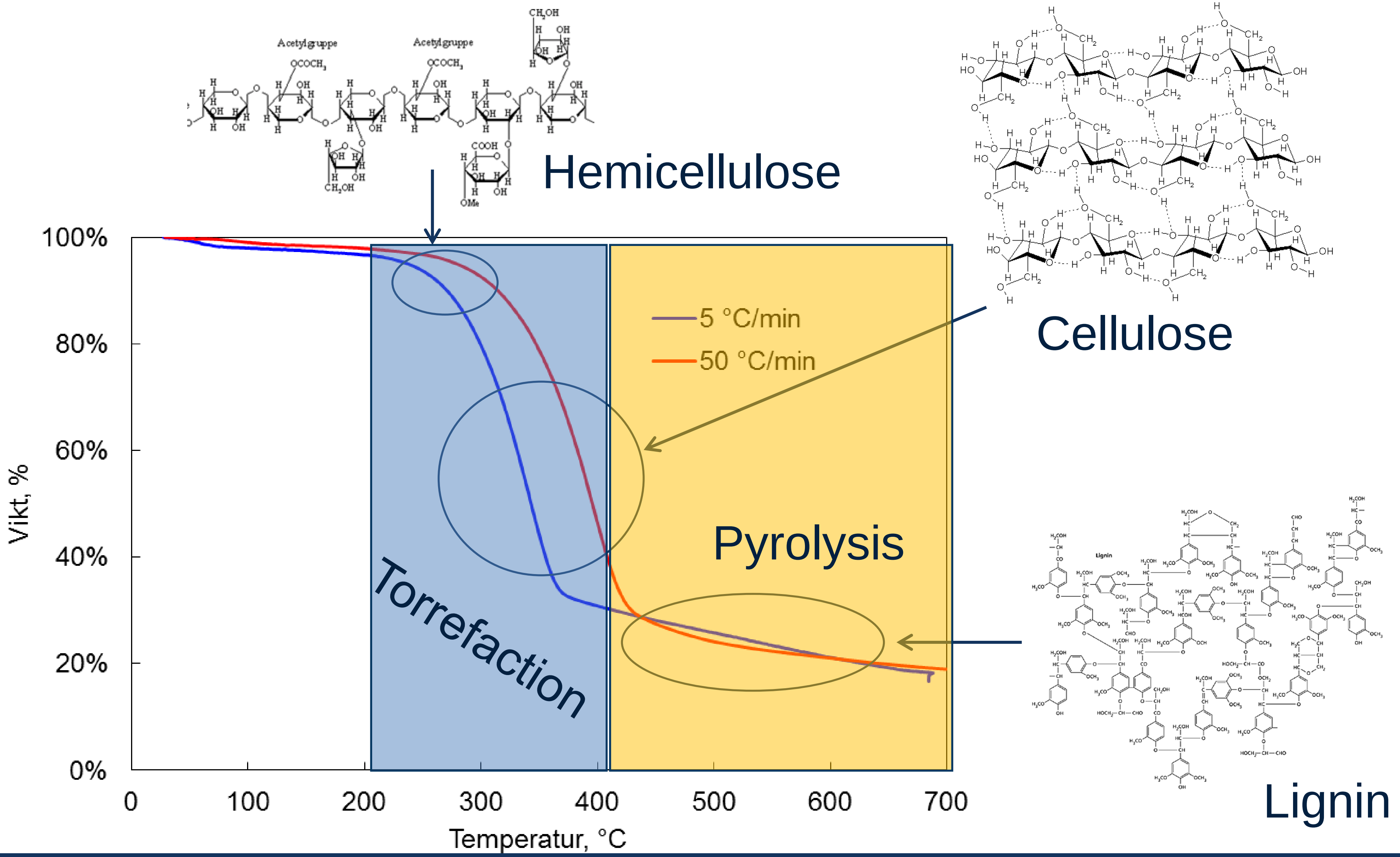
LULEÅ UNIVERSITY OF TECHNOLOGY

Technology options

	Process	Product
Torrefaction	Heating biomass to 200-350 °C	Torrefied biomass
Pyrolysis	Heating biomass to 400-1200 °C	Biocarbon with almost 100% C
HTC (hydrothermal carbonization)	“Pressure cooking” with water/steam at 150-300 °C	Hydrochar

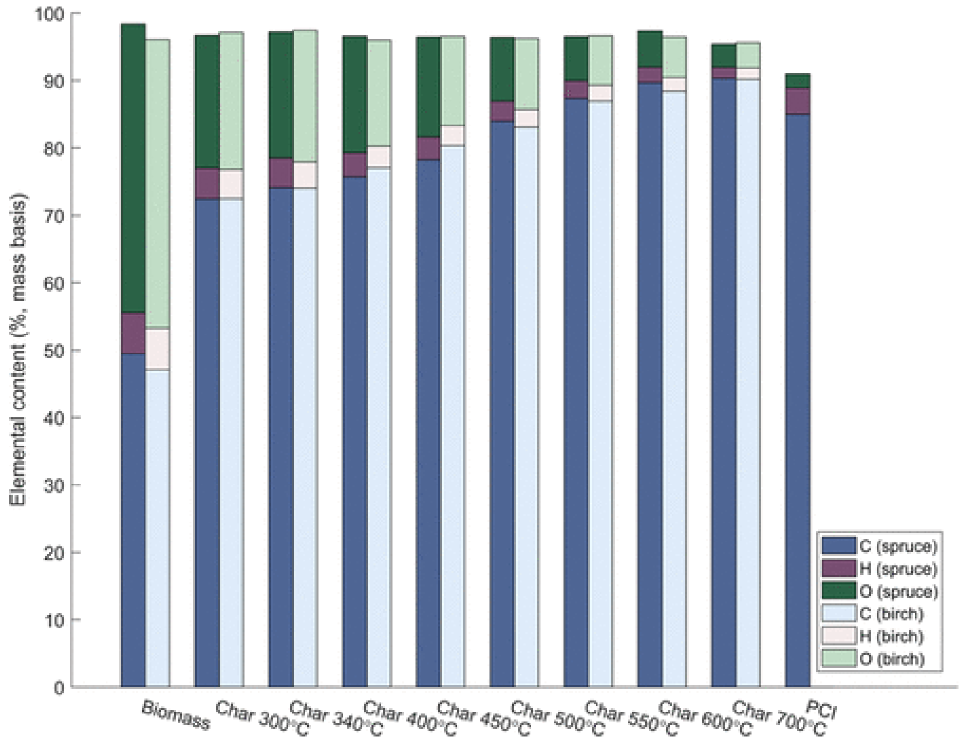


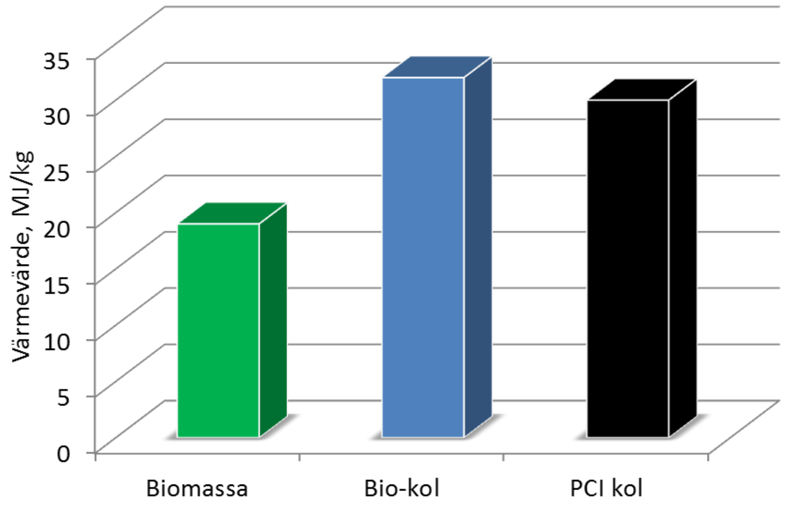
Difference between torrefaction and pyrolysis



Biocarbon properties for metal industry – main requirements

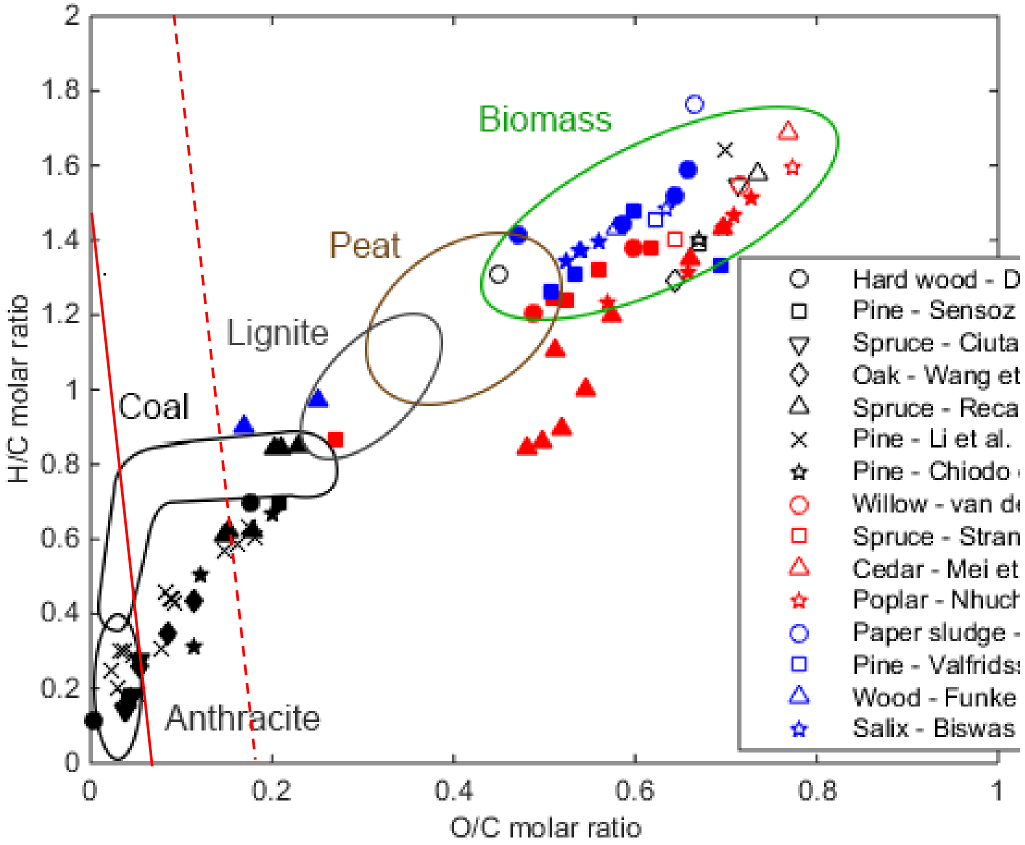
- High C content (low O, H)
- Low volatile content
- High heating value
- Ash content and ash elements

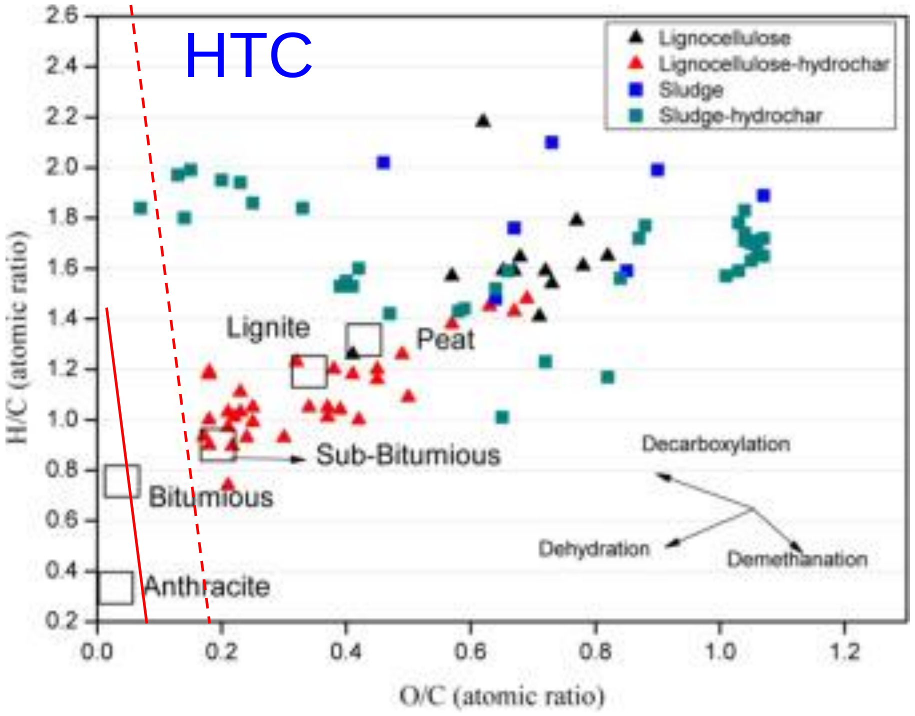




Biocarbon properties for metal industry – carbon content

Black: pyrolysis
Red: torrefaction
Blue: HTC





Requirement: C>80-90% (red lines)

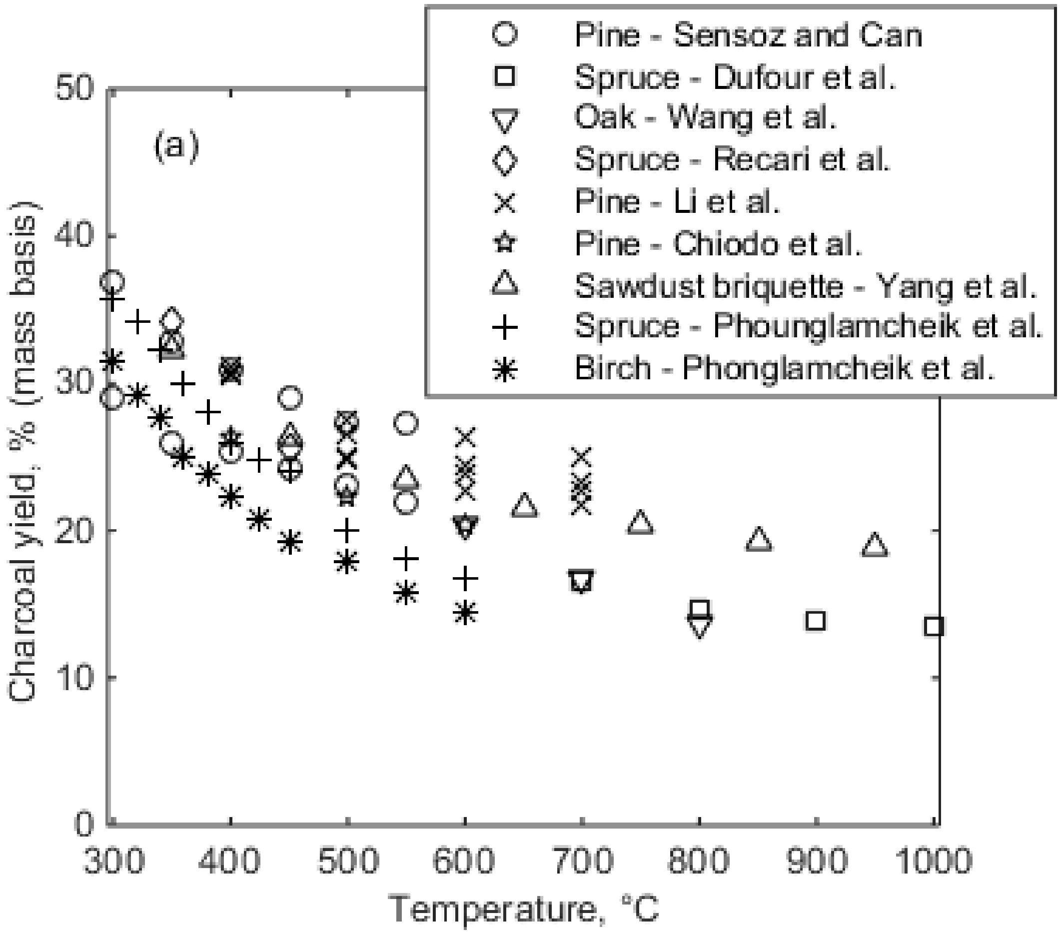
- Torrefaction and HTC unable to provide biocarbon with high C content
- Pyrolysis with T>500 °C only option

Biocarbon properties for metal industry – additional requirements

- Reactivity
  - For carburization – low reactivity
  - For slag foaming – high reactivity
- High density
- Water absorption capacity
- Particle size (grindability) – important for slag foaming

Difficult to control

Drawback – low yields in slow pyrolysis



Process temperature ~700°C

- Biochar yield ~20wt% (50% energy yield)
- Gases ~30% (H_2, CO, CH_4, etc.)
    - Part needed to heat the pyrolysis process
    - Use of excess heat in other industry or in district heating?
- Bio-oil ~40% (phenols etc.)
    - Selling to e.g. refinery?
    - Quality though quite low and important for use in refineries

Summary of biocarbon production processes

- Pyrolysis (high temperature) is always the main process
- HTC and torrefaction can be possible pretreatment processes but that will of course add costs
  - Sawdust needs little to no pretreatment
  - HTC useful at high K/P/S concentrations (sludges, bark, grot etc.)
  - Torrefaction can be useful for compaction (e.g. pelletisation) before pyrolysis

Feedstock candidates – Swedish perspective

Technical suitability

Forestry by-products

- Forestry residues
- Biomass stems from thinning
- (Stumps)

Forest industry by-products

- Sawdust + other
- Sawmill chips
- Pulp mill fibre- and bio-sludges
- Bark
- (Kraft) lignin ?

Other by-products

- Lignin from lignocellulosic ethanol production ?
- Other bio-sludges?
- Agricultural residues

Feedstock candidates – Swedish perspective

Economic suitability / availability

Forestry by-products

- Forestry residues
- Biomass stems from thinning
- (Stumps)

Forest industry by-products

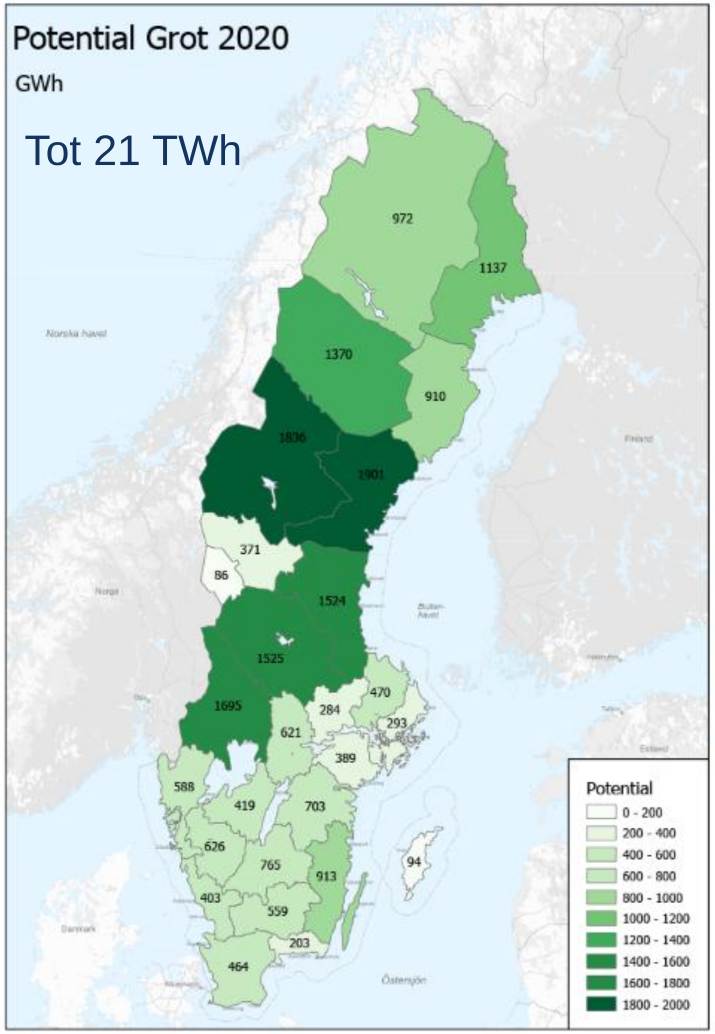
- Sawdust + other
- Sawmill chips
- Pulp mill fibre- and bio-sludges
- Bark
- (Kraft) lignin ?

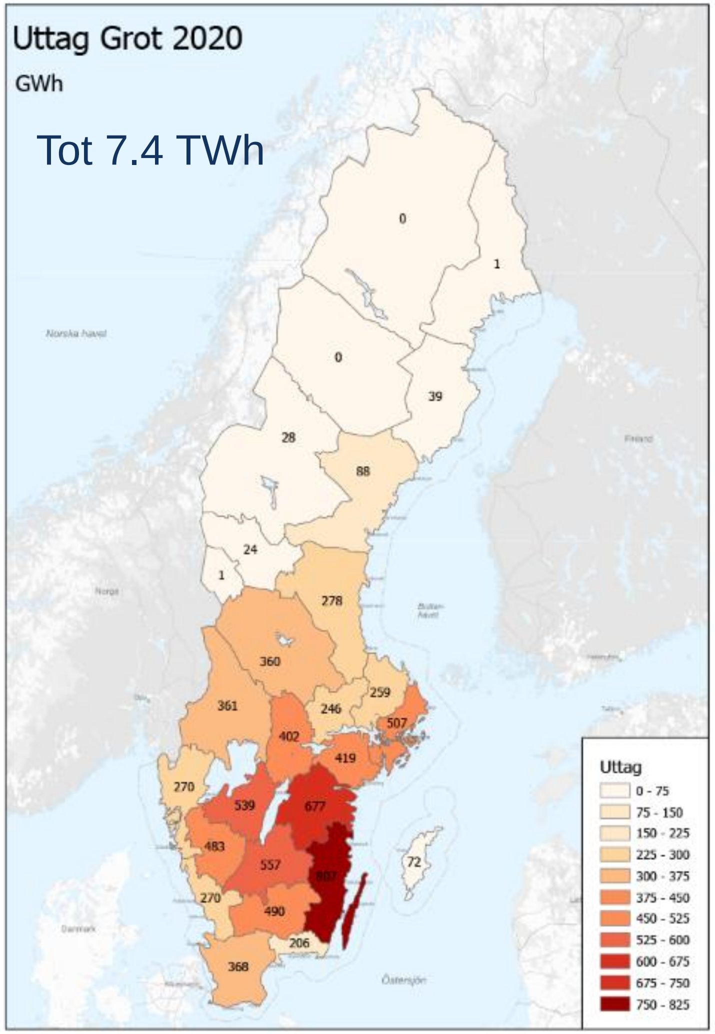
Other by-products

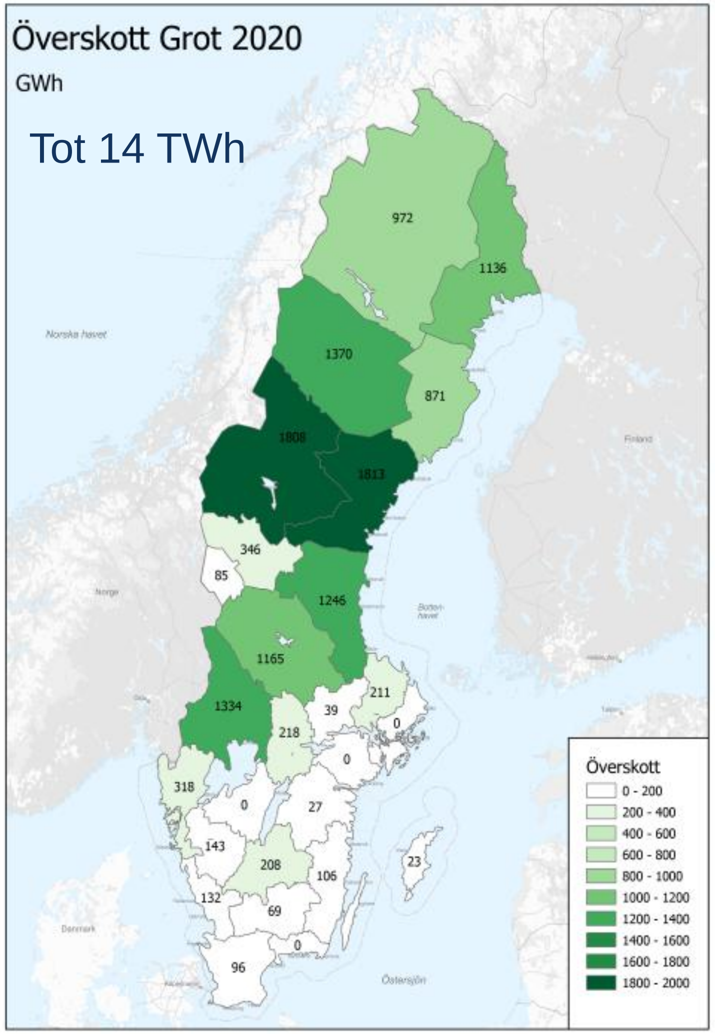
- Lignin from lignocellulosic ethanol production ?
- Other bio-sludges?
- Agricultural residues

Small squares showing the technical suitability

GROT – potential and outlook

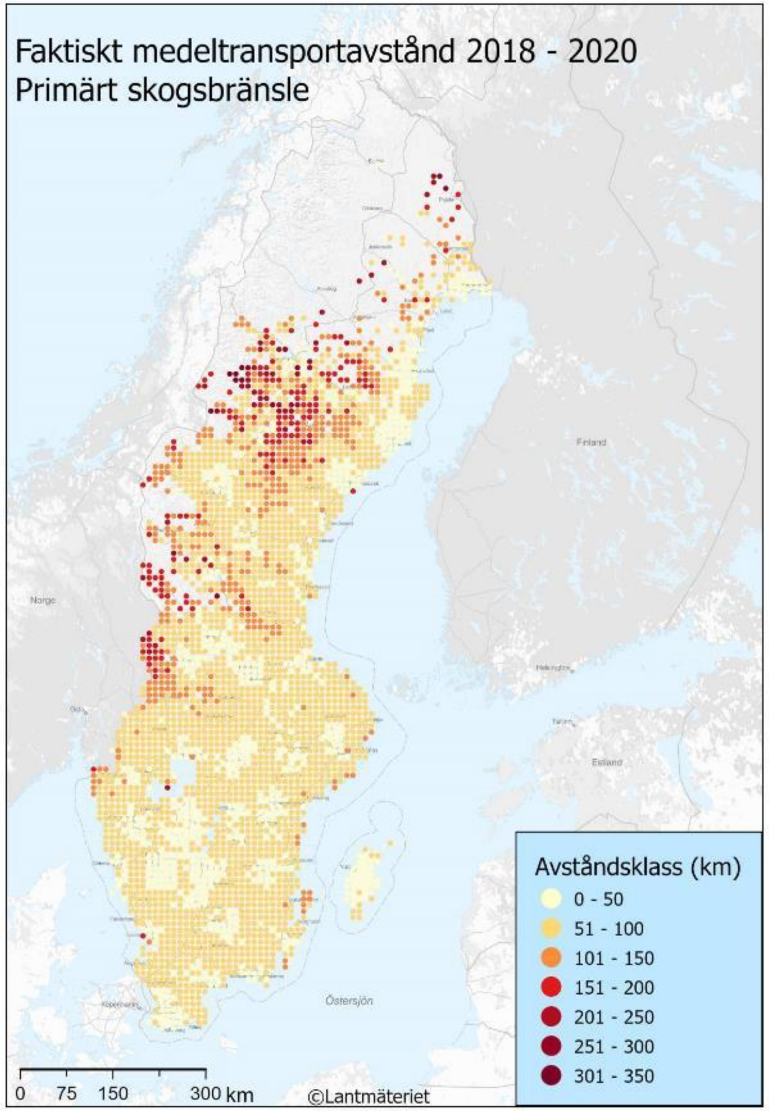


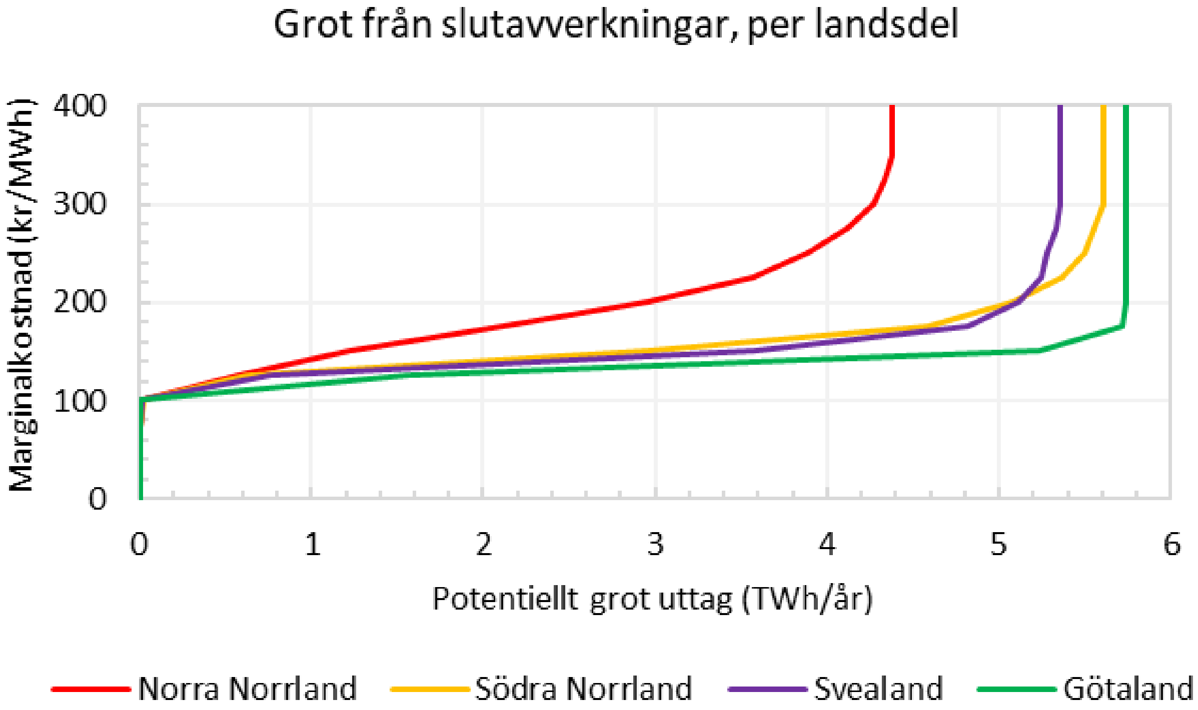




Källa: Skogforsk, Faktablad om grot och dess potential, oktober 2023, https://www.skogforsk.se/kunskap/temasidor/skogsbransle/faktasammanstallning-grot/

GROT – production costs





Källa: Skogforsk (2023), Vad kostar det att ta ut mer biobränsle från skogen? https://www.skogforsk.se/kunskap/kunskapsbanken/2023/vad-kostar-det-att-ta-ut-mer-skogsbiobransle/

What is needed to increase?

- Trust and long-termism
- Engage the contractors again – and the forest owners
- Investments in machinery
- Coverage for risk
- Time – delivery time on machines
- Time – lead times of 1 year in production of grot!
- Vertical integration – involving customers in the supply chain

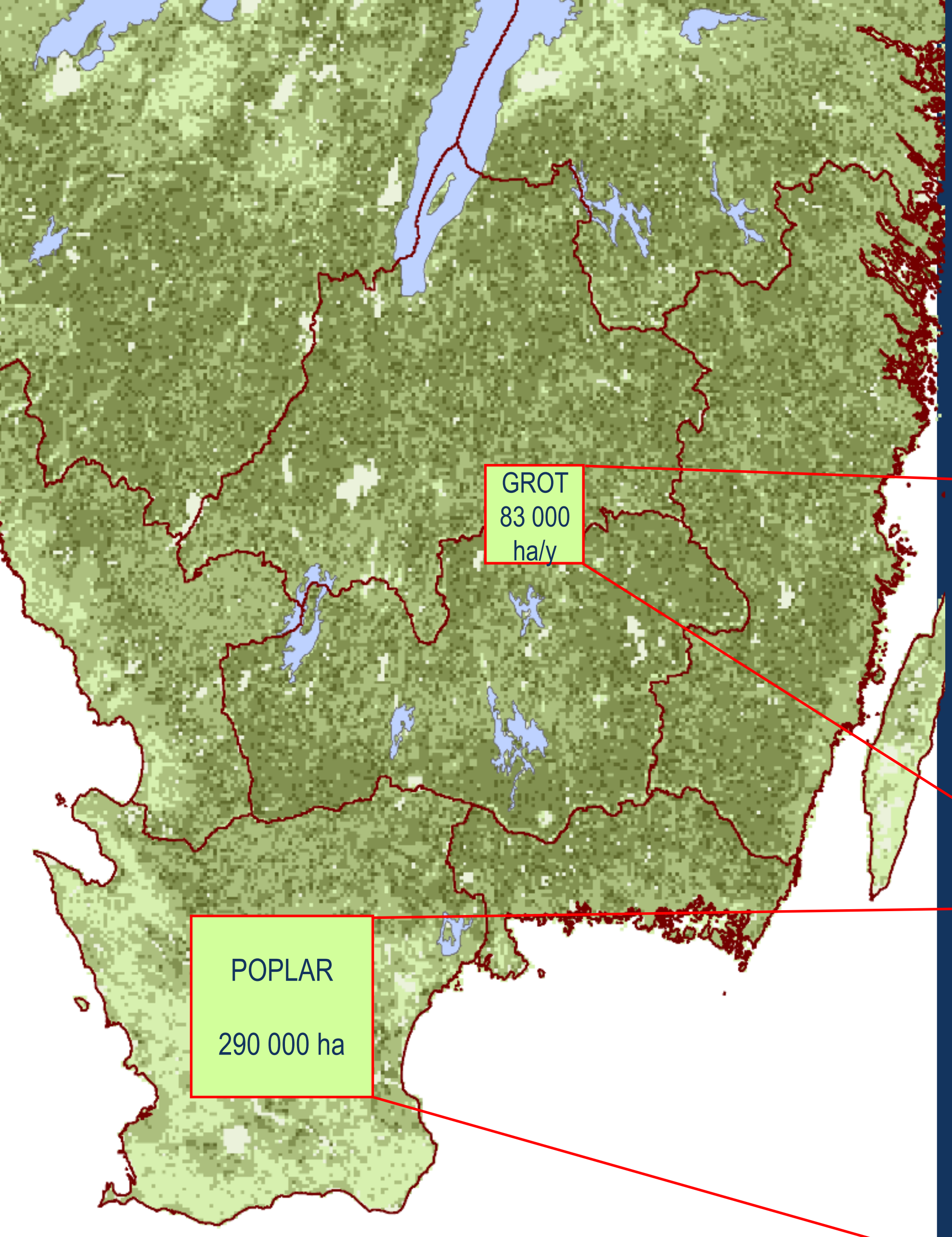
Grot samlad i mindre högar på hygge. Högarna hämtas dels av konventionella skotare, dels av skotare specialbyggda för just terrängtransport av grot.

Grotskotning från hygge till bilväg.

Grotvälta som täckts med papp, och lagras vid bilväg.

Flisning av grot vid bilväg. Här flisas groten med en så kallad lastbilshugg direkt i ett lastbilssläp.

Källa: Skogforsk, Faktablad om grot och dess potential, oktober 2023,
https://www.skogforsk.se/kunskap/temasidor/skogsbransle/faktasammanstallning-grot/



Biomass requirement – Swedish steel industry

Biocarbon requirement	350 000 t DS/y
Feedstock requirement	~1 750 000 t DS/y
volume	~4,2 million m^{3}f/y (55% moisture)
energy	~9 TWh/y

Grot as feedstock

- Final felling area needed:
  83 000 ha/y (Götaland) – 100 000 ha/y (Norrland)

- Corresponds to 60% of entire Sweden's potential for INCREASED grot extraction
- Final felling areas today:
  56 000 ha/y (Götaland) – 120 000 ha/y (Norrland)

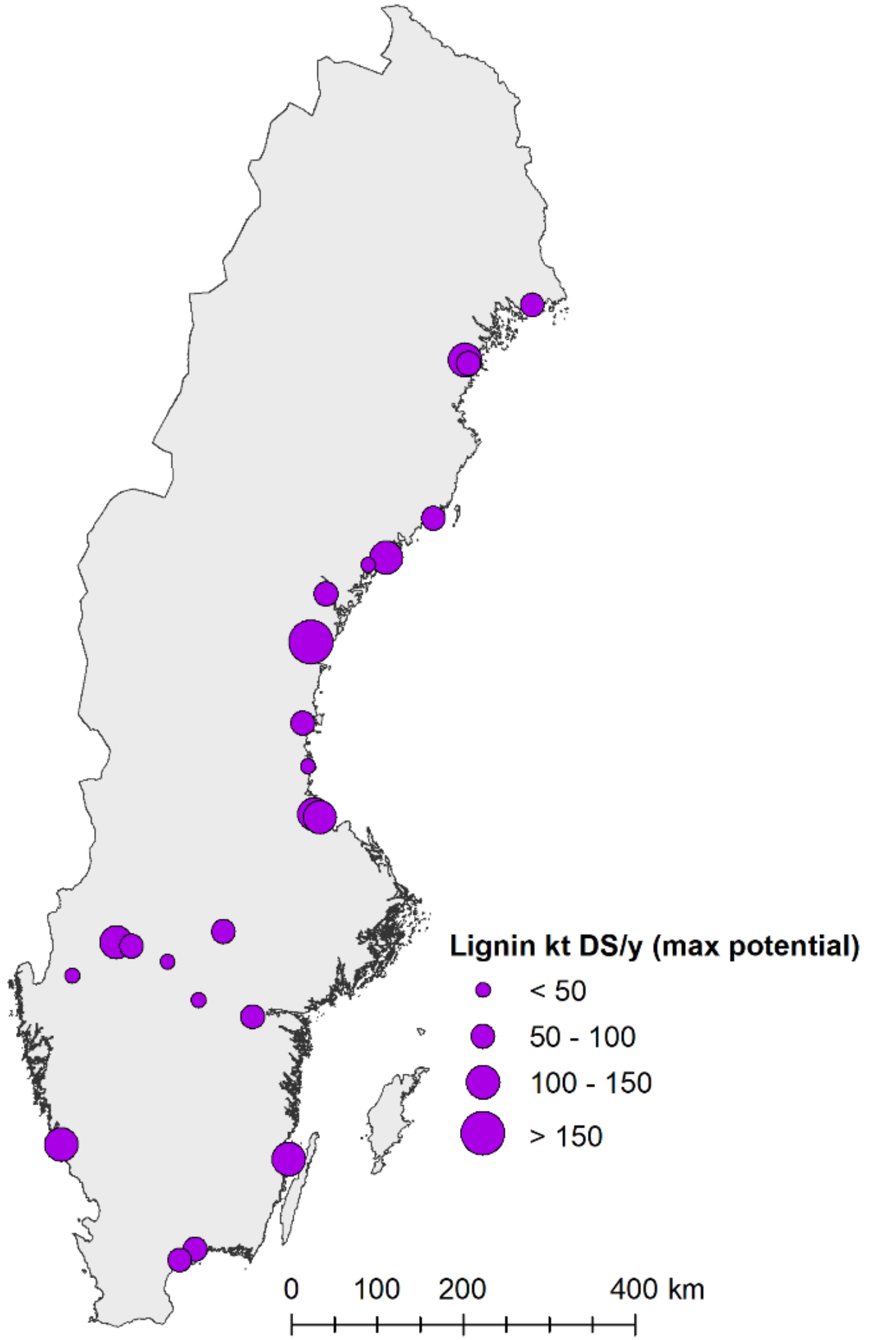
Fast growing poplar as feedstock

- Land area needed:
  290 000 ha

- Rotation time ~20 y, can be grown on unused or forested agricultural land
- Production ~6-8 t DS/ha,y
- Estimated available land for poplar:
  210 000 ha (Skåne) – 930 000 ha (Götaland)

Lignin from pulp industry liquors

- Theoretical max potential ~30% av all black liquor in Swedish chemical pulp mills
  - ~1900 kt lignin per year (dry substance), or 14 TWh/år
  - Corresponds to ~1200 kt C
- Realistic potential limited by the individual recovery boilers
  - ~880 kt lignin per year (dry substance), or 7 TWh/y
  - Corresponds to ~580 kt C



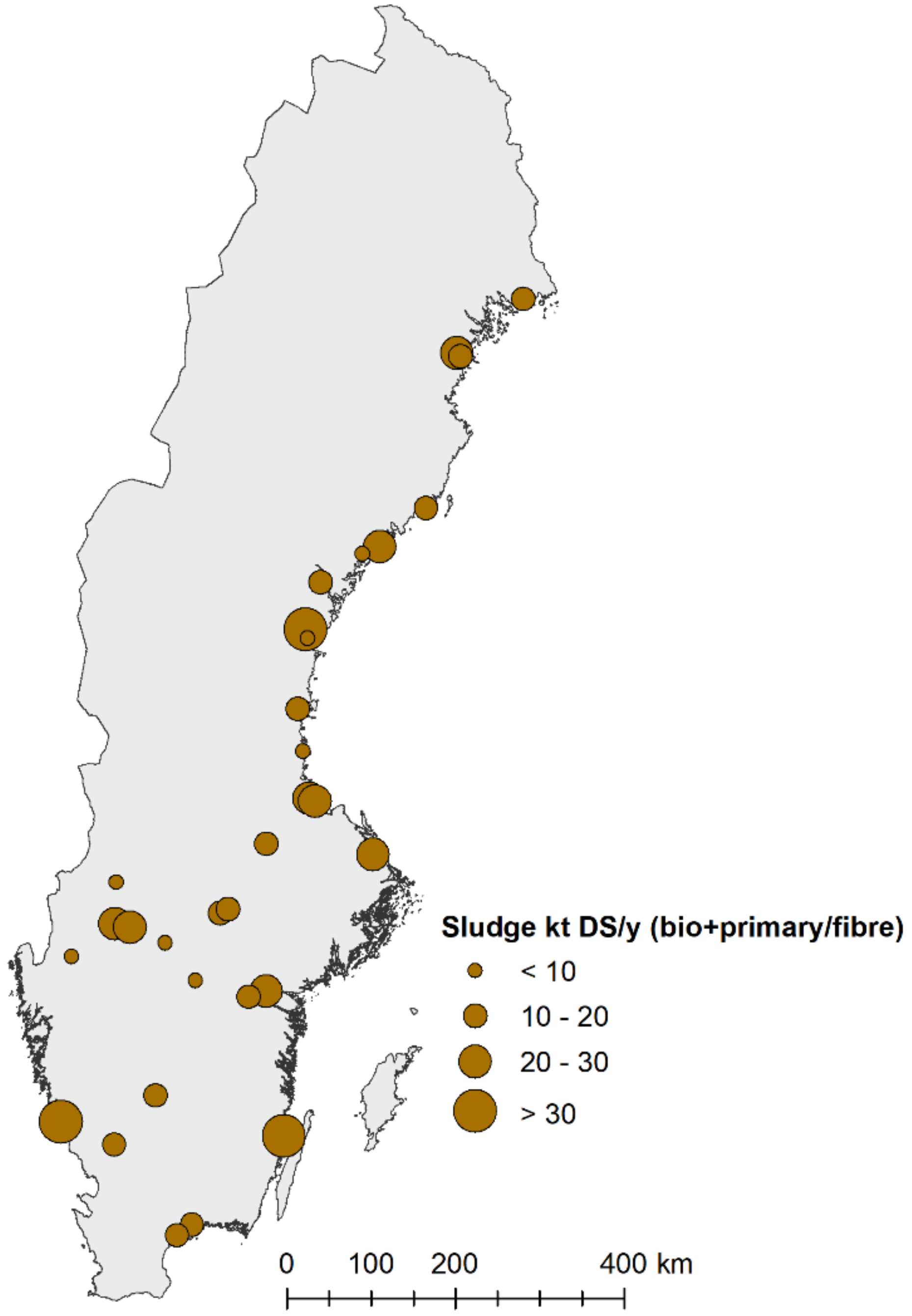
Pulp and paper industry sludges

- ~500 kt sludge per year (dry substance) – bio and fibre sludge combined
  - Corresponds to ~230 kt C

→ Hydrochar potential ~320 kt/y

- The hydrochar has low content of both total and fixed C. In EAF ca 4 kg hydrochar is needed to replace 1 kg of anthracite

- Hydrochar can be pyrolysed for a better biochar



Supplying biocarbons to the steel industry from agricultural residues

Erland Nylund

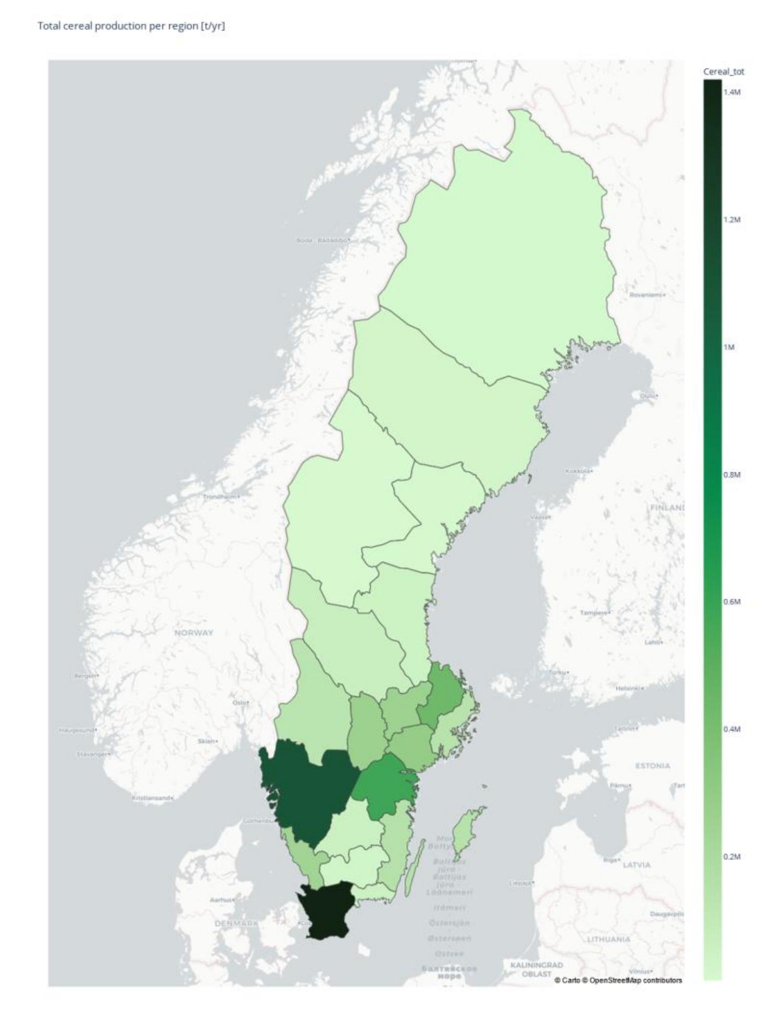
Case study: biohydrogen and biomethane for steel industry

- Short study with Engstam, Falhgren, Tayyebi, 2024
- Three substrate categories: Straw, solid manure, liquid manure
- H2 or CH4 production

Potential straw harvest a big enabler

- Cereal production (1)
- Self-sufficiency on straw (2)

(1)



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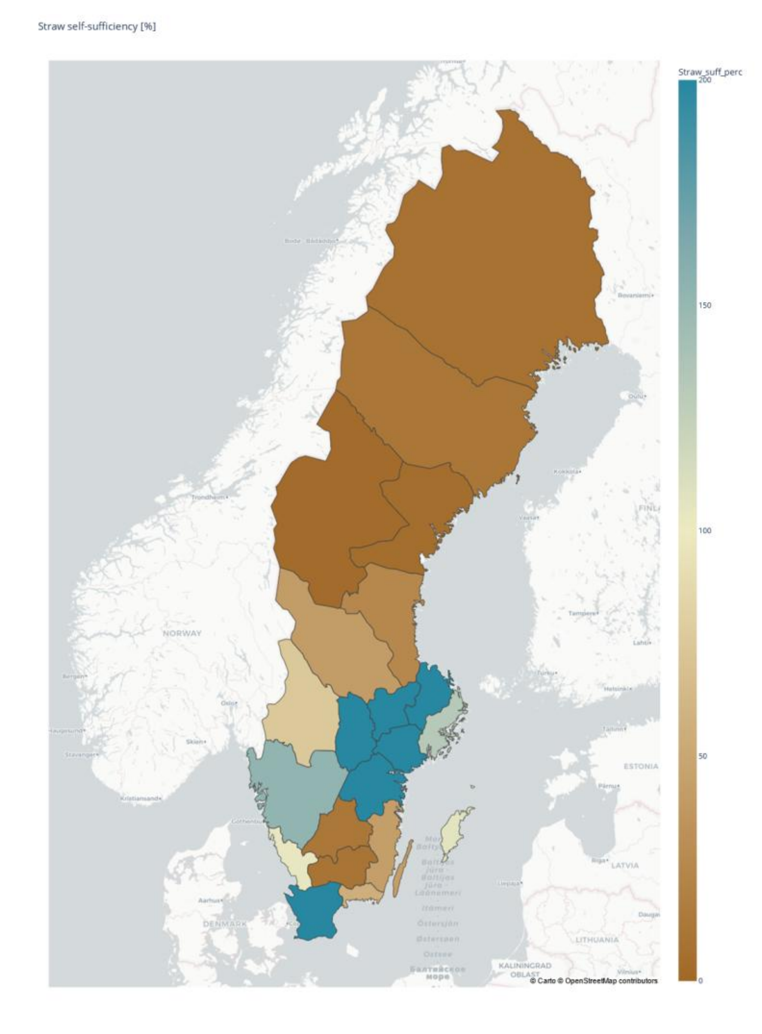
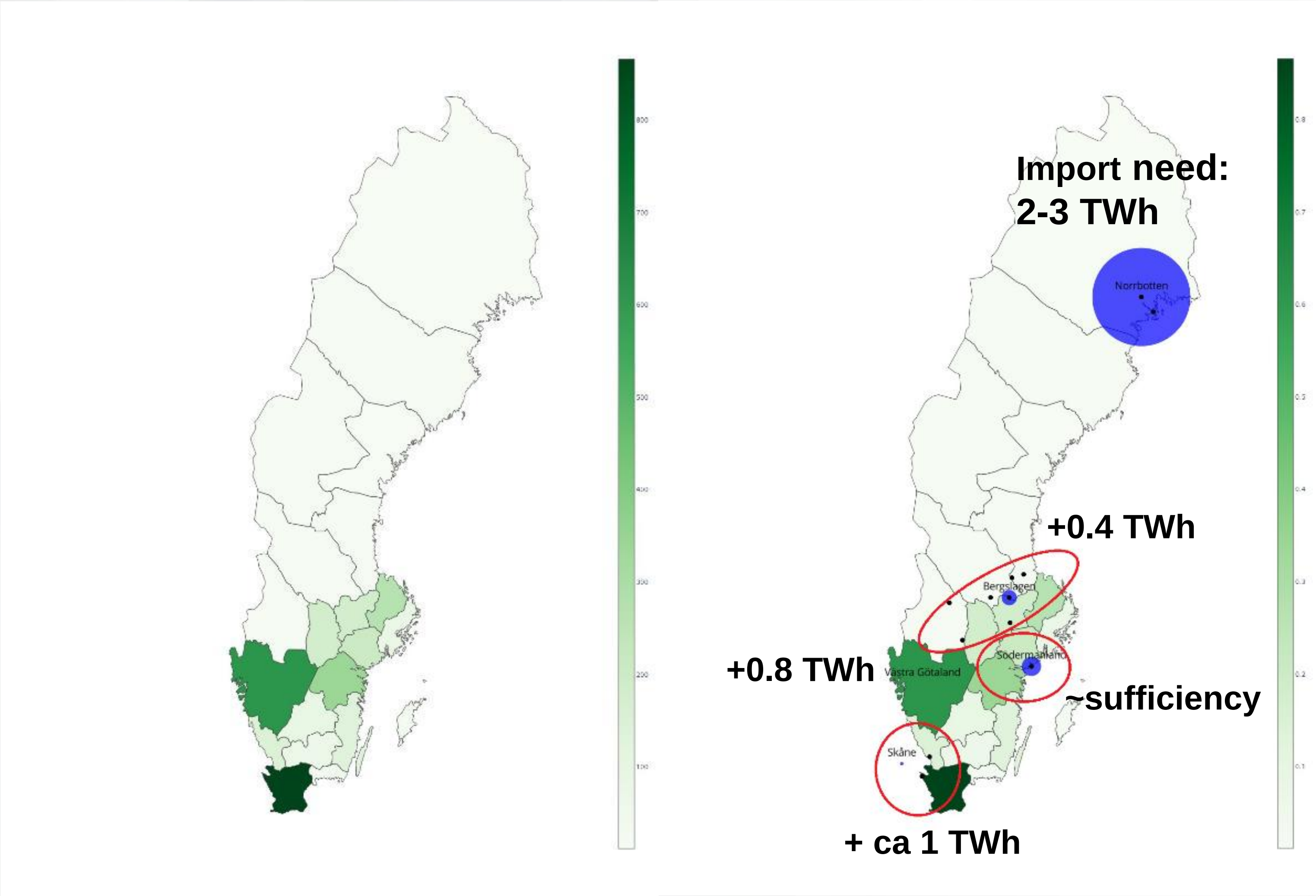


Biogas prouduction potential

- Biomethane potential by region, digestion of manure, gasification of straw (1)
- Steel mills and supply-demand (2)

(1)

(2)



Methane pyrolysis

- Alternative route to biocarbon
- CH_4 + high T → H_2 + C

If Norrbotten gas need is met with H_2 from pyrolysis

→ C-production ~ metallurgical needs

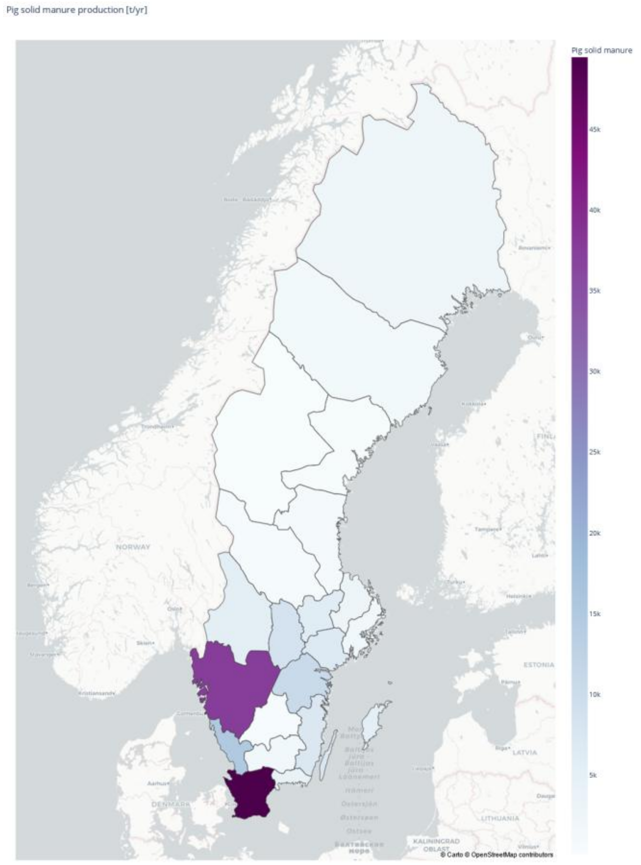
Some conclusions

- Agricultural residue biomass can be significant for metal producers
- Gasification of agricultural residues could reduce demand pressures on some forestry products
- Digestion alone unlikely to supply biomethane need
- Methane preferred for distribution

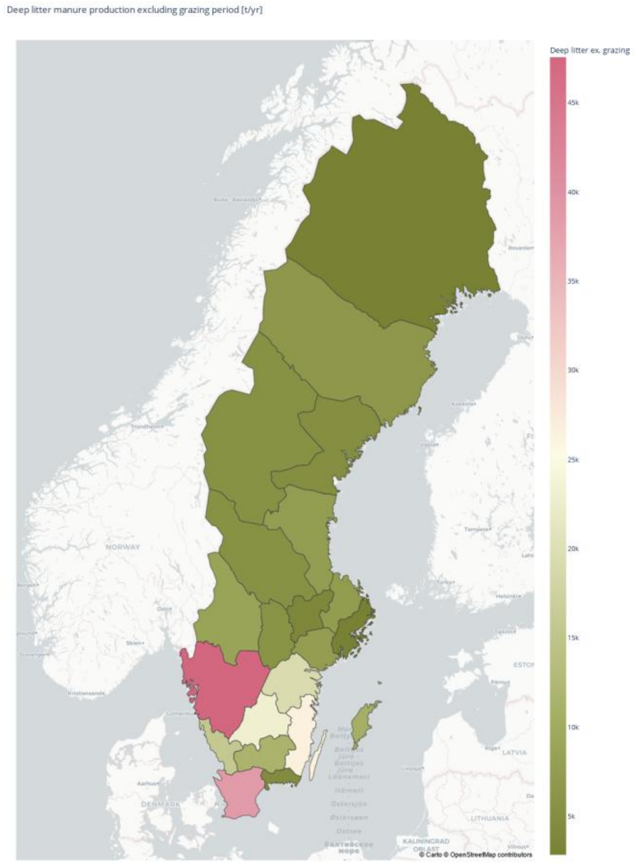
SWERIM

Extra

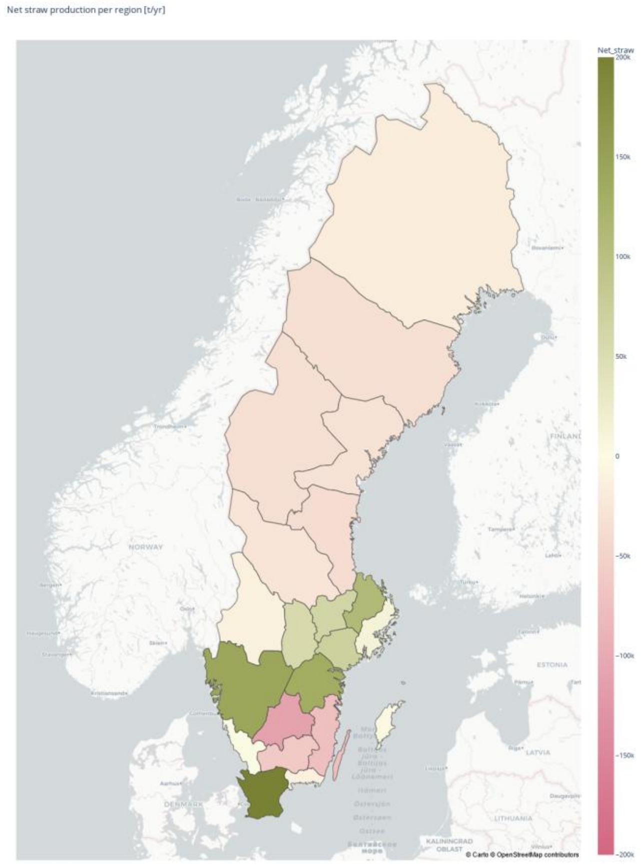
Pig manure



Deep litter (cow)



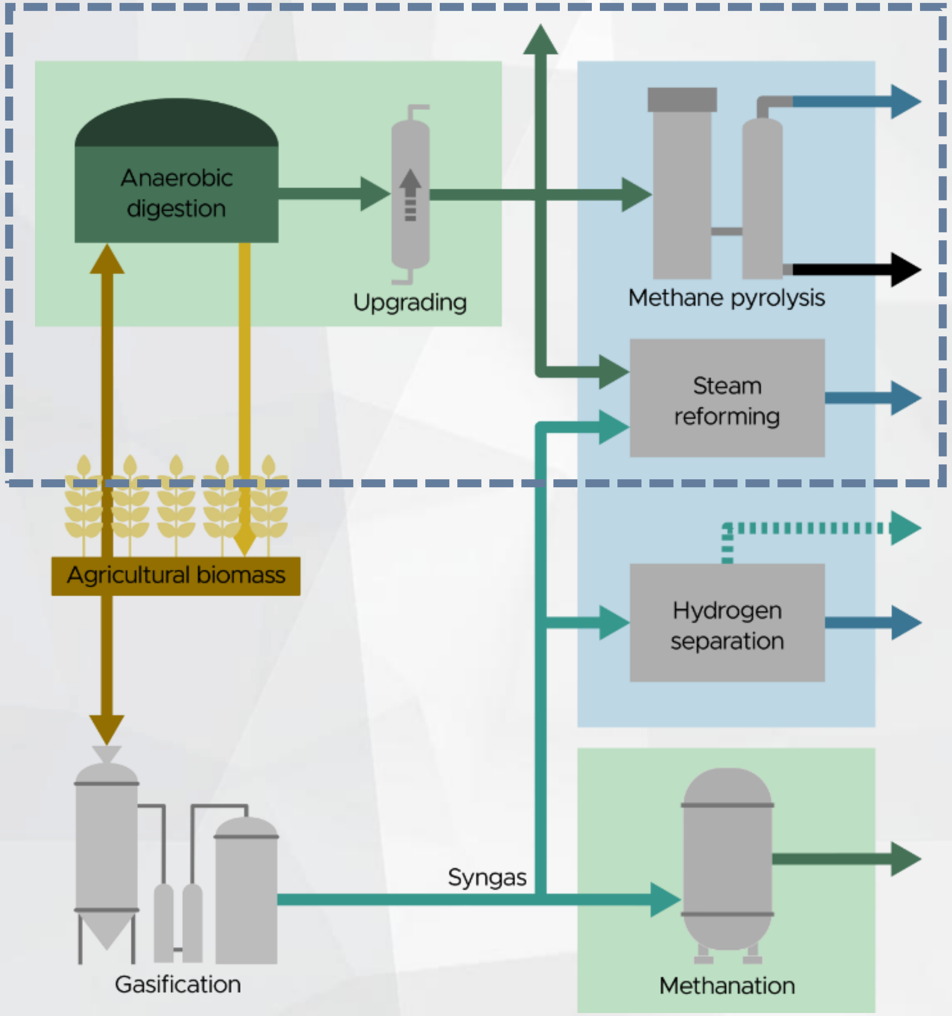
Net straw production



Pathways: anaerobic digestion

- Methane
  - Upgraded biogas

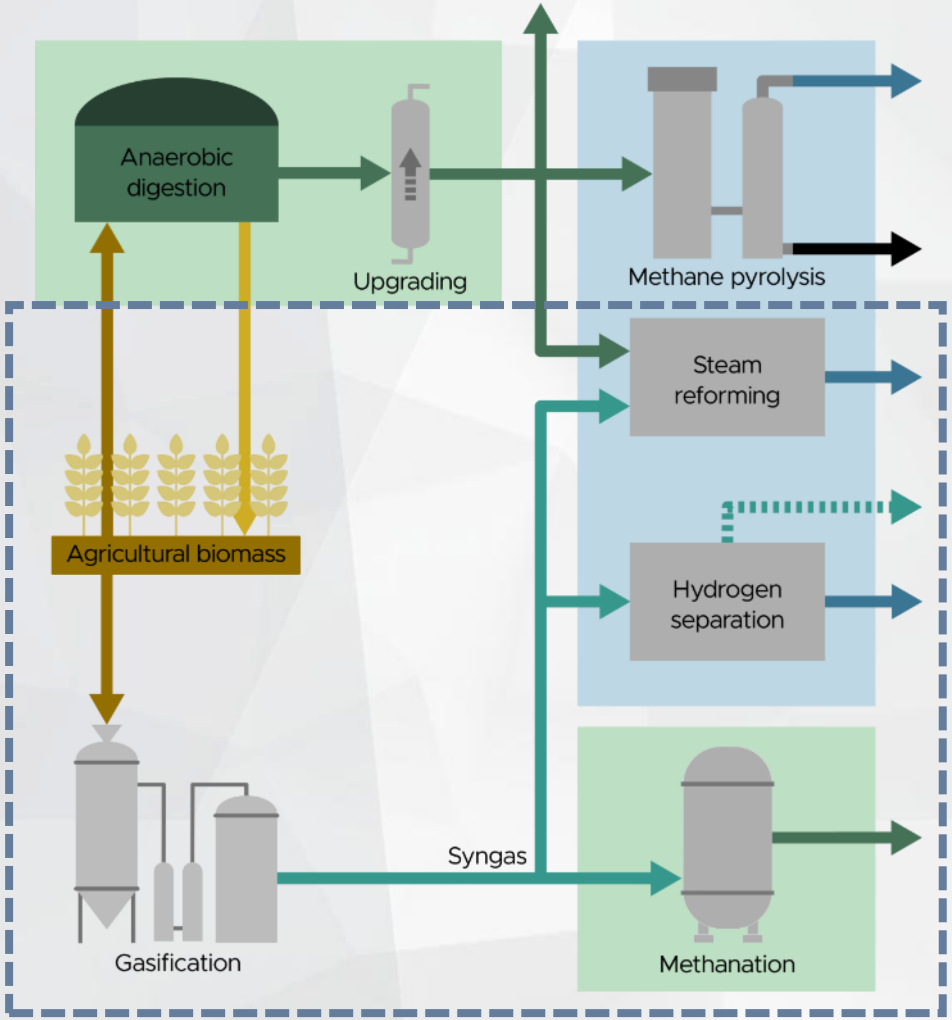
- Hydrogen
  - Methane pyrolysis
  - Steam reforming



Pathways: gasification

- Methane
  - Methanation

- Hydrogen
  - Hydrogen separation
  - Steam reforming



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Antaganden

- Pyrolys: 20% utbyte träråvara till biokol (efter diskussion med Kentaro)
- Grotpotentialer beräknade från Skogsforsks skattningar av hållbart och nuvarande grotuttag, och statistik från Skogsstyrelsen + Riksskogstaxeringen
- Poppelpotentialer beräknade från forskning och långtidsförsök vid SLU Alnarp
- Slampotentialer, hydrokolproduktion och användning i ljusbågsugn från OSMET 3.0 (manuskript)
- Fiber- och bioslam antas kunna samprocessas i HTC

Källmaterial

Omvandlingsfaktorer mellan enheter

- Skogsstatistisk årsbok (äldre publikation, senast utgiven 2014)
- Skogsstyrelsen (2022), Skogliga konsekvensanalyser 2022 – syntesrapport (SKA22), rapport 2022/11

Poppel / snabbväxande lövträd

- Böhlenius et al. (2023) Biomass production and fuel characteristics from long rotation poplar plantations, Biomass & Bioenergy 178:106940, https://doi.org/10.1016/j.biombioe.2023.106940

Grot och andra skogsbränslen

- Skogforsk m.fl. (2021), Skogskunskap: Skogsbränslemängd i beståndet, https://www.skogskunskap.se/skota-barrskog/skorda-skogsbransle/skogsbransle-grunder/skogsbranslemangd-i-bestandet/
- Skogforsk (2023), Fakta skogsbränsle, https://www.skogforsk.se/kunskap/temasidor/skogsbransle/faktasammanstallning-grot/
- Skogsstyrelsen (2023), Avverkningsstatistik, tabell 06 ”Bruttoavverkad volym och areal per region, ägarklass, huggningsart”, https://www.skogsstyrelsen.se/statistik/statistik-efter-amne/avverkning/
- SLU/Riksskogstaxeringen (2023), Skogsdata 2023, https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/skogsdata/skogsdata_2023_webb.pdf

Källmaterial

Jämförelser

- Ahlström et al. (2023), Sustainable aviation fuels – Options for negative emissions and high carbon efficiency, International Journal of Greenhouse Gas Control 125:103886, https://doi.org/10.1016/j.ijggc.2023.103886
- Biometria (2023), Skogsindustrins virkesförbrukning 2018-2022, https://www.biometria.se/media/iugefh4w/skogsindustrins-virkesfoerbrukning-2018-2022.pdf
- Energimyndigheten (2023), Energiläget i siffror 2023, https://www.energimyndigheten.se/statistik/ovrig-energistatistik/energilaget/
- Svebio (2023), Rekord för pelletsproduktion i Sverige 2022, https://www.svebio.se/press/pressmeddelanden/test/

HTC & hydrokol i ljusbågsugn

- Wang et al. (2023) A Pilot Trial Investigation of Using Hydrochar Derived from Biomass Residues for EAF Process, in: Fleuriault et al. (Eds.), Advances in Pyrometallurgy. Springer Nature Switzerland, Cham, pp. 153–163. https://doi.org/10.1007/978-3-031-22634-2_15

Massa- och pappersindustri

- Svensson et al. (2023), Kartläggning av biogena kolflöden i de skogsbaserade värdekedjorna i Sverige, RISE Rapport: P116313.
- von Schenck et al. (2016), Info från LignoJet-projektet (RISE inhouse-info)
- Thuresson & Johansson (2016), Bioenergi från skog och skogsindustri. Stockholm: Pöyry Management Consulting.

More facts about grot

Temasida SKOGSBRÄNSLE + Faktablad och FILM om grot

- Skogsbränsle - Skogforsk
- faktasammanstallning-grot_20231025_press.pdf (skogforsk.se)
- FILM på Youtube Grot - YouTube
- Lunchseminarium om grot 25 oktober - Skogforsk
-

KUNSKAPSARTIKLAR & ARBETSRAPPORTER

- Arbetssätt för uttag av skogsbränslen - Skogforsk
- Hur mycket grot lämnas kvar i skogen? - Skogforsk
- Fuktig eller torr - hur blir groten i år? - Skogforsk
- Vad kostar det att ta ut mer biobränsle från skogen? - Skogforsk
- Effektiv lagring av skogsflis möjliggörs av täckning och sållning av flisen - Skogforsk
- Simulera först – asfaltera sedan! - Skogforsk
- Skogsbränsle - Skogforsk
- Snabb fukthaltsmätning av trädbränsle - Skogforsk
- Kan spån bidra till att Sverige blir världens första fossilfria välfärdsland? - Skogforsk
- Undvik de största misstagen! Systemval för transport och sönderdelning av grot - Skogforsk
- Stora regionala skillnader i förutsättningarna att leverera skoglig råvara till framtidens hållbara samhälle - Skogforsk

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Tack till Mia Iwarsson Wide, Skogforsk, för sammanställningen!

SVEBIO

HåBiMet Nulägesseminarium

Johnny Kjellström

30 januari 2025

Johnny Kjellström

- Näringspolitisk chef, Svebio, sedan i mars 2024
- LRF, 2021-2024
- Länsstyrelsen Sthlm, 2016-2021
- Regeringskansliet, 1999-2016
- Jordbruksverket, 1996-1999

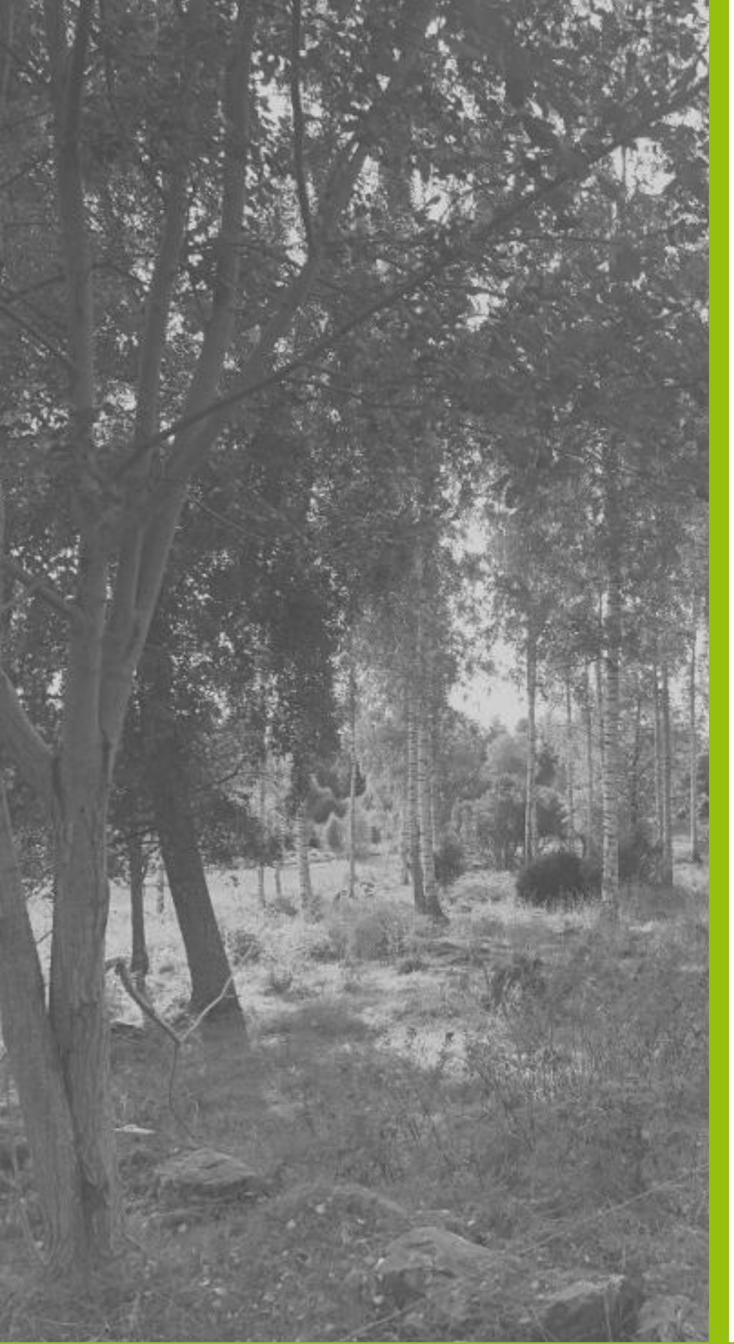
- Smålänning
- Lundaekonom
- Nackabo sedan 2011

Vilka är vi?

Svenska Bioenergiföreningen (Svebio) är en branschorganisation för drygt 250 företag, organisationer och personer som är verksamma i bioenergibranschen i Sverige. Vi är starkt grundade i våra värderingar som bygger på ett hållbart och tryggt energisystem, företagande och marknadsekonomi. Är medlemmar i Bioenergy Europe och World Bioenergy Association.

<u>Vision och verksamhet</u>

- Vara den ledande företrädaren och ett internationellt föredöme för att utveckla bioenergi i ett hållbart samhälle.
- Ta tillvara medlemmarnas intressen genom bl.a. politiskt påverkansarbete.
- Vi företräder företag som tillverkar och använder bioenergi i fast, gasformig och flytande form.
- Vara en mötesplats för företag, forskare, opinionsbildare och beslutsfattare.
- Organisera konferenser och seminarier
- Två tidningar: Bioenergitidningen och Bioenergy International



Svebio i hela näringskedjan

BIOMASSA

RÅVARA

Skogsbruk
Lantbruk
Avfallshantering

RAFFINERING

PROCESSNING

Flisning
Pellets
Biodrivmedelsproduktion etc.

SLUT-ANVÄNDNING

Värme
El
Drivmedel
Industri

Tillverkning av utrustning →

Transport och logistik →

Forskning och rådgivning →

250 medlemmar: företag, institutioner och privata medlemmar

Bioenergi i Sverige

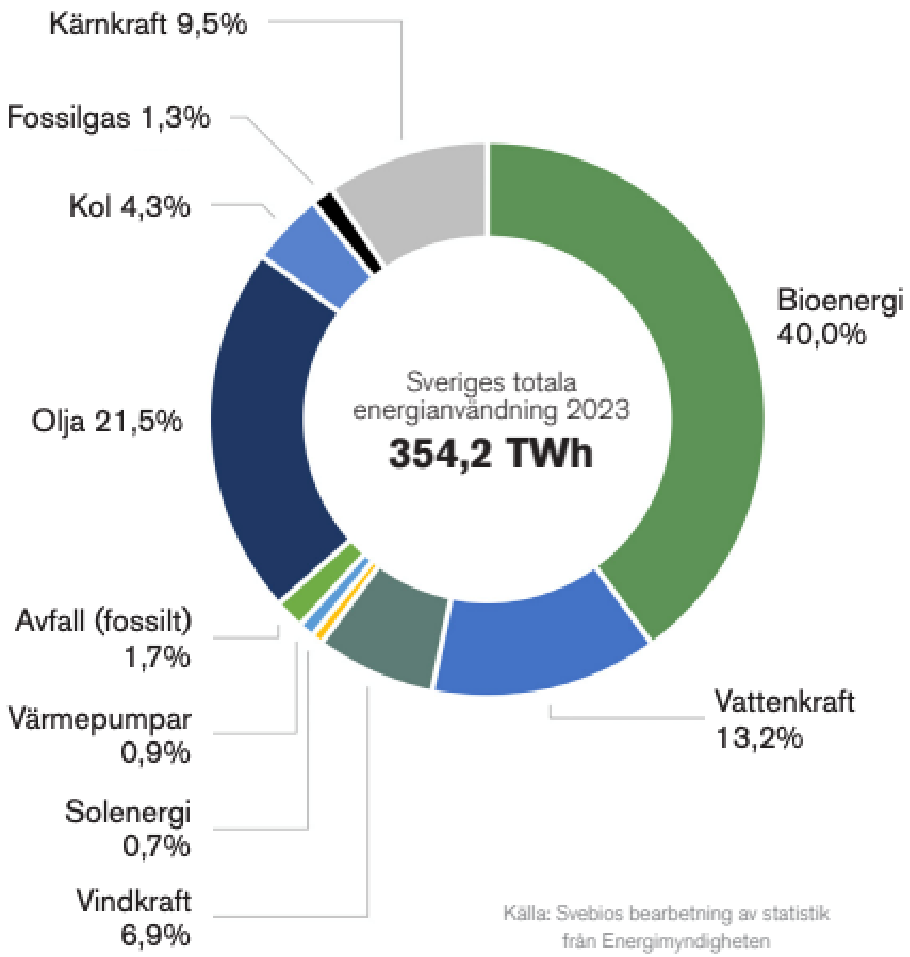
Sveriges energianvändning 2023

Bioenergi är Sveriges största energislag och stod **2023 för 40 procent** av den slutliga energianvändningen i Sverige.

Andelen förnybar energi var 61,7 procent.

Export och energiförluster är ej medräknade

	TWh	%
Bioenergi	141,5	40,0
Olja	76,2	21,5
Vattenkraft	46,9	13,2
Kärnkraft	33,5	9,5
Vindkraft	24,6	6,9
Kol	15,1	4,3
Avfall (fossilt)	6,1	1,7
Fossilgas	4,6	1,3
Värmepumpar	3,3	0,9
Solenergi	2,4	0,7



Källa: Svebios bearbetning av statistik från Energimyndigheten (Kortsiktsprognos mars 2024)

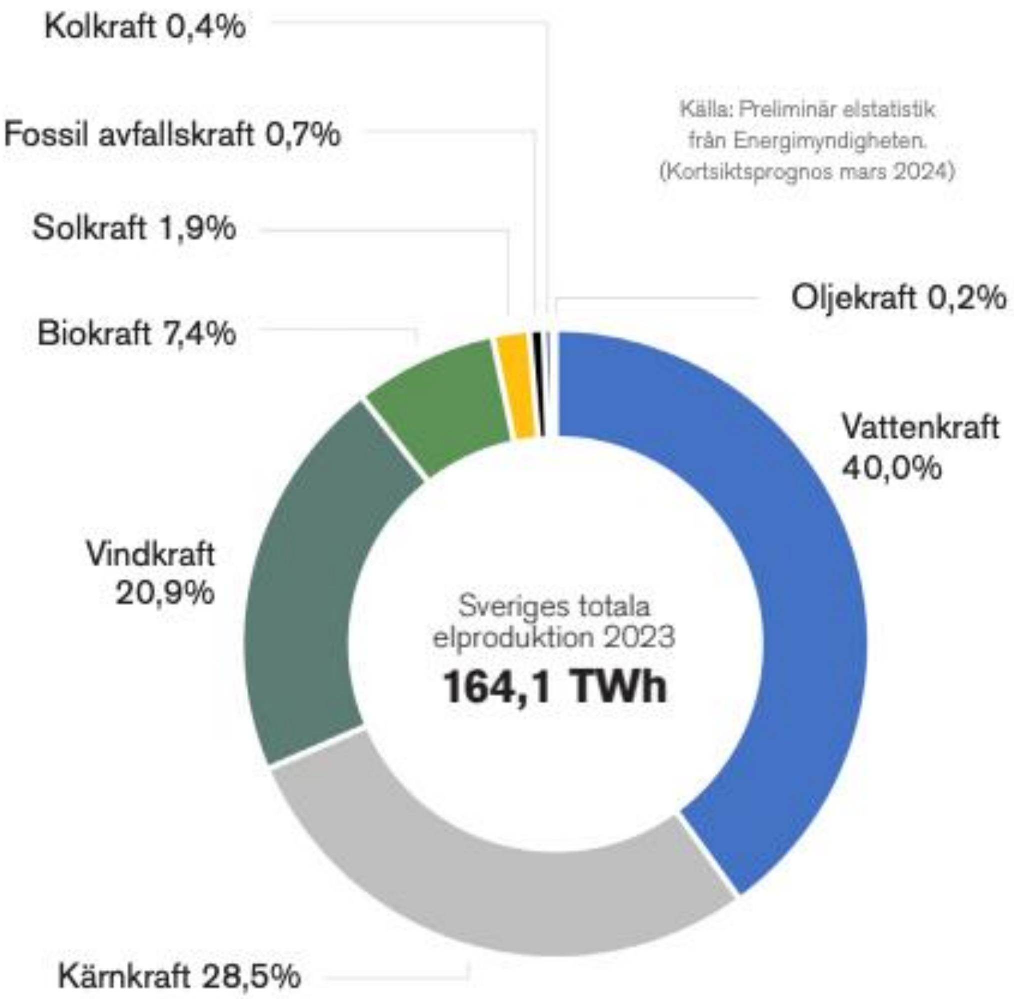
Sveriges elproduktion 2023

Det fossilfria står för 98,6 procent.

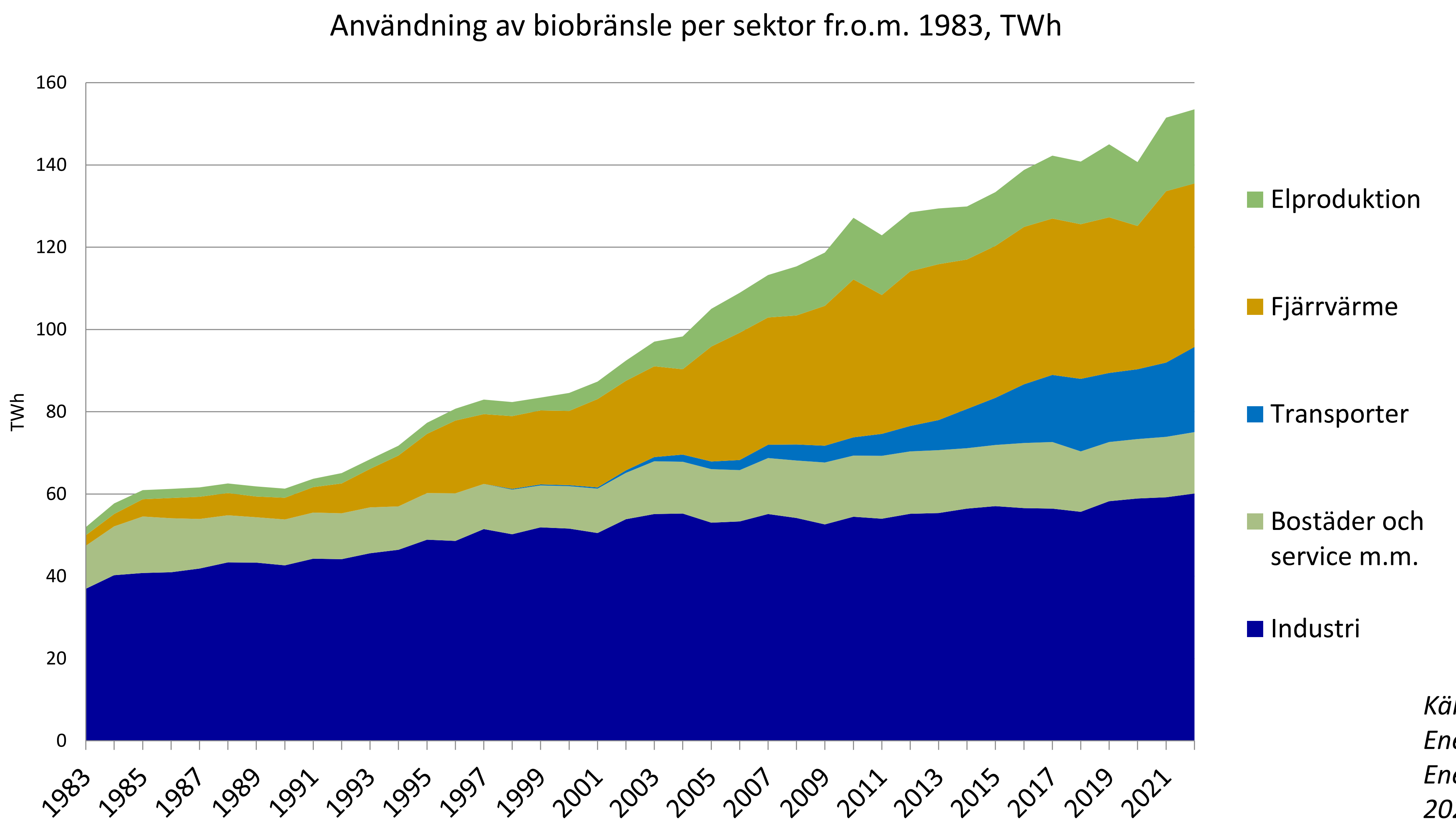
Biokraften ligger på fjärde plats inom svensk elproduktion.

Fossilkraft (olja, kol och naturgas) stod endast för 1,5 procent av Sveriges elproduktion 2023.

	TWh	%
Vattenkraft	65,7	40,0
Kärnkraft	46,7	28,5
Vindkraft	34,3	20,9
Biokraft	12,1	7,4
Solkraft	3,1	1,9
Fossil avfallskraft	1,2	0,7
Kolkraft	0,7	0,4
Oljekraft	0,3	0,2

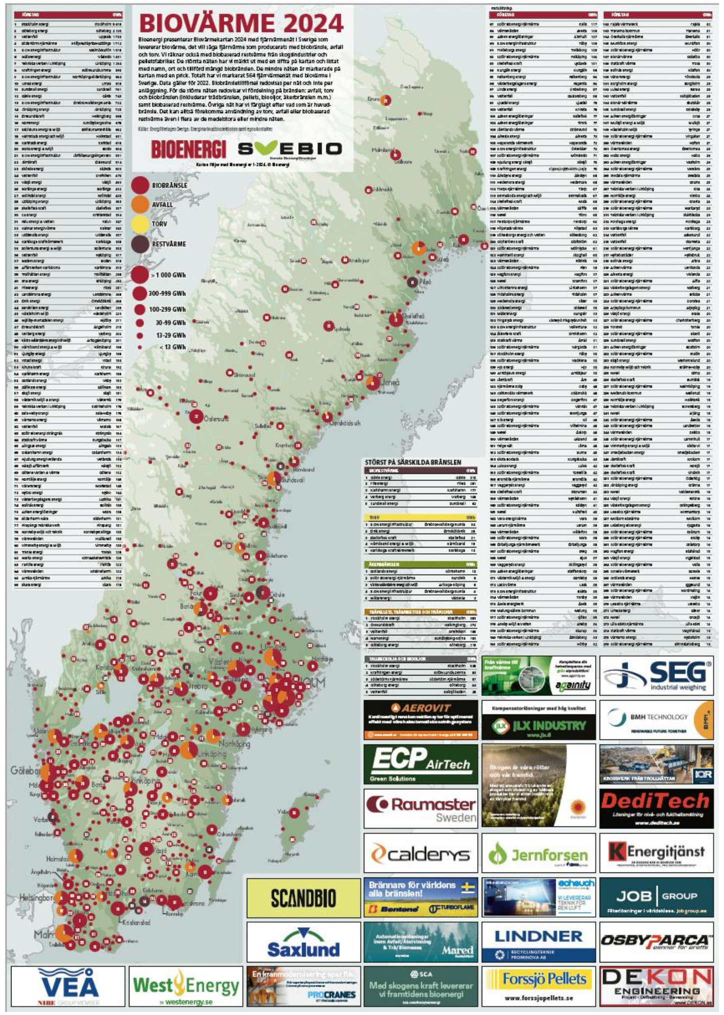


Användning av bioenergi per sektor (TWh)

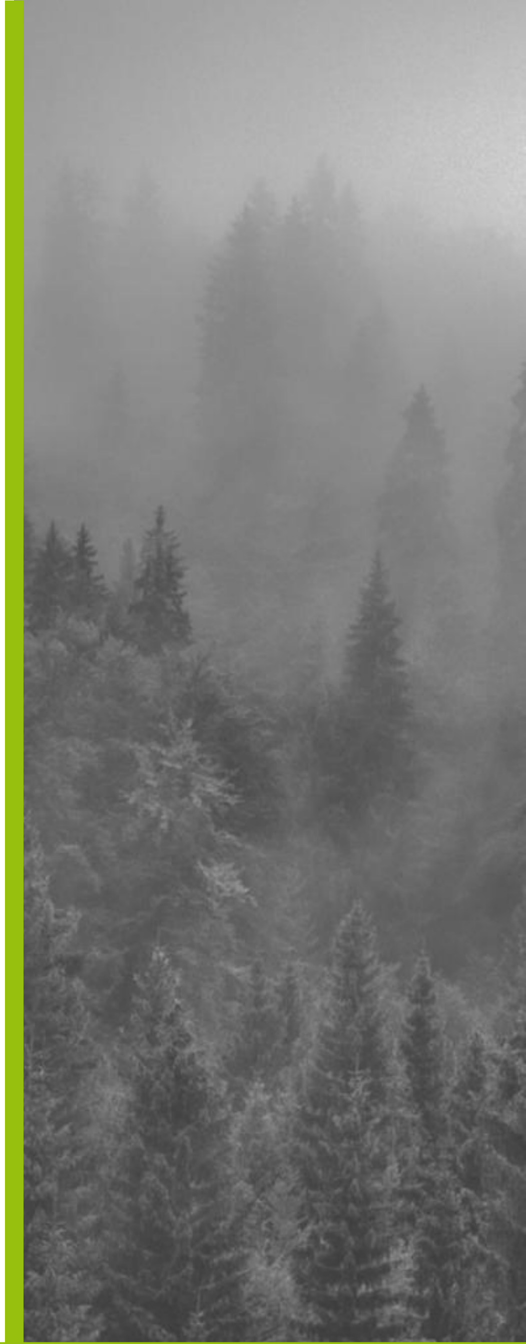


Källa: Energimyndigheten, Energiläget i siffror 2023

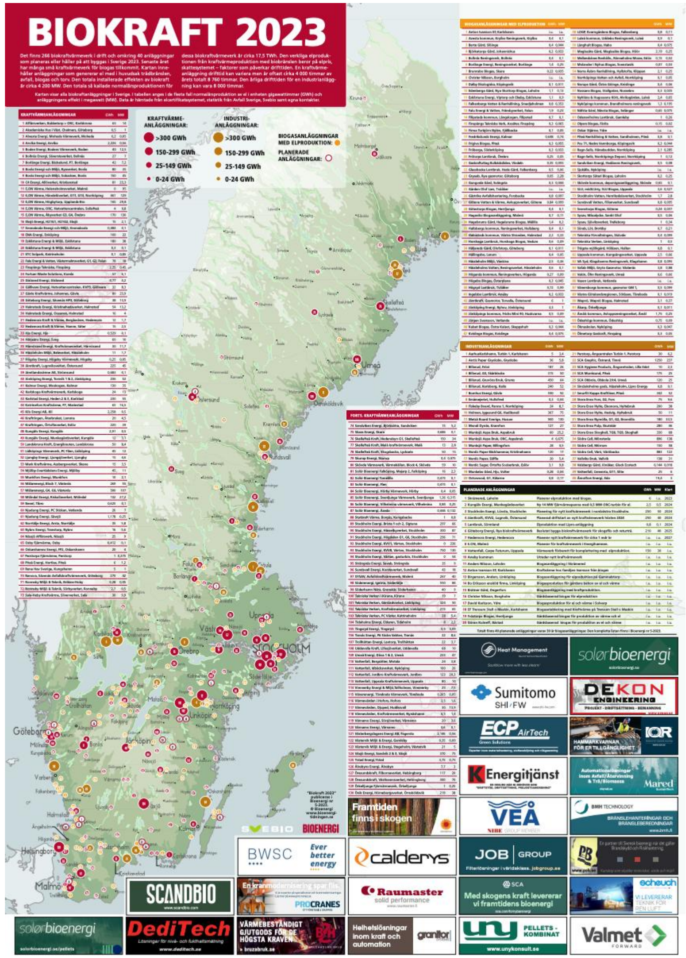
Biovärme



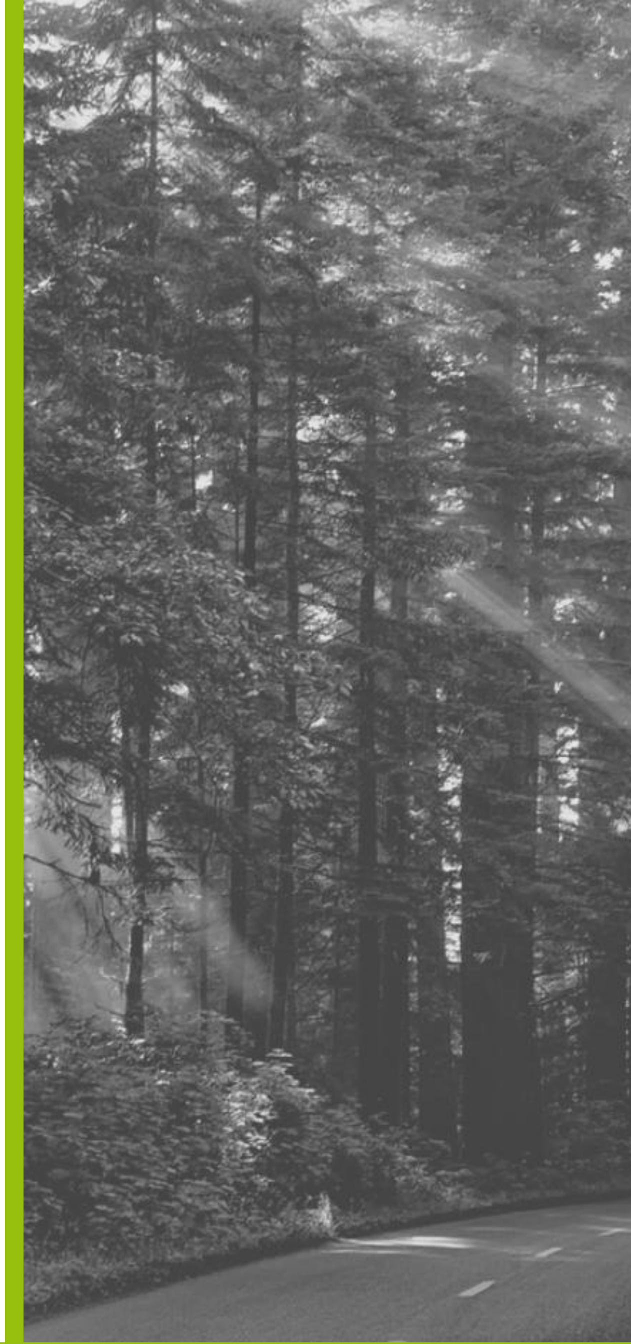
- År 2024 fanns det 564 fjärrvärmenät som levererar biovärme i Sverige
- Ca 90 procent av flerfamiljshus värms idag upp genom fjärrvärme
- Många fjärrvärmeverk eldas med avfall, som till 70 procent består av biogena avverkningsprodukter från till exempel skogsindustri som inte går att återvinna
- Biobränslen står för omkring 70% av all fjärrvärme + spillvärme från skogsindustri



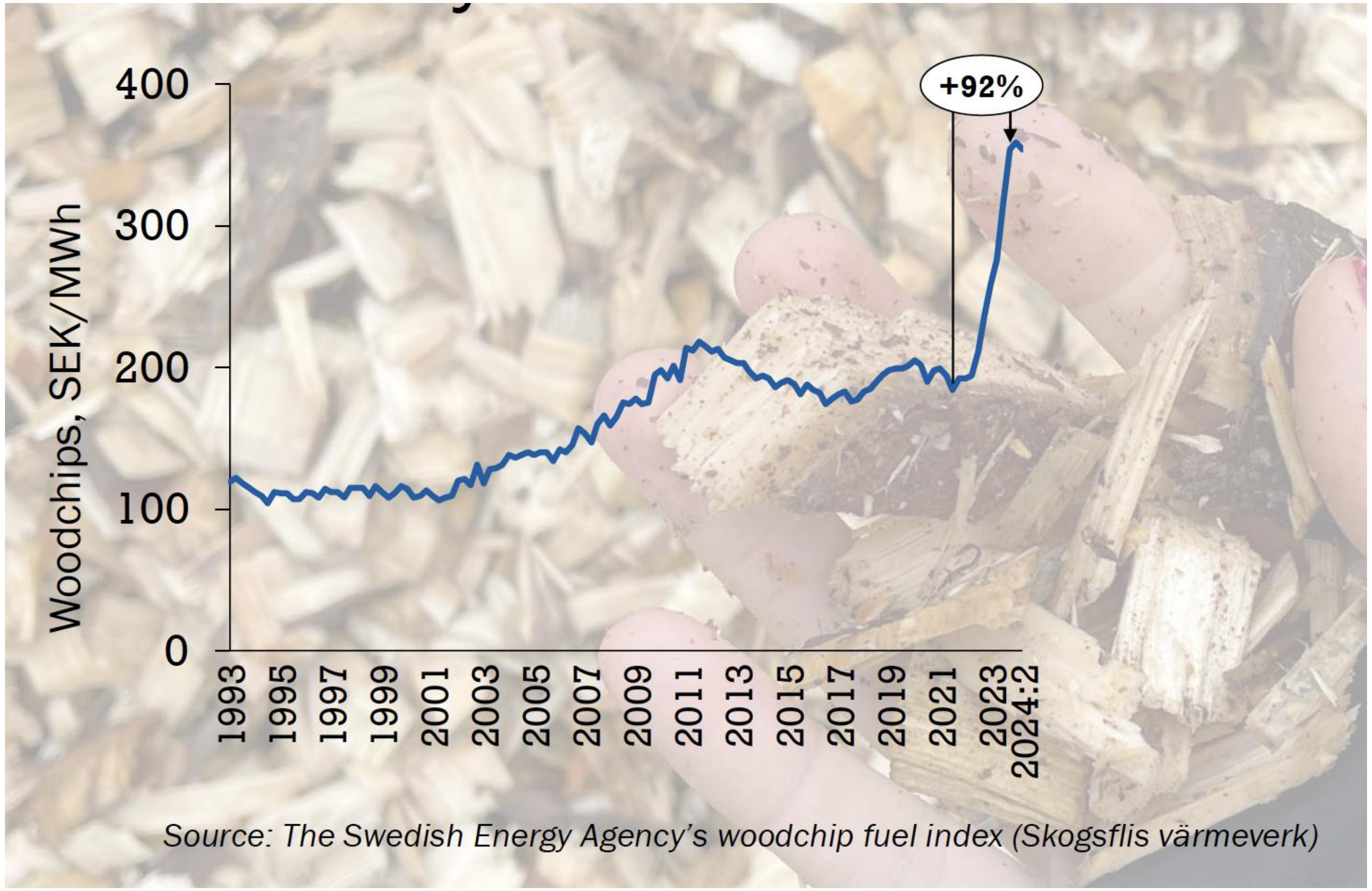
Biokraft



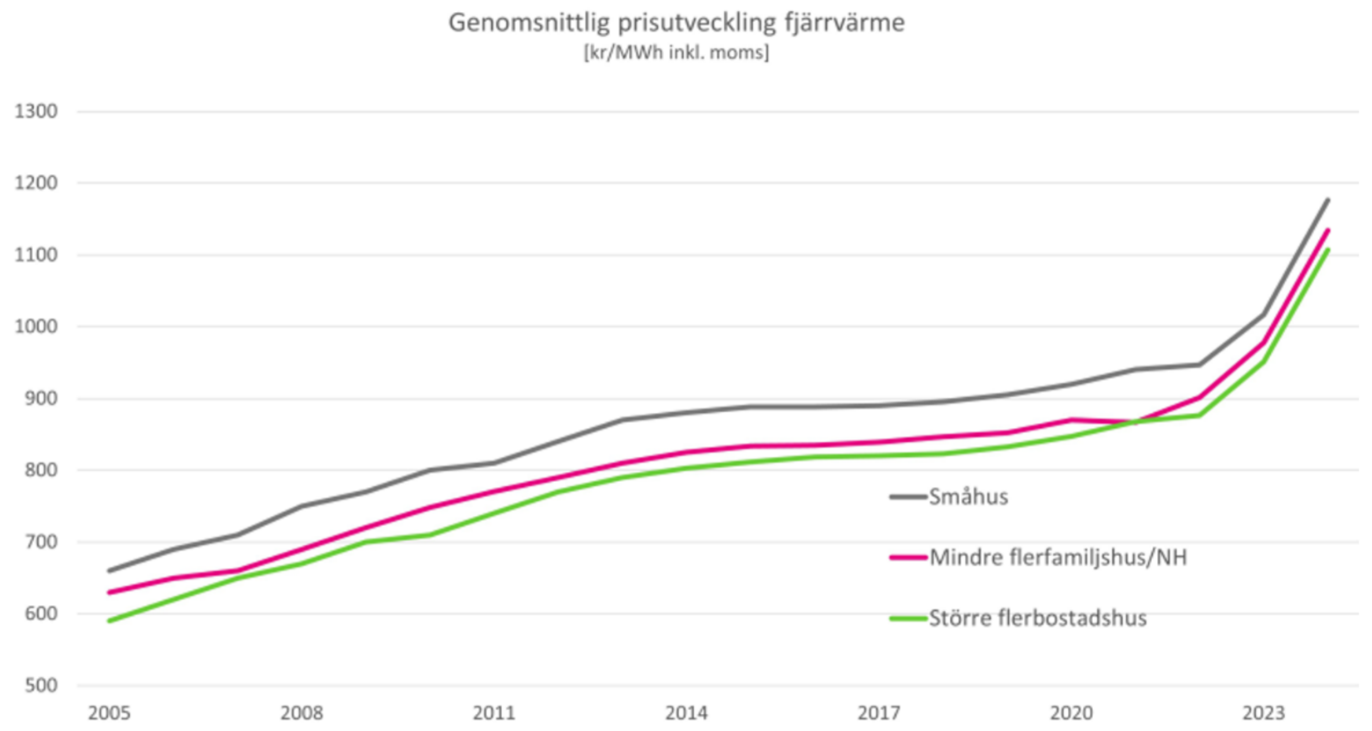
- Det finns 266 biokraftvärmeverk i drift och omkring 40 anläggningar som planeras eller håller på att byggas.
- Den totala installerade effekten av biokraft är cirka 4 800 MW.
- Den totala normalårsproduktionen för dessa kraftvärmeverk är cirka 17,5 TWh el.



Priserna på biomassa har fördubblats under de senaste två åren

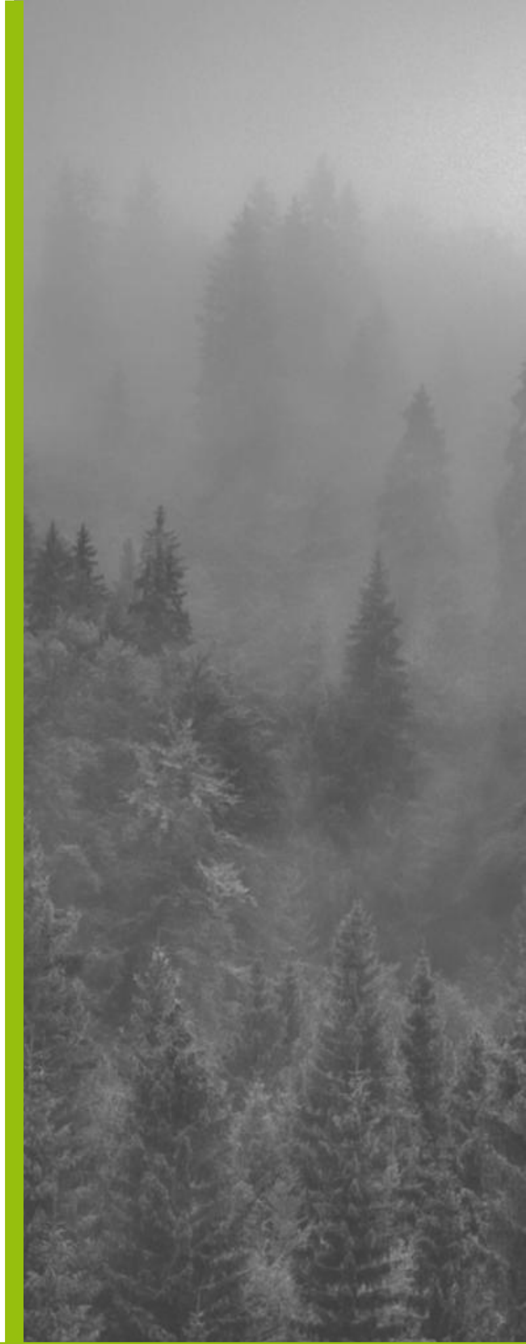


Fjärrvärmen ökar i pris



Källa: Nils Holgersson, 2024

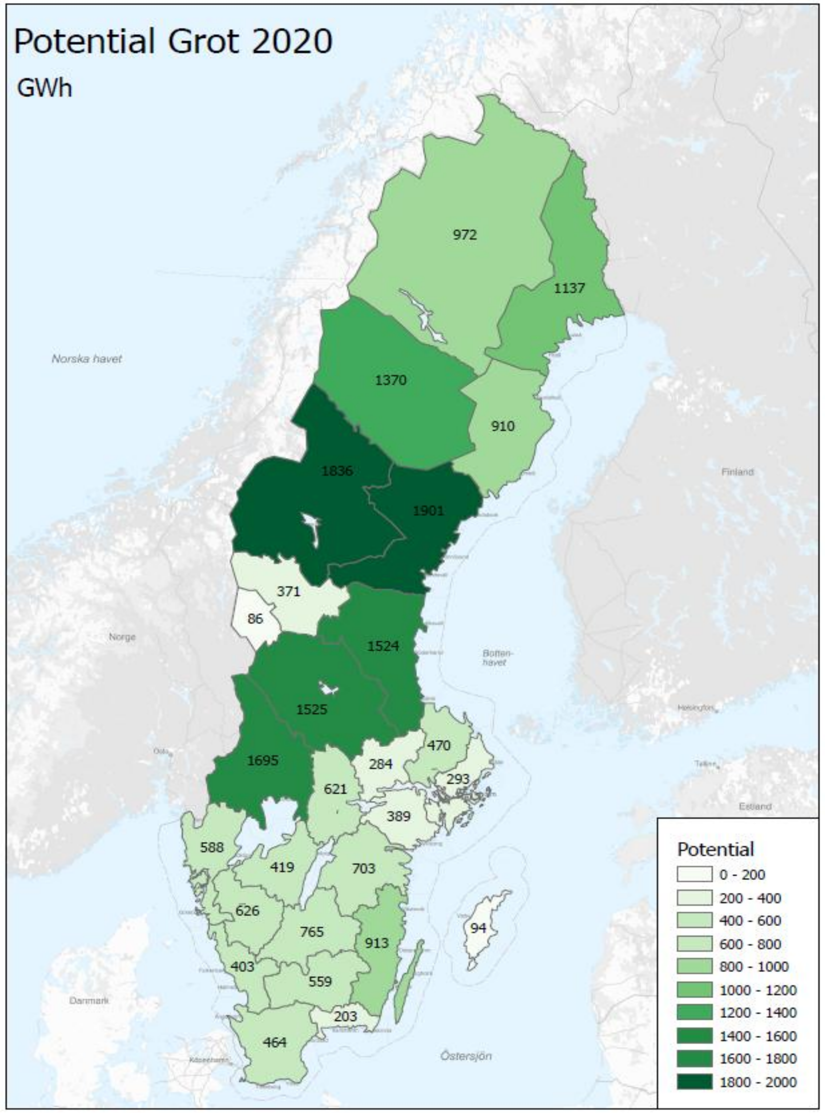
- Prisökning i snitt ca 16 procent 2024
- Orsaker: Minskad import av biomassa från Ryssland, Ukraina och Belarus. EU-länder köper från Sverige (låg kronkurs), minskat byggande (mindre restavfall) höjda ETS-priser



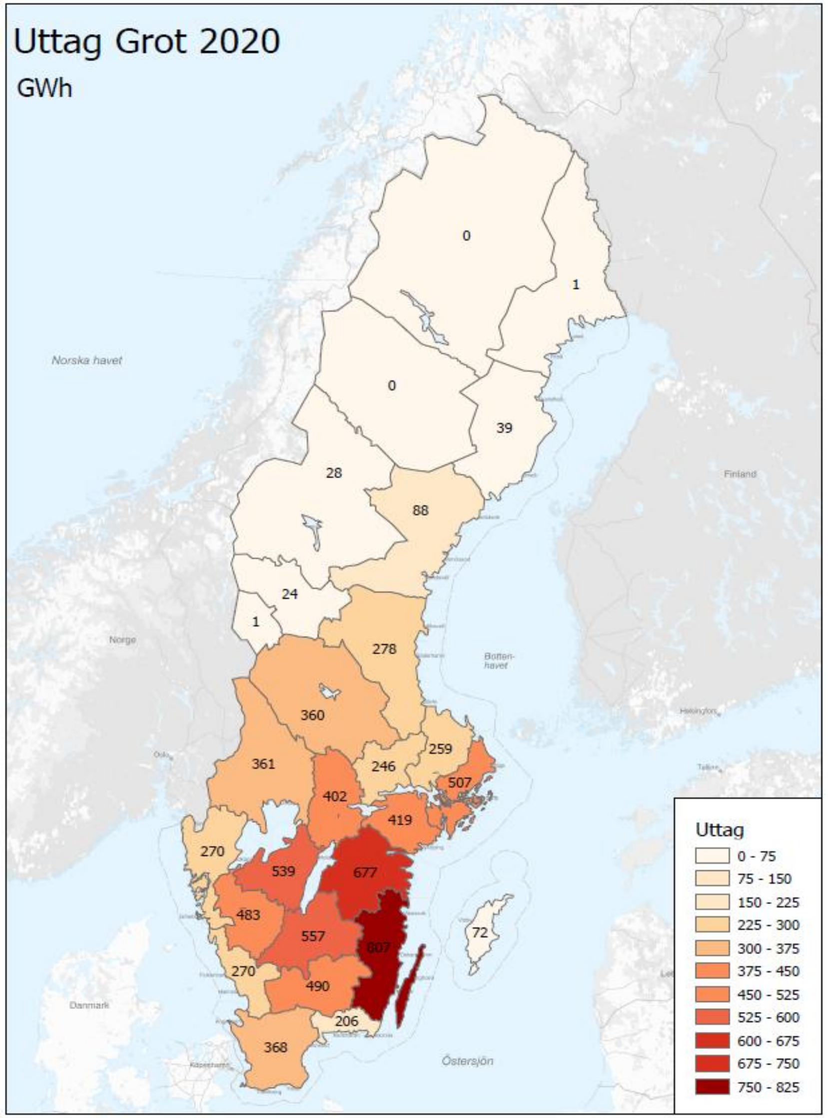
Ökad biomassapotential

Ökad potential jordbruksbaserad bioenergi	Energi (TWh)	Ökad potential skogsbaserad bioenergi	Energi (TWh)
Halm (spannmål och oljeväxter)	2-3	Grenar och toppar (grot)	13-16
Gödsel och organiska restprodukter (biogas)	8-10	Skadad rundved (insekter, storm m.m.)	3-4
Biomassa från outnyttjad åkermark m.m.	5-10	Klen rundved (eftersatta röjningar m.m.)	2-3
Slytäkt (åkerkanter, igenväxande betesmarker, ledningsgator m.m.)	8-10	Biprodukter (bark, spån, lignin m.m.)	6-12
Summa	**18-26**	**Summa**	**24-35**
Medeltal	22	*Medeltal*	29

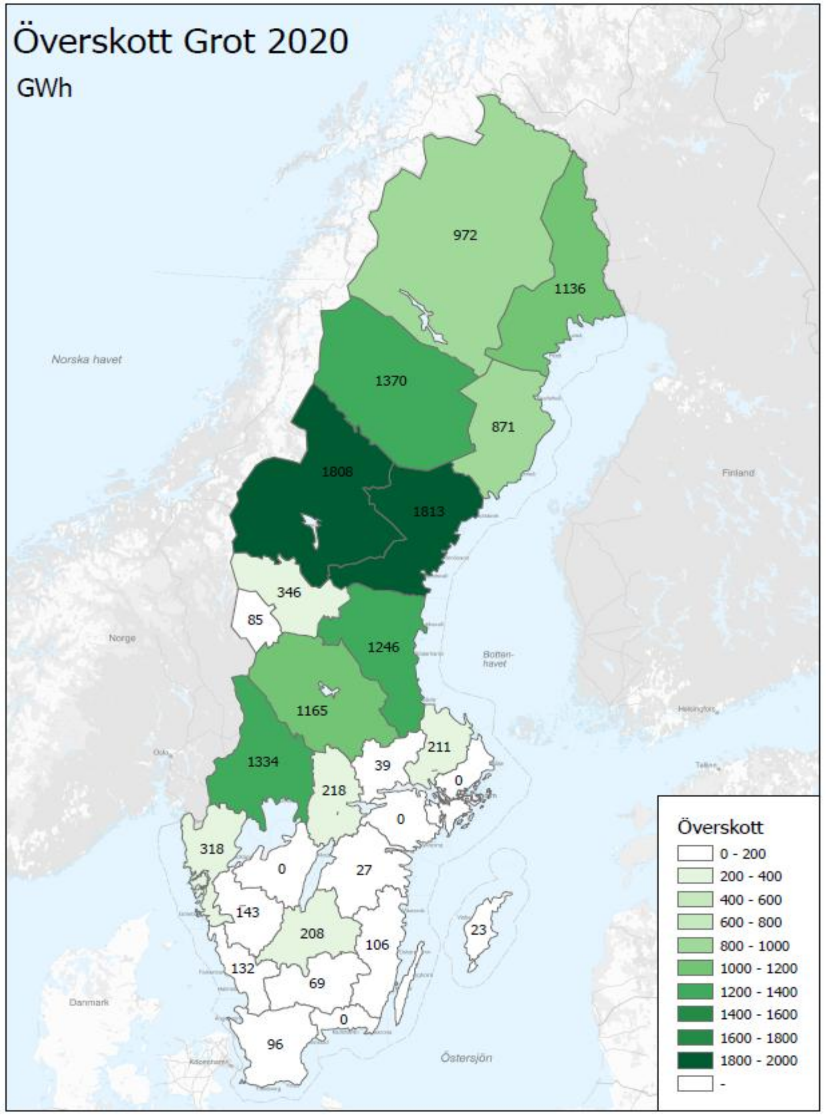
Källor: Baserat på sammanställd statistik från Skogforsk, Skogsstyrelsen, Energimyndigheten, Jordbruksverket och KSLA.



Hållbar potential 21 100 GWh



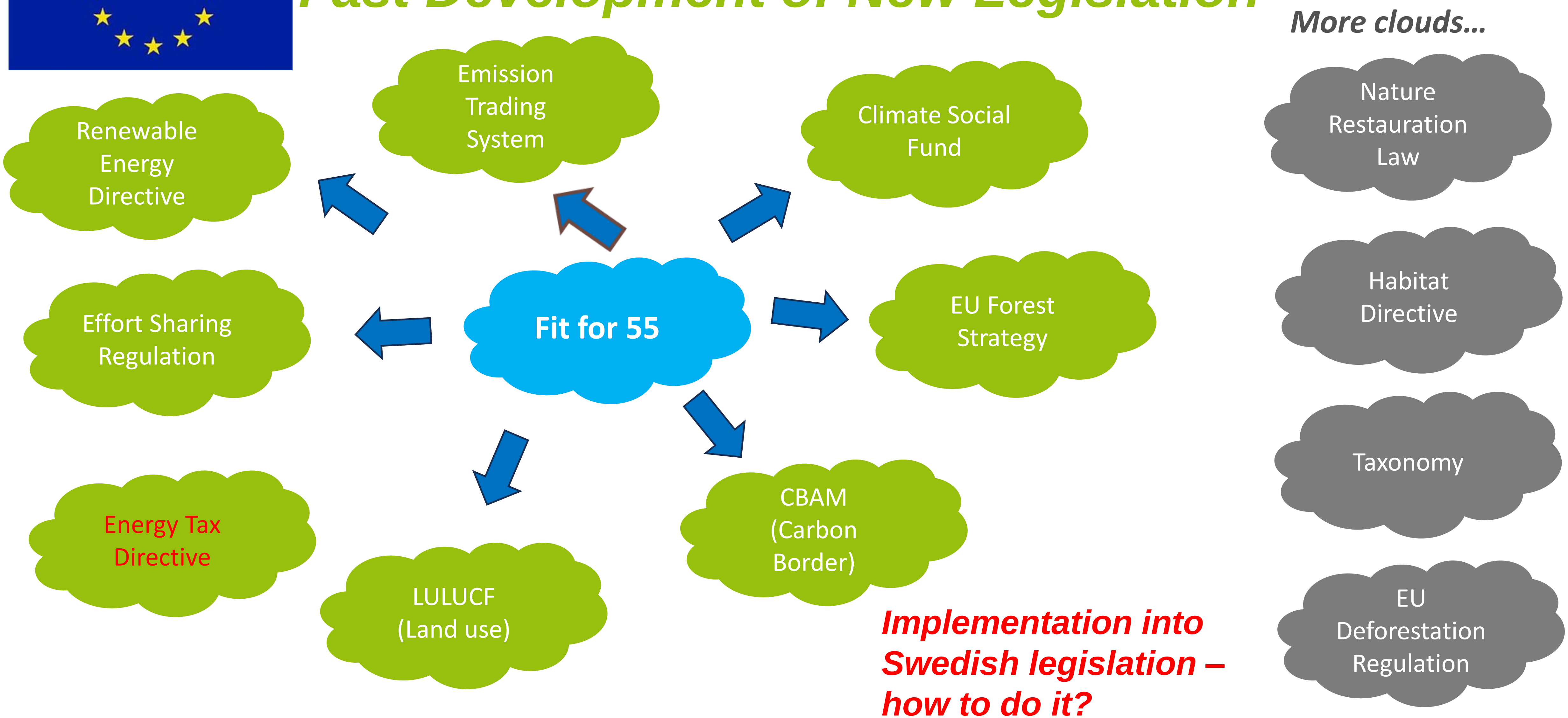
Nuvarande uttag 7 400 GWh (37%)



Utrymme för expansion 13 700 GWh

Källa: Skogforsk

Fast Development of New Legislation



Implementation into Swedish legislation – how to do it?

Johnny Kjellström,
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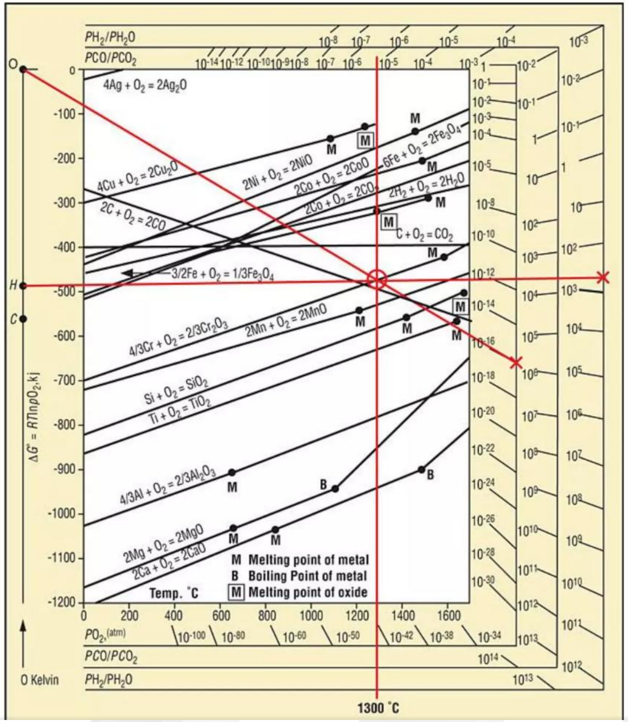
Svenska Bioenergiföreningen
www.svebio.se

Tekniska försök biokol i metallurgi

Chuan Wang

Why biocarbon is needed in various metallurgical processes?

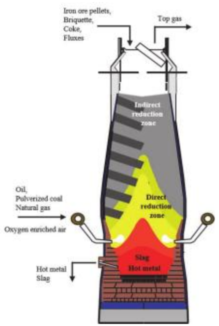
- Fossil carbon (coal, coke, natural gas, etc.) is still in use, thus leading to the emission of fossil CO_2;
- Thermodynamic constraints: not all carbon can be replaced by hydrogen, e.g. Cr_2O_3, SiO_2, TiO_2, etc.;
- Carbon is still needed as carburizing agent, slag foaming agent in EAF, etc.;
- Economic feasibility: hydrogen vs. biocarbon.



Ellingham Diagram

Carbon for iron- and steelmaking

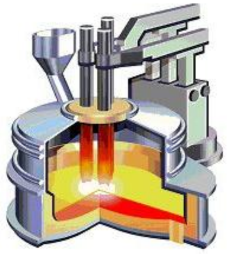
BF



(450-500 kg/thm)

- Reducing agent
- Fuel
- Carburization
- Skeleton (coke)

EAF

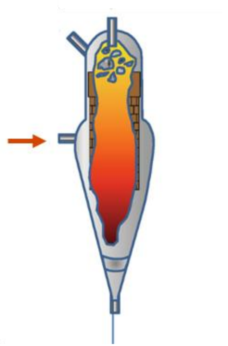


(12-55 kg/t-steel)

- Slag foaming agent
- Reducing agent
- Carburizing agent
- Fuel

DR-SF

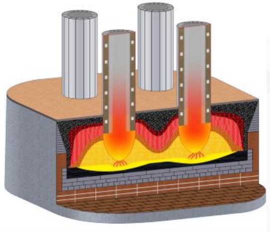
Natural gas/
Syngas



0.2-0.6 MWh/t-DRI

- Carburizing agent
- Fuel

SAF



(300-500 kg/thm)

- Reducing agent
- Fuel
- Carburization

Number of biocarbon projects at Swerim

	2012-2014	2015-2017	2018-2020	2021-2023	2024-
Others				1	1
SAF				1	1
CF		1	1		
EAF		2	1	6	1
BF	3	12	4		

Required properties of biocarbon for metallurgical applications

In general, it requires high heating value, low P and S, low alkali (Na and K), low ash content.

For injection
- Good grindablity/fluidability
- Combustability/burnt-out rate

For top charging
- High density
- High mechanical strength

Fuel
- High heating value
- High C and H

Carburization
- High fixed carbon
- Low reactivity

Reductant
- High C and H
- High volatile content

Slag foaming agents
- High C and H
- High volatile content

Biocarbon powder

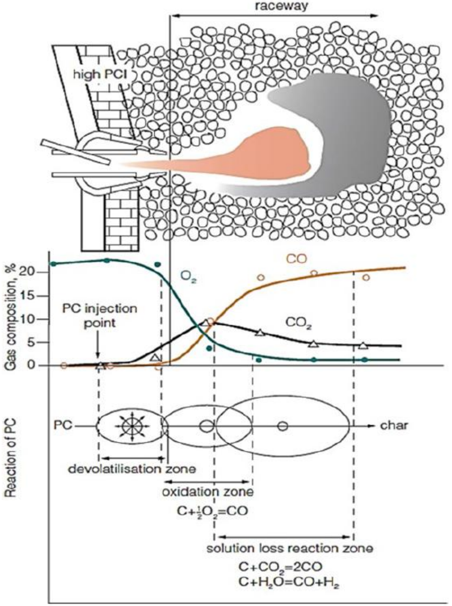
Biochar

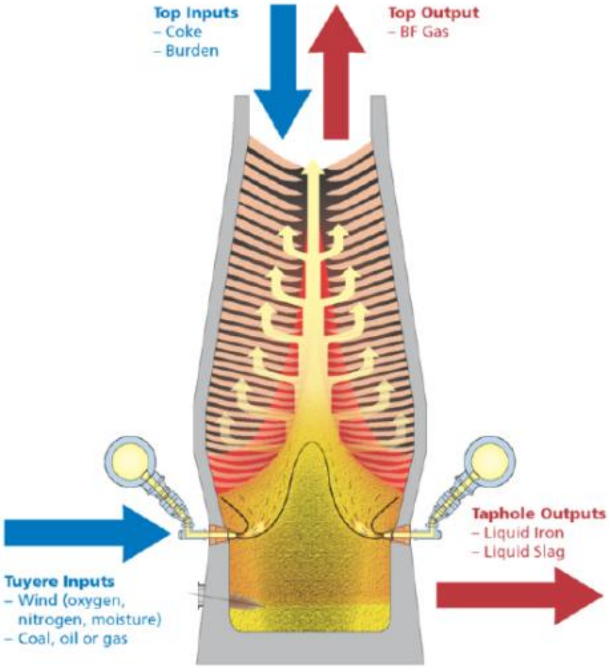
Torrefied material

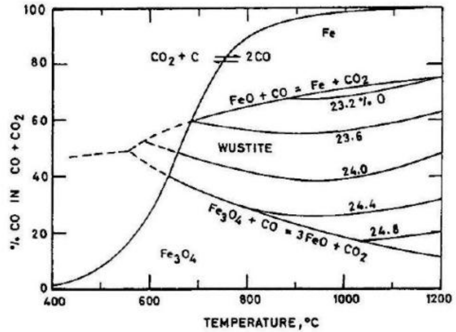
Hydrochar

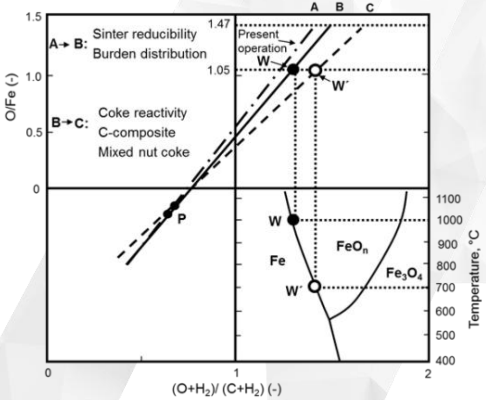
SWERIM

Utilization of biomass in the blast furance



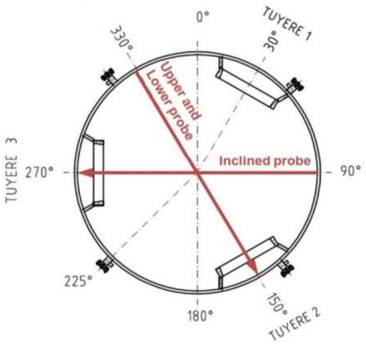


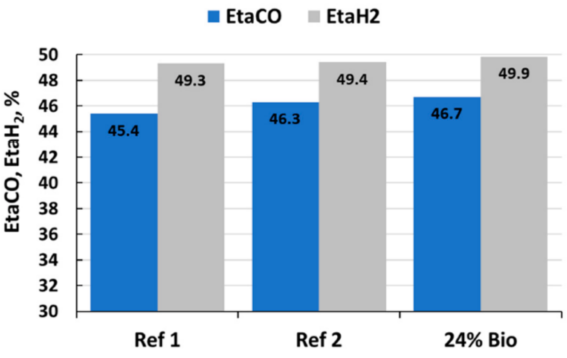


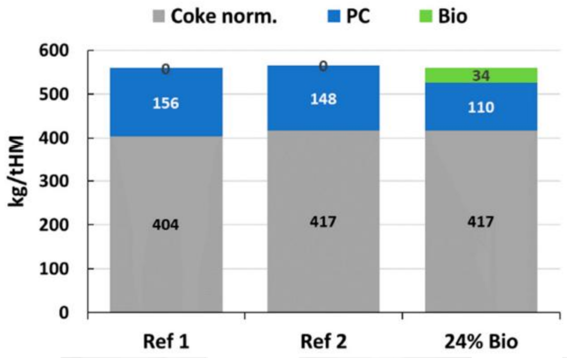


Injection of bio-coals – EBF trials

- Pilot test in the Experimental blast furnace (EBF) with torrefied material of bio-coal
  - ✓ The gas efficiency was somewhat higher during the test period with biocoal
  - ✓ In comparison to the reference periods, the fossil CO_2 emissions could be reduced compared with an average of approximately 8% in the two reference periods



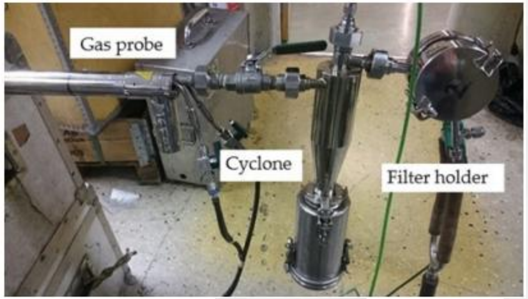




EU RFCS project: IMPCO

Bio-coal for lowering fossil greenhouse gas emissions from the blast furnace

- Practically demonstrate the potential of industrial use of biomass (**charcoal** and **TS**), consisting of renewable energy, in Swedish blast furnaces to reduce fossil CO_2 emissions from the process in the short term.
- Full scale trials with charcoal in SSAB BF No. 4 in Oxelösund with coal injection through **one tuyere**.
- Injection of up to 10% of charcoal (CC) with PC can be safely achieved without negative impacts on PC injection plant or BF operational conditions and **without losses of CC with the dust**.



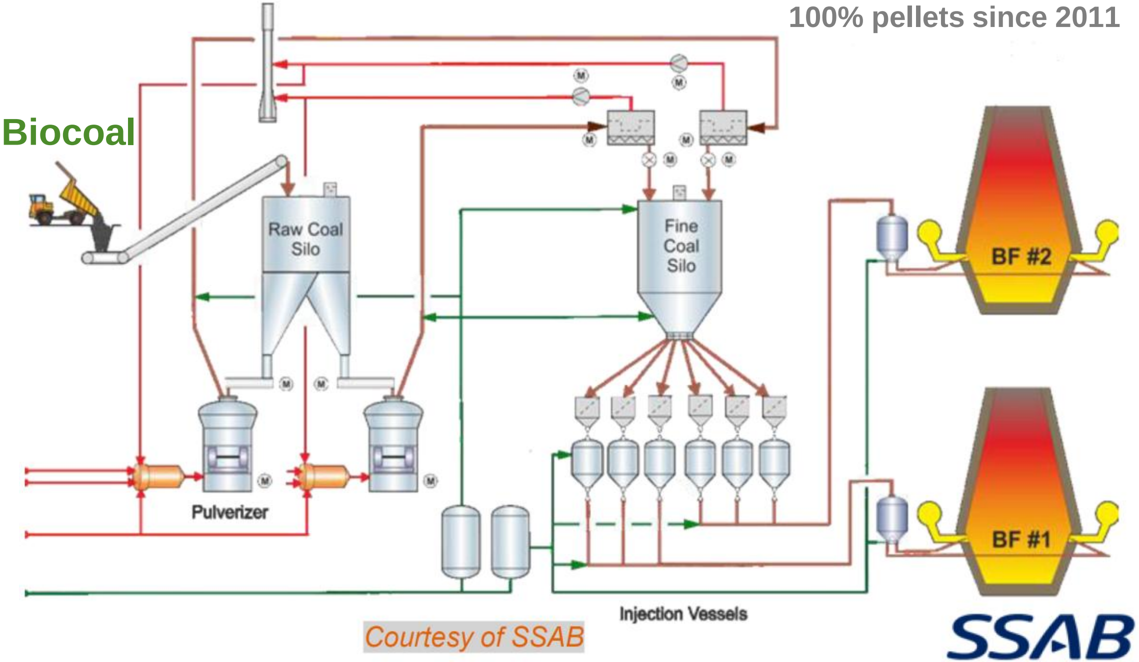
Energimyndigheten project: Bio4BF

Biocoal injection at SSAB Raahe

SWERIM

Hearth diameter: 8.0 m
Working volume: 1220 m^3
Tuyere: 21
100% pellets since 2011

- System designed for fossil coal
- The most straightforward option would be to utilized existing system also for biocoal
- Successful 9-days trial run by SSAB Raahe Steelworks to replace 10% of PCI in August 2019
- Lower need of limestone due to low ash and low S content in biocoal
- Up to 20% could be possible with the current technical solutions



SSAB

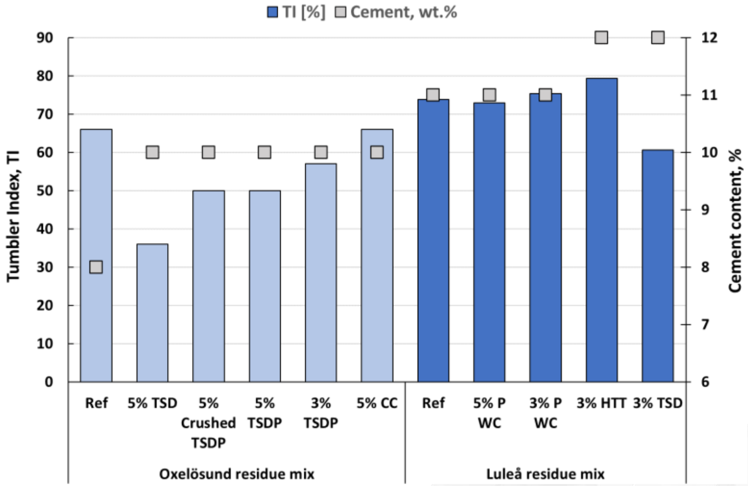
Juha Hakala, et al. IEA Bioenergy ExCo86 workshop October 20 , 2020

Trials with sawdust pellets CBBs

SWERIM

Industrial trials at SSAB Öxelsöund

1.8% of torrefied sawdust (TS) pellets and 12% cement, November 2019



- Improved gas utilization
- Lowering of thermal reserve zone temperature by 45 ºC with 55% bio-briquette addition reduced the C-consumption with ~ 9-11 kg/tHM
- Compared to the reference period, no negative effects were noticed regarding the hot metal analysis, slag and dust analysis.

Swedish energy agency (energimyndigheten) project: Bio-agglomerate

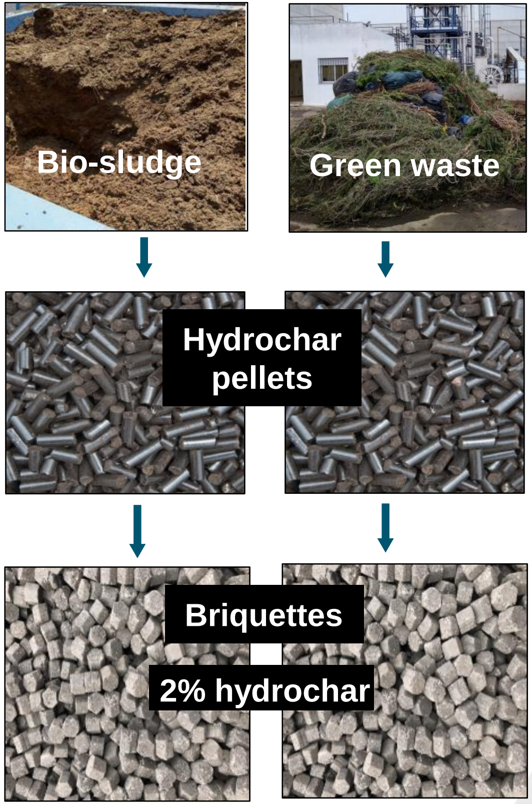
Industrial trials in BF at SSAB

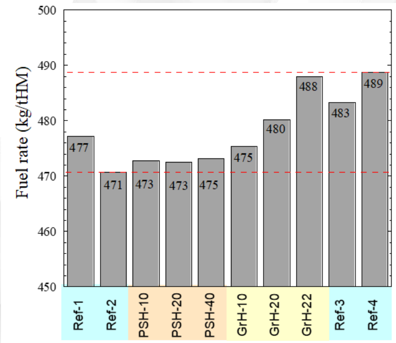
SWERIM

Hydrochar containing cold bonded briquettes (CBBs) 418 ton were top-charged into BF, January-February, 2020.

- No negative effects were noticed regarding the hot metal analysis, slag analysis and their properties, carbon and sulfur content in dust and sludge.

- The trials with hydrochar from paper sludge showed a slightly better results than green waste.

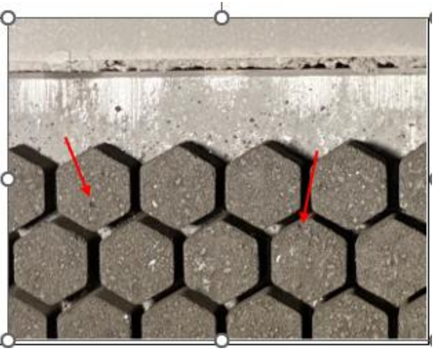


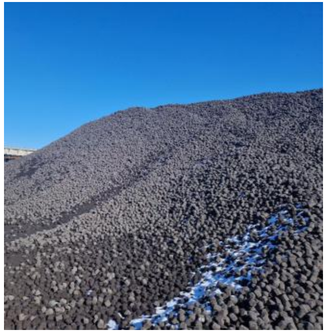


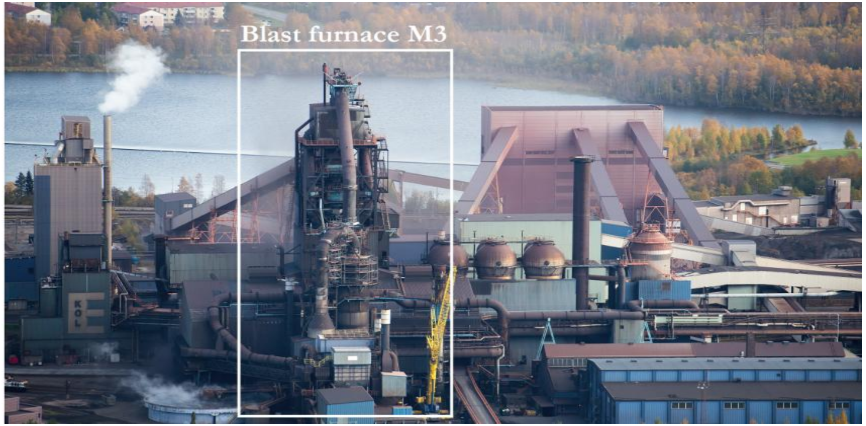
Vinnova project: OSMET 2.0

Industrial Scale CCBs trials at BDX/SSAB

SWERIM







- Full-scale tests, but then with a higher admixture of biochar from 1.8% to 12%.
- 5500 tons of biochar CBBs were produced and top charged in the BF at Luleå.

Energimyndigheten project: MICO

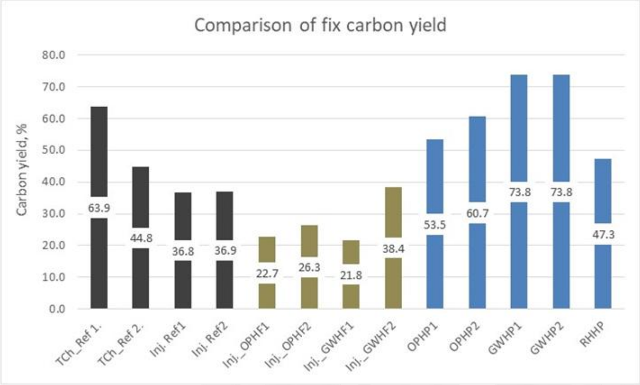
EAF - Carburization test at Swerim

SWERIM

EAF trials in Swerim's test bed were performed in Week 50, 2021 to investigate the use of various types of hydrochar as carburizers to replace anthracite.

EAF injection charge

EAF top charge



Carbon yield/carburization

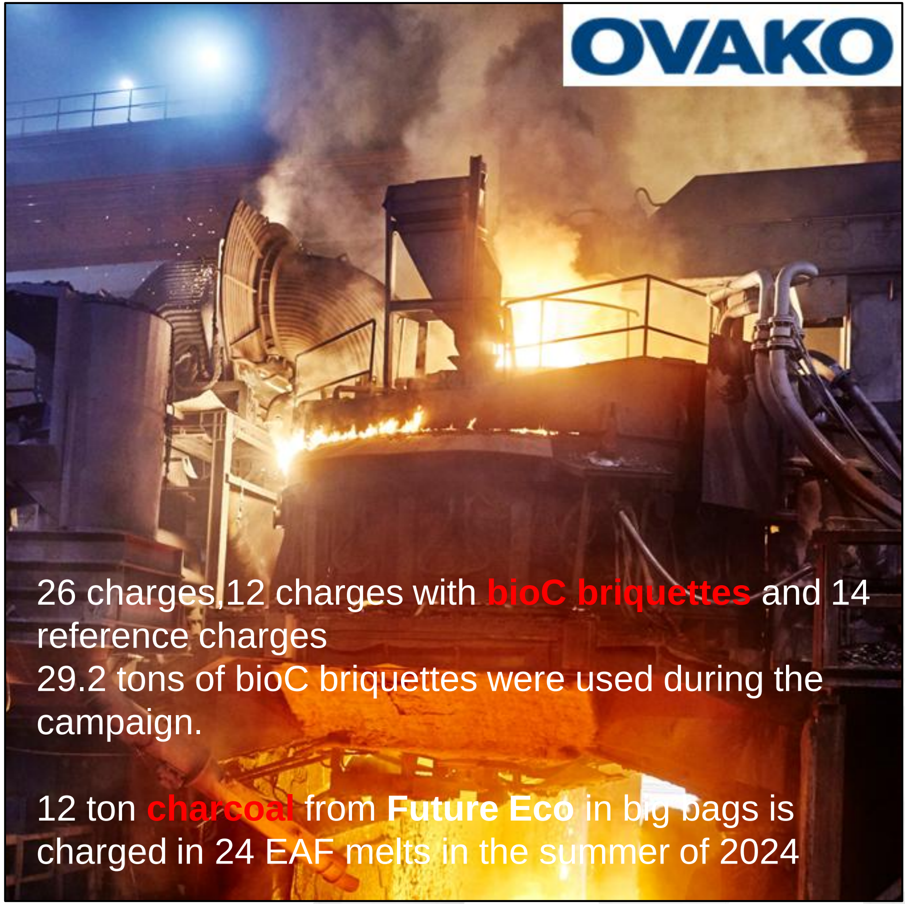
BioChargeEAF project

SWERIM

Components	Biocarbon	Mill scale	Lignin	FP-P (liquid lignin)	Lime	water
	wt.%					
Ratio	40.1	26.7	15.0	13.4	0.5	4.3

Component	Total C	VM	Ash/oxides	Moisture	S	H	O	N	Cl
wt.%	50	30.8	40.3	4.1	1.5	2.2	5.9	<0.11	<0.01

Aska/ Ash	Al	P	Fe	Ca	Mg	Si	K	Na	Mn	Ti	Co	Cu	Cr	Mo	Ni	V	Zn
Wt. %	0.53	0.033	51	3.4	0.61	1.8	0.46	0.42	0.37	0.023	0.008	0.072	0.46	0.08	0.23	0.016	0.01



26 charges, 12 charges with bioC briquettes and 14 reference charges
29.2 tons of bioC briquettes were used during the campaign.

12 ton charcoal from **Future Eco** in big bags is charged in 24 EAF melts in the summer of 2024

EAF industrial trials with at Uddeholm

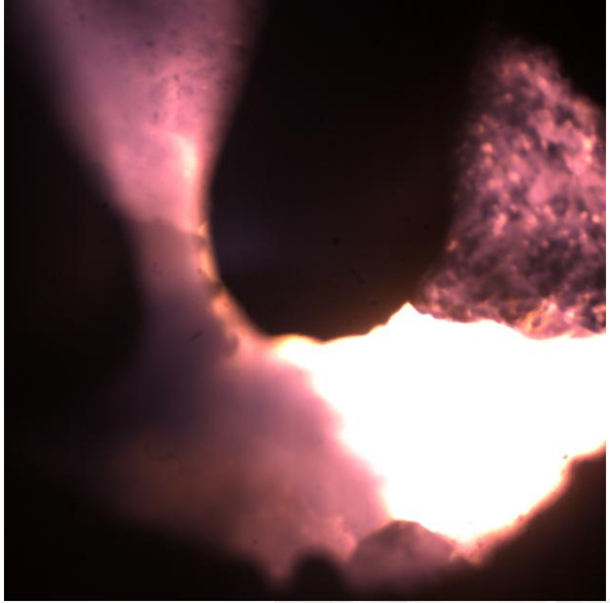
SWERIM

Uddeholm trial 1: 3 ton charcoal from **Envigas** in big bags is charged in 7 EAF melts in November and December 2023.

Uddeholm trial 2: 2.4 ton charcoal from **Future Eco** in big bags is charged in 7 EAF melts in February 2024

4 reference charges with petcoke for comparison.

Cupola furnace injection



- Hydrochar injection at Volvo Power Truck, Skövde, Sweden
- 1600 kg injection through one tuyere in May, 2019

Vinnova project: OSMET 2.0

Cupola furnace top charging

Bio-briquettes developed:

- Dimensions: Ø 80-150 mm, H= 50-150 mm
- C-content: 50 – 70 %
- S-content: 0.2 - 0.35 %
- CCS: up to 14 MPa
- Density: up to 1.000 kg/m³
- Abrasive losses: < 4.5 %

In 2020 - 2022 over 50 pc. different test series with durations 6-120 hours using a total amount of about 800 ton of testing material were carried out at 13 different cupola plants all over europe:

- Hot- and cold-blast cupola furnaces
- Nominal melting rates 6-75 t/h
- Dry and wet gas cleaning systems
- GJL and GJS products
- Automotive parts and other castings (e.g. tubes etc.)

Source: Dipl.-Ing. F. Wondra, Herp Gießereitechnik GmbH

Bio4SAF

Energimyndigheten

SWERIM

Bio4SAF

Energimyndigheten SWERIM

Pre-trials
Week 39-40 2023

Scale up from lab scale to industrial scale

- 24 recipes with biocarbon

Evaluation of briq:

- Mechanical strength
- Hot strength

Large-scale briq
Week 50 2023

Briquettes 360t = 36t biocarbon

- Dust to silo

Evaluation of briquttes

- Drop test
- Tumbler index

Furnace campagin
Week 5&6 2024

Week 5

- Charge REF Briquette

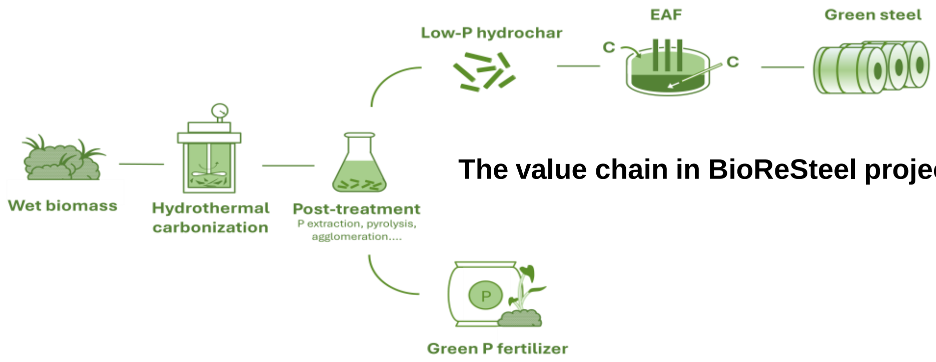
Week 6 & 7

- Charge Bio briq
- Charge REF briq

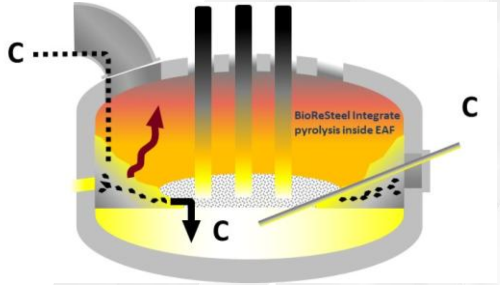
Ongoing BioReSteel prroject

Objective: to replace fossil carbon in the electric arc furnace (EAF) by biocoal, produced from low-value locally available wet biomass residues by means of a hydrothermal carbonization (HTC) process.

Methodology: The BioReSteel concept will be proved by the means of laboratory and EAF testbed trials. Furthermore, the industrial EAF trials will be performed at three EAF plants to test hydrochar injection, hydrochar top charging and bio-oxides agglomerates in order to prove the concept's flexibility and generality.



The value chain in BioReSteel project



Functions: **heating; carburization; reductant; slag foaming**

EU RFCS: **BioReSteel**

Industrial trials at EAF steel plants

EAF (150 ton), PITTINI, Italy

Top charging of hydrochar as slag foaming agent and fuel to reduce natural gas and anthracite assumption.

EAF (85 ton), ORI Martin, Italy

Top charging of bio- agglomerates (made of hydrochar and iron oxides) for the function tests of carburizing agent and reductant.

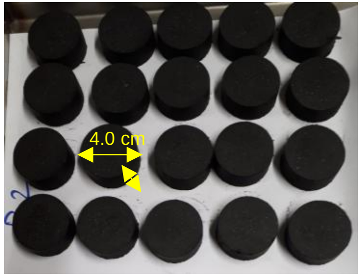
EAF (150 ton), CELSA, Spain

Injection trials for hydrochar at different blending ratio with anthracite for slag foaming and fuel.

Briquetting at lab scale

manual piston press

semi-automatic piston press

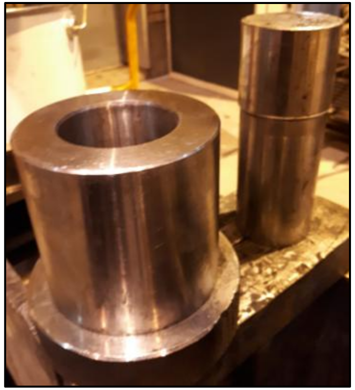


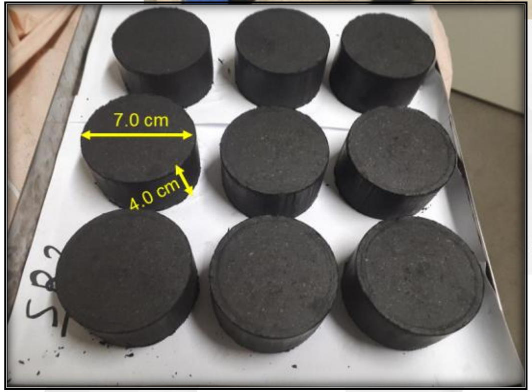
2.0 cm

Ø 20 mm

Ø 40 mm

Ø 70 mm





Briquetting at technical and pilot scale

Pilot scale briquetting

Roller press

Pillow shape: 40 x 30 x 20 mm

Vibro press

Hexagonal shape briquettes

Summary

- Many projects on using biocarbon in metallurgical applications.
- Biocarbon (different types) has been tested in BF via tuyeres injection and top charging in the form of CCBs.
- The current work about EAF industrial pilots has been focusing on topcharging of biocarbon as carburizing agents, and in the future other functions of heating, reductants and slag foaming agent will be also tested.
- Research interests in other metallurgial processes, for instance, SAF, DR, etc. have been increasing.
- Woody biomass to organic waste to produce biocarbon (e.g. hydrochar) in the view of economic feasiblity and sustainabilty.

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