CHALMERS

Industrial Symbiosis
MATCHMAKING TUTORIAL

Leonardo Rosado and João Patrício
6th of March 2020

Supported by Circu-Mat project from European Institute of Innovation & Tecnhology - Raw Materials KIC

Select development objectives

What are the needs and priorities of your region?

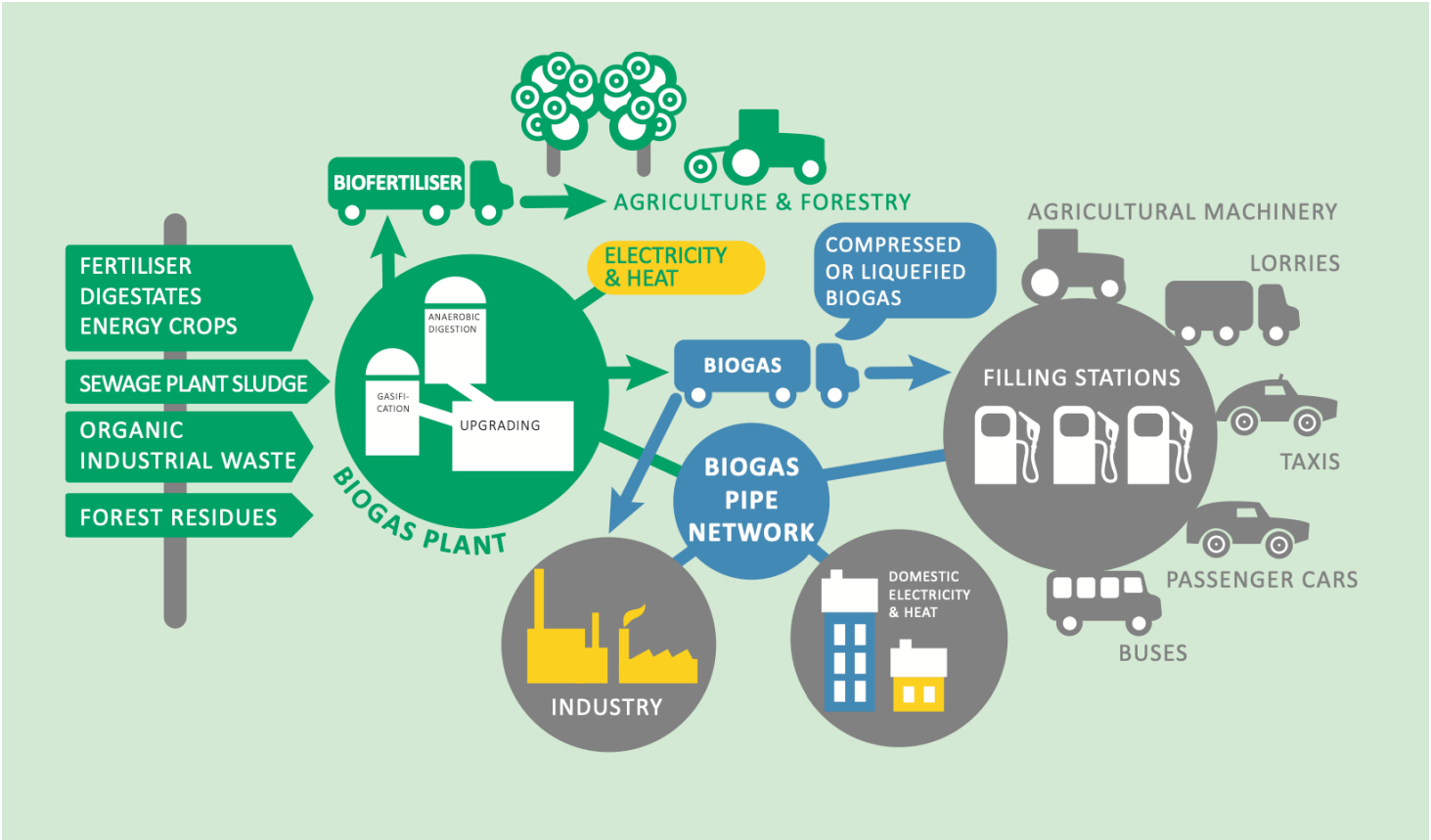
PROCEDURE

The development priorities are based on the needs and opportunities of the studied region. These priorities determine which waste types are to be studied.

Identify a need or priority of the region from strategic documents (planning, policies) that could benefit from Industrial Symbiosis schemes.

Select development objectives

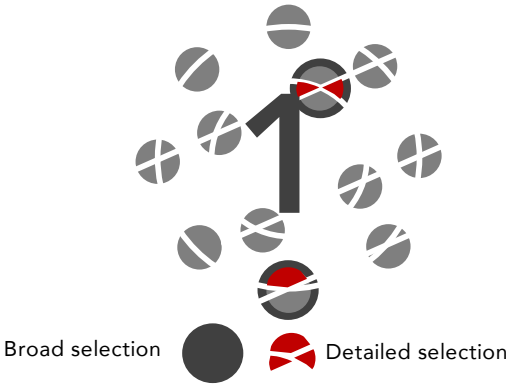
What are the needs and priorities of your region?



Västra Götaland region set the target of raising biogas production to 2 TWh by 2020, from the current production of 0.329 TWh

Identification and selection of target wastes

Which wastes have more potential to support my needs/priorities?

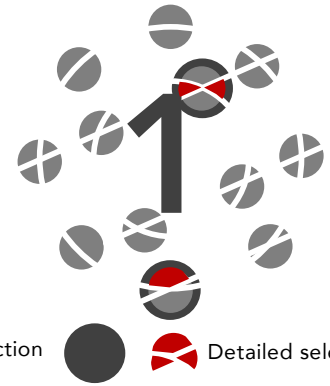


PROCEDURE

This step identifies the corresponding categories from the EWC12 and EWC42 nomenclatures for the wastes selected according to the development priorities. The identification is made by comparing the development priorities with the descriptions of the EWC12 and EWC42 categories. As an example, if metallic waste has been selected as the waste type, the EWC12 category '06 Metallic Wastes' should be selected.

Identification and selection of target wastes

Which wastes have more potential to support my needs/priorities?

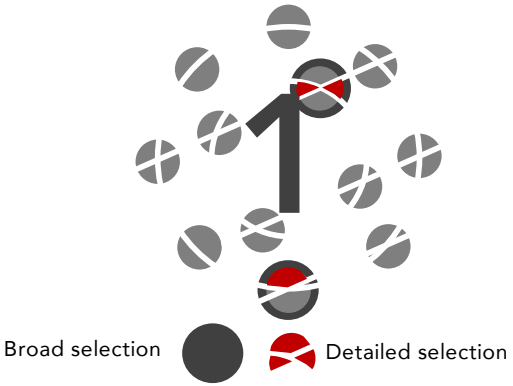


EWC 12
01 Chemical compound wastes
02 Chemical preparation wastes
03 Other chemical wastes
05 Health care and biological wastes
06 Metallic wastes
07 Non-metallic wastes
08 Discarded equipment
09 Animal and vegetal wastes
10 Mixed ordinary wastes
11 Common sludges
12 Mineral wastes
13 Solidified, stabilised or vitrified waste

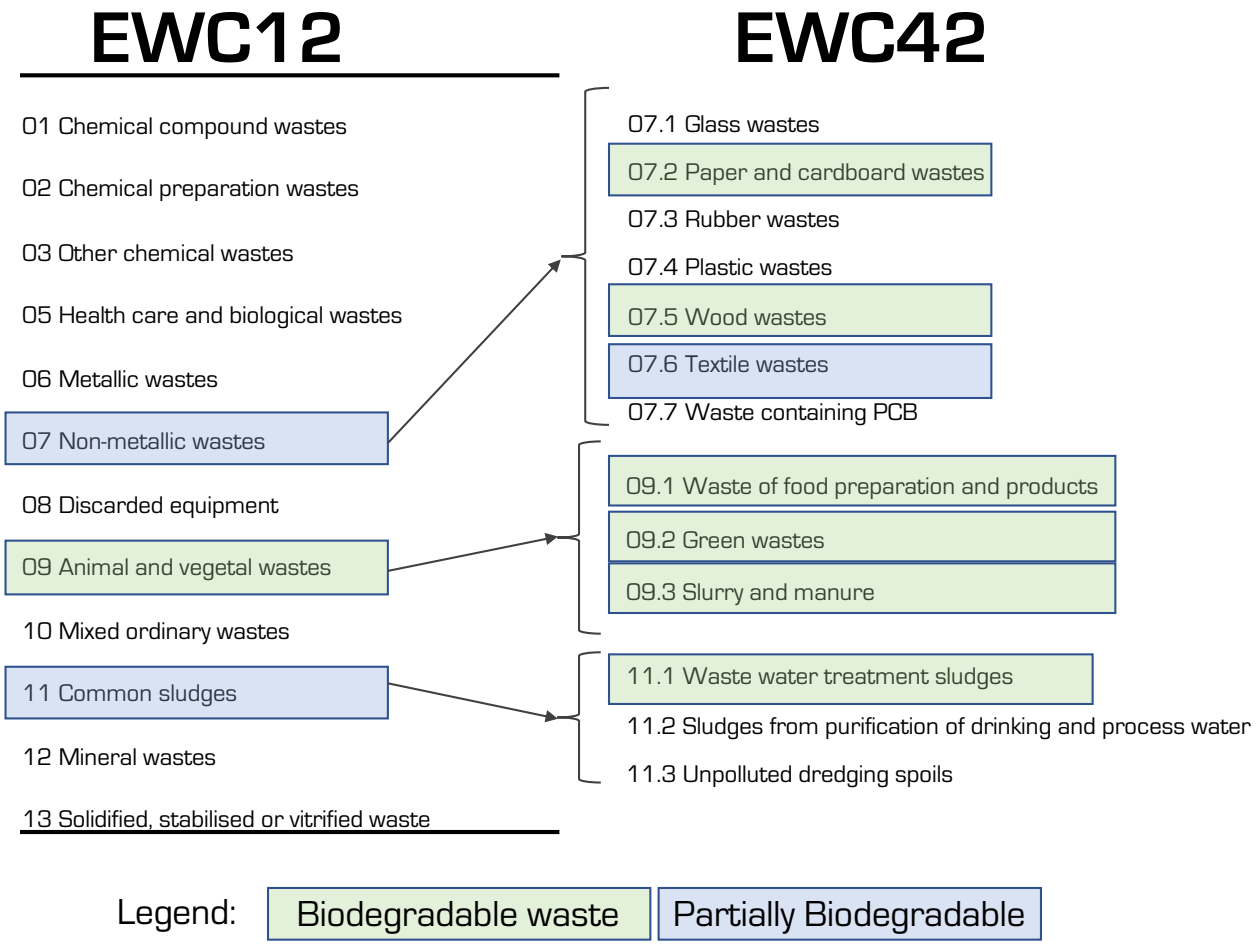
EWC 42
01.1 Spent solvents
01.2 Acid, alkaline or saline wastes
01.3 Used oils
01.4 Spent chemical catalysts
02.1 Off-specification chemical wastes
02.2 Unused explosives
02.3 Mixed chemical wastes
03.1 Chemical deposits and residues
03.2 Industrial effluent sludges
05.1 Infectious health care wastes
05.2 Non-infectious health care wastes
06.1 Ferrous metal waste and scrap
06.2 Non-ferrous metal waste and scrap
06.3 Mixed metal wastes
07.1 Glass wastes
07.2 Paper and cardboard wastes
07.3 Rubber wastes
07.4 Plastic wastes
07.5 Wood wastes
07.6 Textile wastes
07.7 Waste containing PCB
08.1 Discarded vehicles
08.2 Discarded electrical and electronic equipment
08.4 Discarded machines and equipment components
09.1 Waste of food preparation and products
09.2 Green wastes
09.3 Slurry and manure
10.1 Household and similar wastes
10.2 Mixed and undifferentiated materials
10.3 Sorting residues
11.1 Waste water treatment sludges
11.2 Sludges from purification of drinking and process water
11.3 Unpolluted dredging spoils
11.4 Cesspit contents
12.1 Construction and demolition wastes
12.2 Asbestos wastes
12.3 Waste of naturally occurring minerals
12.4 Combustion wastes
12.5 Various mineral wastes
12.6 Contaminated soils and polluted dredging spoils
13.1 Solidified or stabilised waste
13.2 Vitrified wastes

Identification and selection of target wastes

Which wastes have more potential to support my needs/priorities?



Example for Biogas production using biodegradable waste



Characterization and selection of economic sectors
Which sectors produce larger percentage of selected wastes?

PROCEDURE

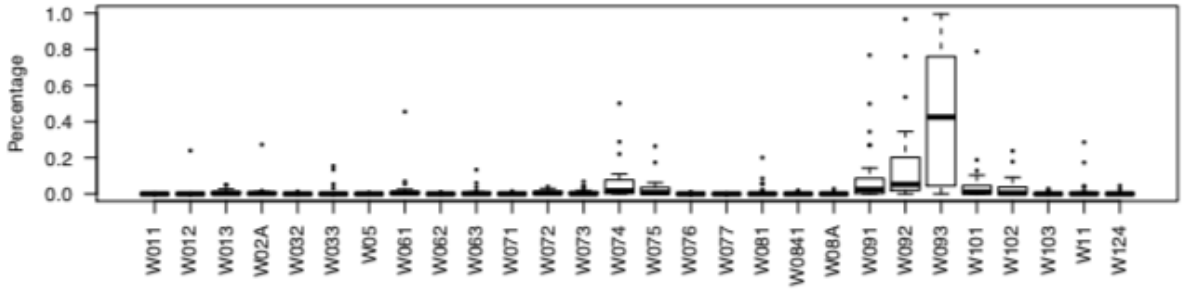
Sectors generating relevant waste categories are selected by filtering the waste generation profiles database for sectors by the EWC12 and then by the EWC42 categories that were selected in Step 1.

Sectors with the highest Sector Waste Ratios (SWR) for the relevant EWC categories are selected for further study. Figures in next slides shows the quantified waste generation profiles as the SWR expected for the EWC42 waste types, in shares per ton of the waste generated by each sector.

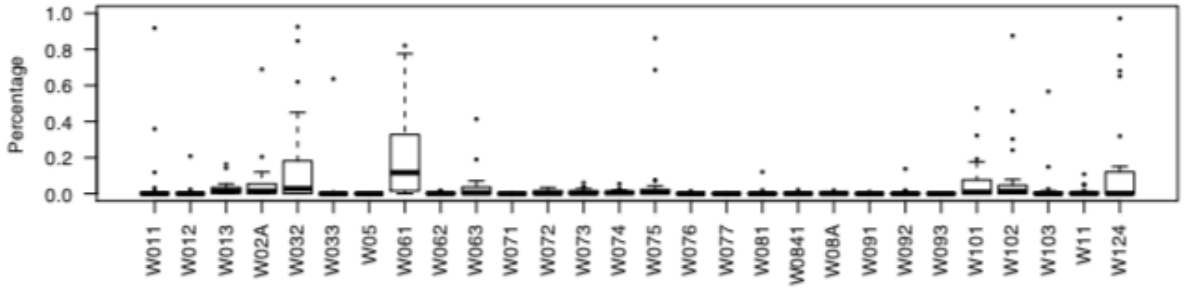
EXCEL FILE: Waste Ratios in Europe EWC42.xlsx

Characterization and selection of economic sectors
Which sectors produce larger percentage of selected wastes?

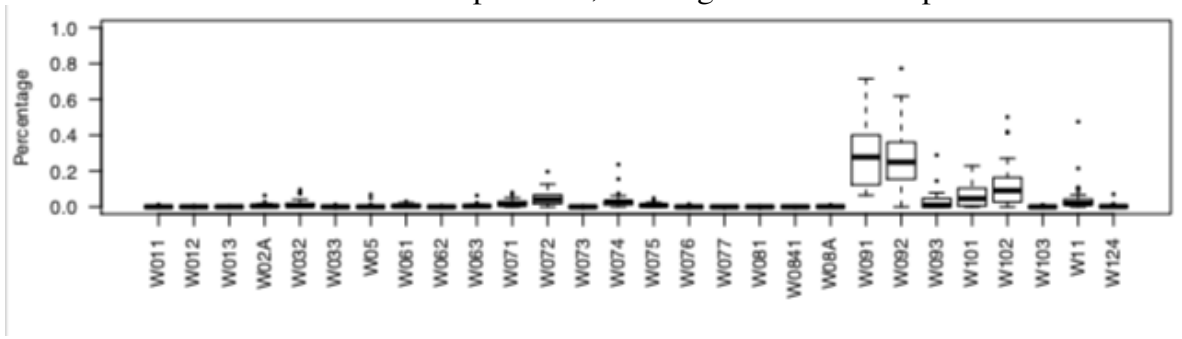
Agriculture, forestry and fishing



Mining and quarrying



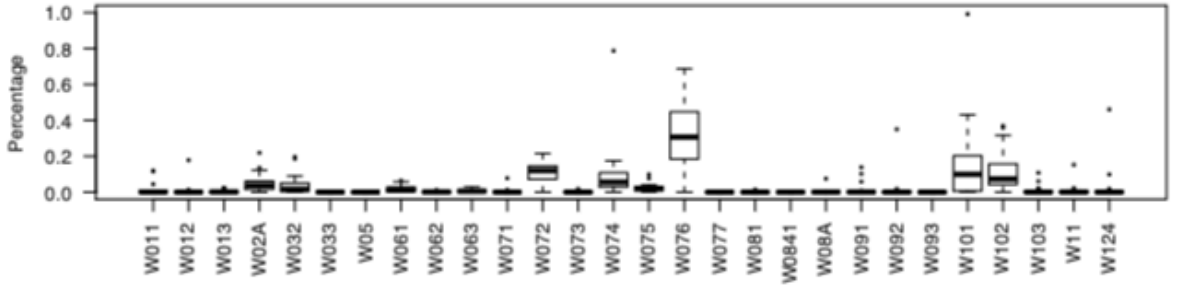
Manufacture of food products; beverages and tobacco products



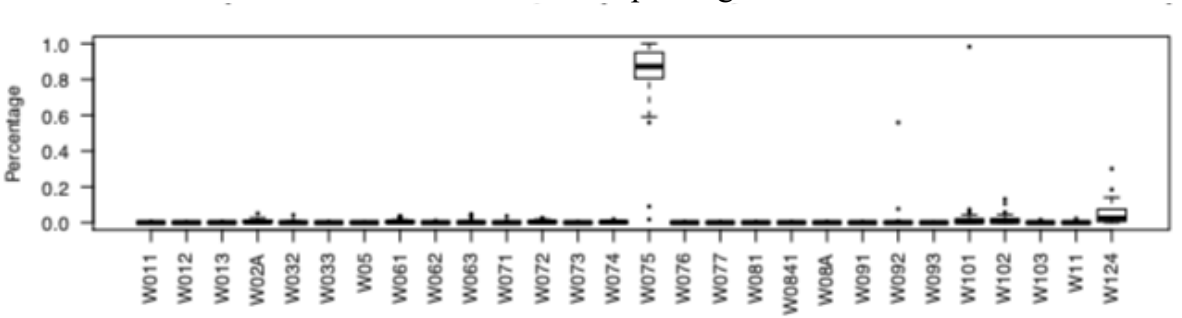
Economic Sectors and waste types produced (EWC42)

Characterization and selection of economic sectors
Which sectors produce larger percentage of selected wastes?

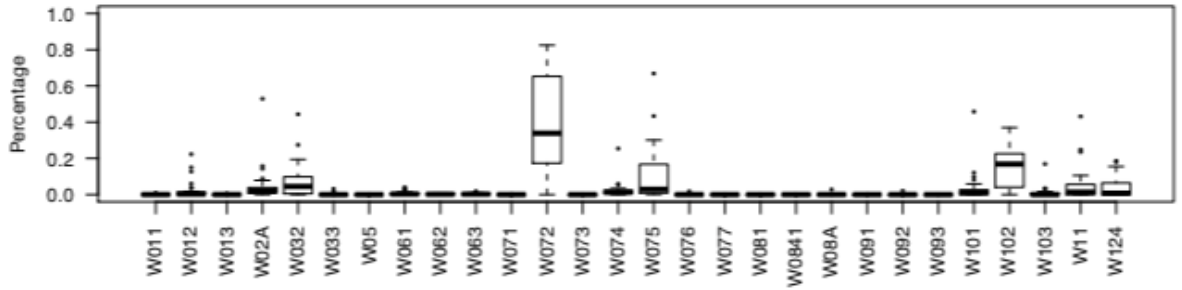
Manufacture of textiles, wearing apparel, leather and related products



Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials



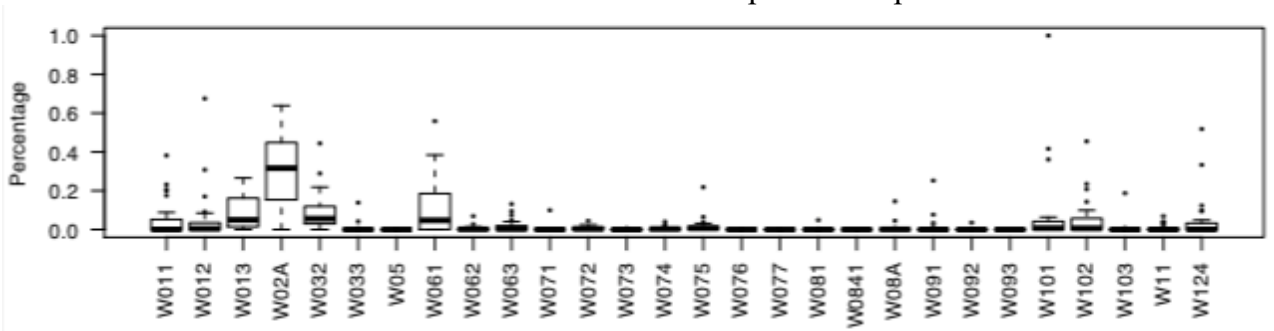
Manufacture of paper and paper products; printing and reproduction of recorded media



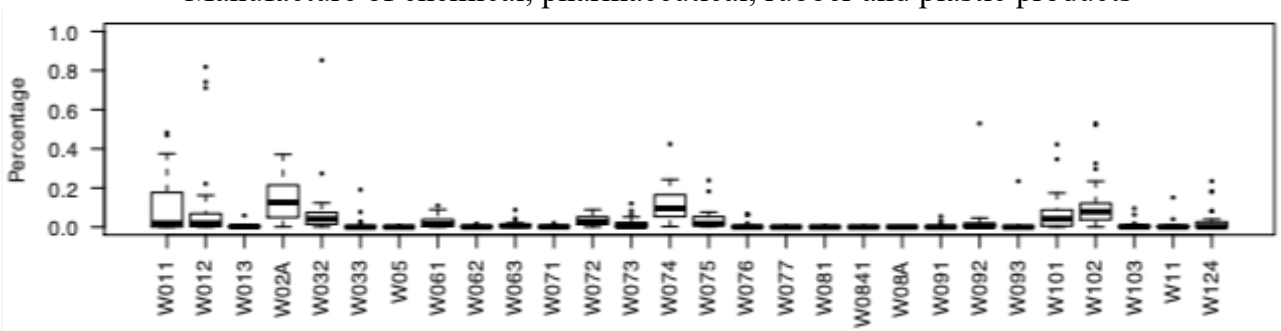
Economic Sectors and waste types produced (EWC42)

Characterization and selection of economic sectors
Which sectors produce larger percentage of selected wastes?

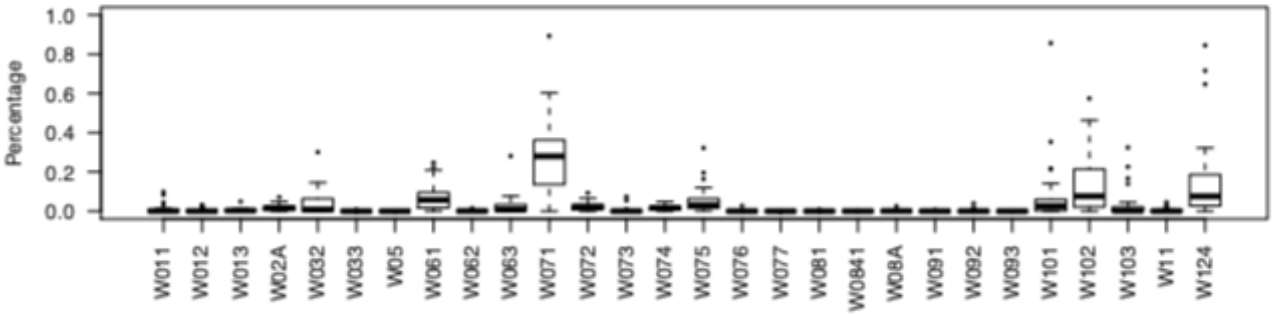
Manufacture of coke and refined petroleum products



Manufacture of chemical, pharmaceutical, rubber and plastic products



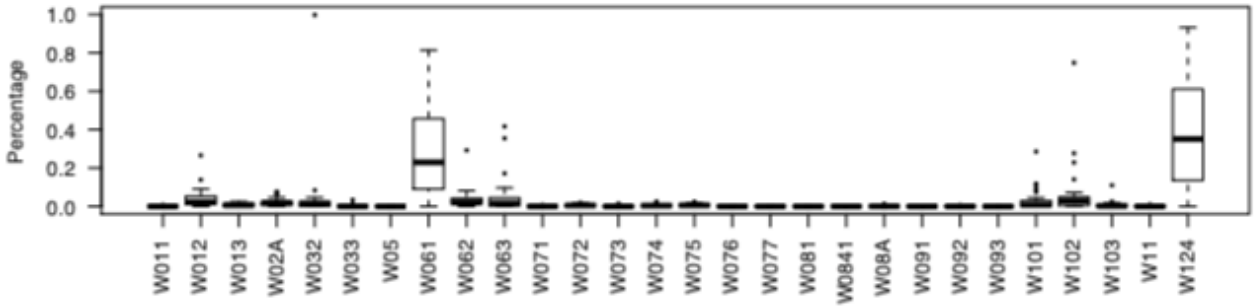
Manufacture of other non-metallic mineral products



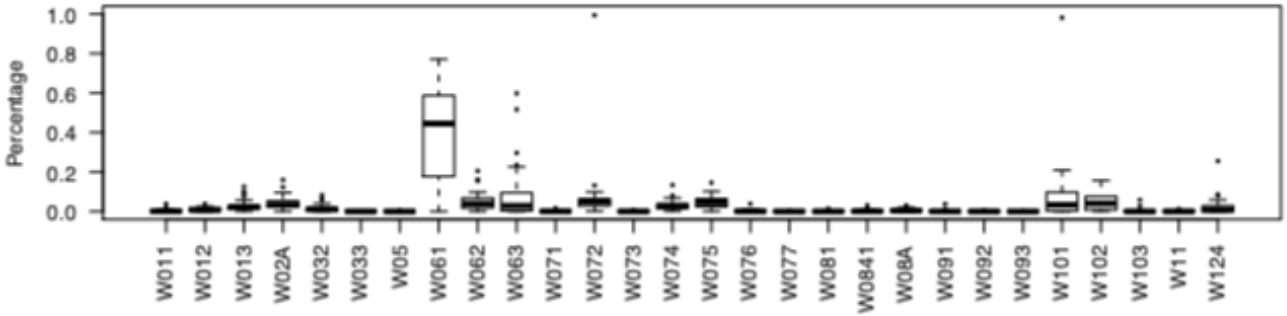
Economic Sectors and waste types produced (EWC42)

Characterization and selection of economic sectors
Which sectors produce larger percentage of selected wastes?

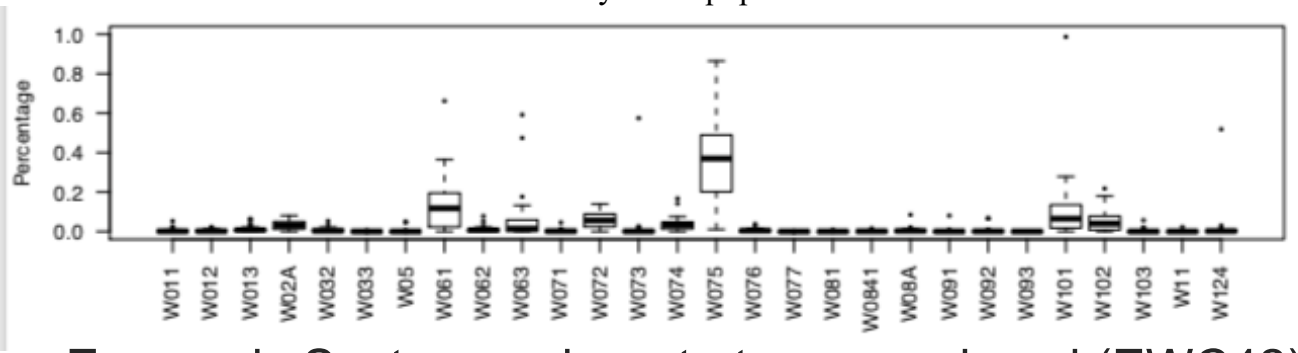
Manufacture of basic metals and fabricated metal products, except machinery and equipment



Manufacture of computer, electronic and optical products, electrical equipment, motor vehicles and other transport equipment



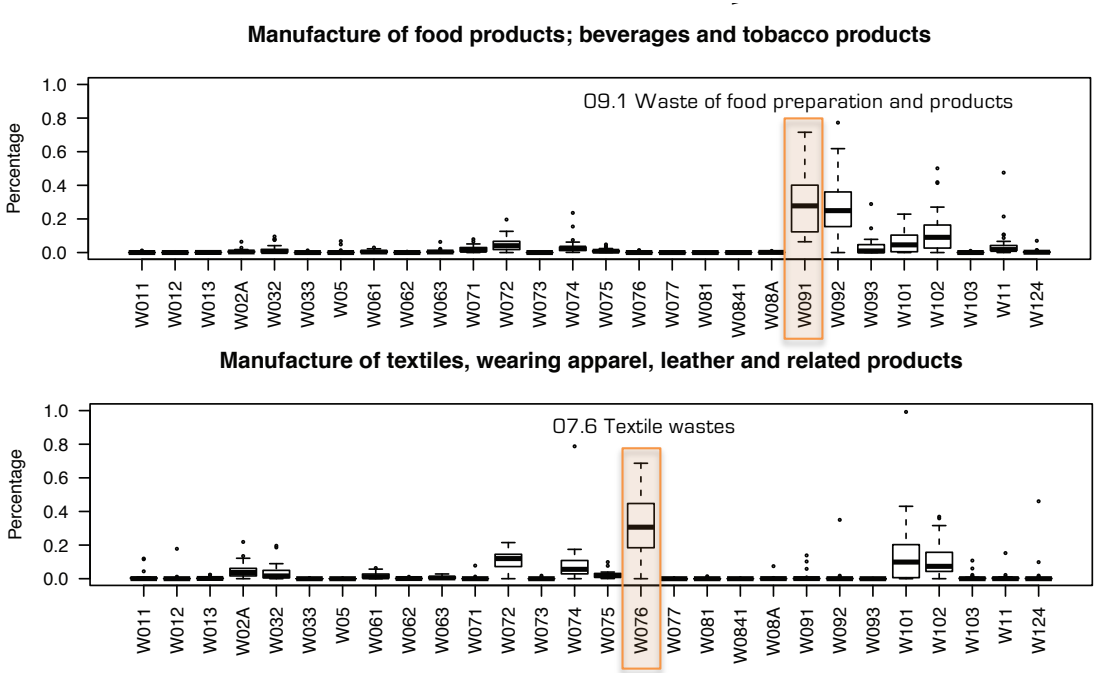
Manufacture of furniture; jewellery, musical instruments, toys; repair and installation of machinery and equipment



Economic Sectors and waste types produced (EWC42)

Characterization and selection of economic sectors
Which sectors produce larger percentage of selected wastes?

Example for Biogas production



Detailed description of industries waste generation

Which specific industries within the identified general sector should I focus?

PROCEDURE

Industries within the selected sectors are studied further. In the developed waste generation profiles database for industries, industries' waste generation profiles are quantified by their shares of EWC42 categories wastes.

Use the Danish database for wastes produced
https://www.statbank.dk/statbank5a/default.asp?w=2021

For the data follow the following trajectory.
Geography, environment and energy
Environmental-Economic Accounts
Material flows and waste

Detailed description of industries waste generation

Which specific industries within the identified general sector should I focus?

https://www.statbank.dk/statbank5a/default.asp?w=2021

DST.DK | LOG ON | DANSK | HELP

STATISTICS DENMARK

SEARCH

StatBank Denmark

SUBJECTS

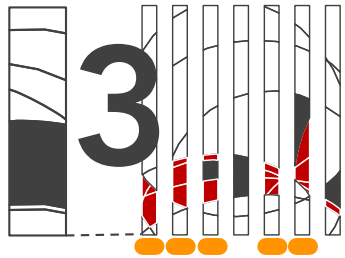
- Population and elections
- Living conditions
- Education and knowledge
- Culture and National Church
- Labour, income and wealth
- Prices and consumption
- National accounts and government finances
- Money and credit market
- External economy
- Business sector in general
- Business sectors

Geography, environment and energy

GEOGRAPHY, ENVIRONMENT AND ENERGY

show all...

- Area
- Infrastructure
- Environment and energy
- Environmental-Economic Accounts
  - Energy and air emissions
  - Water and waste water
  - Material flows and waste
    - Economy Wide-Material Flow Accounts
      - MRM2 Economy-wide material flow accounts by material type and indicator (1993-2018)
      - RME1 Material flows converted to raw material equivalents by type of raw material and indicator (2008-2016)
      - RME2 Raw material equivalents by type of raw material, imports and exports and goods and services (2008-2016)
    - Waste Accounts
      - AFFALD Waste generation by industry, kind of treatment and waste category (2011-2017)
      - AFFALD01 Waste generation by industry and waste category (2011-2017) SELECT THIS DATABASE
      - AFFALD02 Waste generation by industry and kind of treatment (2011-2017)
      - AFFALD03 Waste generation by industry and hazardousness (2011-2017)
      - AFFALD04 Im- and exports of waste by waste category, kind of treatment and imports and exports (2011-2017)
    - Waste multipliers
      - AFF1MU1 Direct and indirect generation of waste by industry and waste category (2011-2017)
      - AFF1MU2 Direct and indirect generation of waste by final demand and waste category (2011-2017)
      - AFF1MU3 Generation of waste caused by final demand by industry and waste category (2011-2017)
      - AFF2MU1 Direct and indirect generation of waste by industry and kind of treatment (2011-2017)
      - AFF2MU2 Direct and indirect generation of waste by final demand and kind of treatment (2011-2017)
      - AFF2MU3 Generation of waste caused by final demand, by industry and kind of treatment (2011-2017)
      - AFF3MU1 Direct and indirect generation of waste by industry and hazardousness (2011-2017)
      - AFF3MU2 Direct and indirect generation of waste by final demand and hazardousness (2011-2017)
      - AFF3MU3 Generation of waste caused by final demand, by industry and hazardousness (2011-2017)
    - *Archive*
  - Green economy
  - Natural resources



Selected detailed wastes

Selected industries

Detailed description of industries waste generation

Which specific industries within the identified general sector should I focus?

PROCEDURE

Find the general industries you selected previously in the database, and compare how much waste is generated by the industries that belong to selected categories. This will allow selecting specific industries.

			2011	2012	2013	2014	2015
Total waste (incl. soil)	V	Total	11198224	11500043	13327782	14258584	12856636
MIXED MUNICIPAL WASTE AND SIMILAR	V01000	01000 Agriculture and horticulture	1064	2502	1559	1694	2176
Biodegradable waste	V	Total	226254	257191	242259	224817	230977
Biodegradable waste	VA	A Agriculture, forestry and fishing	12168	13115	4282	4529	5116
Biodegradable waste	V01000	01000 Agriculture and horticulture	11429	11652	2200	2418	3664
Biodegradable waste	V010000	010000 Agriculture and horticulture	11429	11652	2200	2418	3664
Biodegradable waste	V02000	02000 Forestry	637	734	394	269	347
Biodegradable waste	V020000	020000 Forestry	637	734	394	269	347
Biodegradable waste	V03000	03000 Fishing	102	729	1688	1842	1105
Biodegradable waste	V030000	030000 Fishing	102	729	1688	1842	1105
Biodegradable waste	VB	B Mining and quarrying	0	1	81	63	61
Biodegradable waste	V06090	06090 Mining and quarrying	0	1	81	63	61
Biodegradable waste	V060000	060000 Extraction of oil and gas	0	0	0	0	0
Biodegradable waste	V080090	080090 Extraction of gravel and stone	0	1	4	0	2
Biodegradable waste	V090000	090000 Mining support service activities	0	0	77	63	59
Biodegradable waste	VC	C Manufacturing	175211	207098	185506	153040	145260
Biodegradable waste	VCA	CA Manufacture of food products, beverages and tob	161831	199997	177206	144578	138133
Biodegradable waste	V10120	10120 Manufacture of food products, beverages and	161831	199997	177206	144578	138133
Biodegradable waste	V100010	100010 Production of meat and meat products	60186	114046	60754	66230	80627
Biodegradable waste	V100020	100020 Processing and preserving of fish	7095	4622	6363	6630	401
Biodegradable waste	V100030	100030 Manufacture of dairy products	80795	61964	78183	18567	26956
Biodegradable waste	V100040	100040 Manufacture of grain mill and bakery produc	955	4146	14983	37918	15554
Biodegradable waste	V100050	100050 Other manufacture of food products	12731	14152	15032	11470	11851
Biodegradable waste	V110000	110000 Manufacture of beverages	69	1067	1891	3763	2744
Biodegradable waste	V120000	120000 Manufacture of tobacco products	0	0	0	0	0
Biodegradable waste	VCB	CB Textiles and leather products	11448	177	13	7	9
Biodegradable waste	V13150	13150 Textiles and leather products	11448	177	13	7	9
Biodegradable waste	V130000	130000 Manufacture of textiles	92	5	7	6	4
Biodegradable waste	V140000	140000 Manufacture of wearing apparel	0	0	1	1	1
Biodegradable waste	V150000	150000 Manufacture of leather and footwear	11356	172	5	0	4
Biodegradable waste	VCC	CC Wood and paper products and printing	134	35	60	84	81
Biodegradable waste	V16000	16000 Manufacture of wood and wood products	15	13	28	19	22
Biodegradable waste	V160000	160000 Manufacture of wood and wood products	15	13	28	19	22
Biodegradable waste	V17000	17000 Manufacture of paper and paper products	87	1	17	56	52
Biodegradable waste	V170000	170000 Manufacture of paper and paper products	87	1	17	56	52

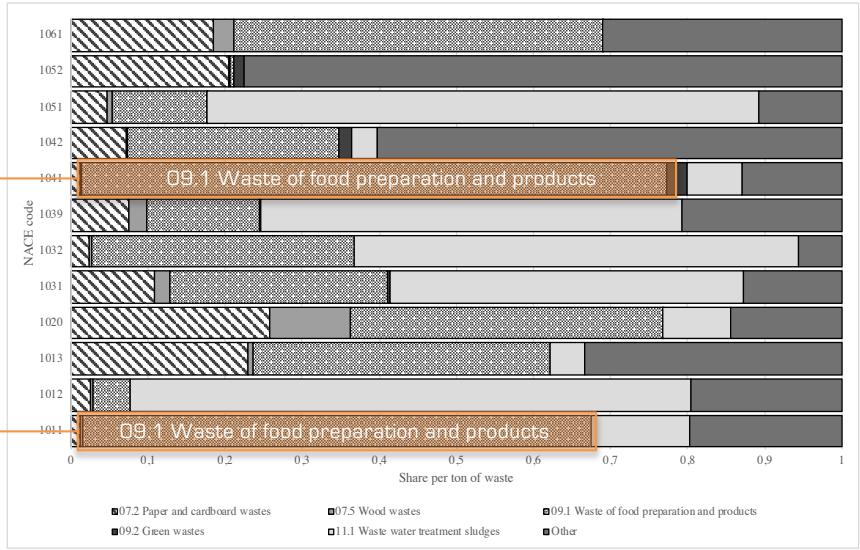
Detailed description of industries waste generation

Which specific industries within the identified general sector should I focus?

Food processing sector

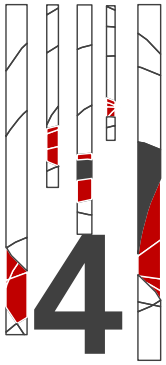
10111	Livestock slaughtering
10112	Processing and preserving of meat in cuts
10120	Processing and preserving of poultry meat
10130	Production of meat and poultry meat products
10200	Processing and preserving of fish, crustaceans and molluscs
10310	Processing and preserving of potatoes
10320	Manufacture of fruit and vegetable juice
10390	Other processing and preserving of fruit and vegetables
10410	Manufacture of oils and fats
10420	Manufacture of margarine and similar edible fats
10511	Cheese production
10519	Other dairy production
10520	Manufacture of ice cream
10611	Production of flour
10612	Manufacture of breakfast cereals, blended flour mixes and other prepared grain mill products
10620	Manufacture of starches and starch products
10710	Manufacture of bread; manufacture of fresh pastry goods and cakes
10721	Manufacture of crispbread
10722	Manufacture of rusks, biscuits and preserved pastry goods and cakes
10730	Manufacture of macaroni, noodles, couscous and similar farinaceous products
10810	Manufacture of sugar
10821	Manufacture of sugar confectionery
10822	Manufacture of cocoa and chocolate confectionery
10830	Processing of tea and coffee
10840	Manufacture of condiments and seasonings
10850	Manufacture of prepared meals and dishes
10860	Manufacture of homogenised food preparations and dietetic food
10890	Manufacture of other food products n.e.c.
10910	Manufacture of prepared feeds for farm animals

Example for Biogas production



Waste generation intensity

How much waste is produced in the industrial sites?



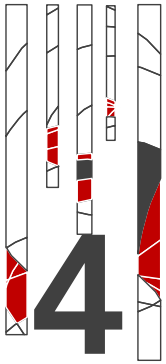
PROCEDURE

The Waste Factor per employee (WF) is used to estimate the amount of waste produced by a sector in a given region, or by an individual company within the sector. Equations shows the expected WF factors for the total waste generated per sector, based on data for 28 EU countries.

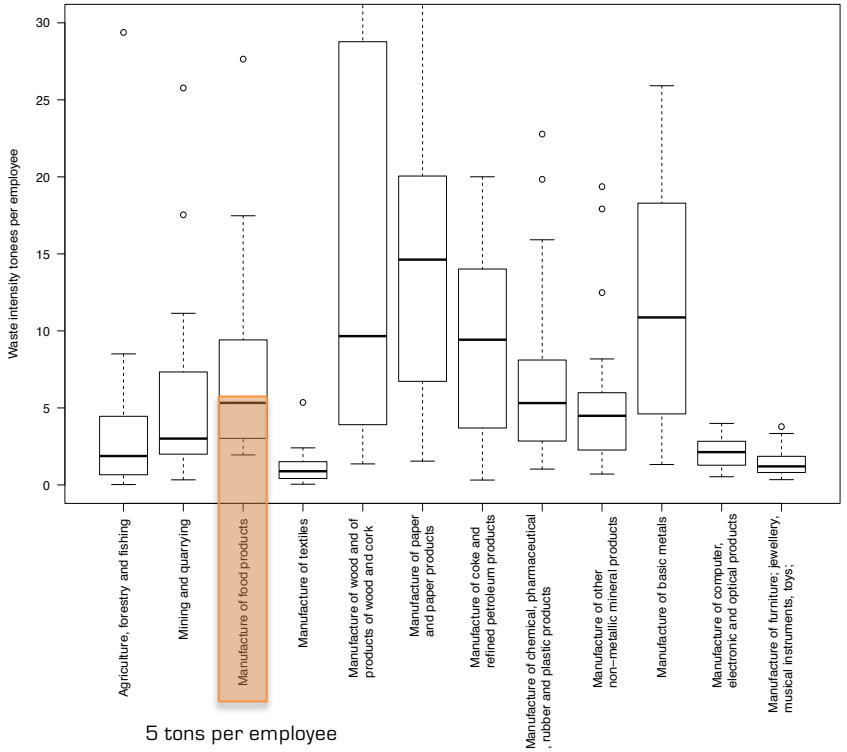
Industrial Sectors	Waste generation equation (x=number of employees, y=waste in tons)
Agriculture, forestry and fishing	$y = 3{,}3733x^{0{,}7701}$
Mining and quarrying	$y = 3{,}6854x^{0{,}9906}$
Manufacture of food products	$y = 2{,}095x^{1{,}1935}$
Manufacture of textiles	$y = 1{,}1831x^{0{,}8422}$
Manufacture of wood	$y = 4{,}7547x^{1{,}17}$
Manufacture of paper	$y = 4{,}0424x^{1{,}302}$
Manufacture of coke	$y = 5{,}7524x^{1{,}3727}$
Manufacture of chemical	$y = 1{,}0237x^{1{,}2667}$
Manufacture of other non-metallic mineral	$y = 3{,}1975x^{1{,}0191}$
Manufacture of basic metals	$y = 2{,}1393x^{1{,}3062}$
Manufacture of computer, electronic	$y = 0{,}9434x^{1{,}1137}$
Manufacture of furniture	$y = 1{,}1575x^{0{,}9883}$

Waste generation intensity

How much waste is produced in the industrial sites?

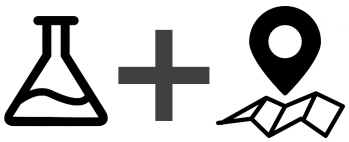


Example for Biogas production



Symbiosis identification

Where are wastes located in my region?



Waste characteristics + industry location

PROCEDURE

Obtain data about the companies that operate in your region. Data should be obtained with information about the industrial activity, the number of employees and location. Using the equations in step 4, and the selected wastes as well as their % in the total amount of waste (step 2), it is possible to identify the amounts of waste produced in the region.

For each company:

Raw Data:
Company name
Industrial Activity
Company Size

Estimated:
Amounts of waste
Types of waste

Symbiosis identification

Where are wastes located in my region?

Waste characteristics + industry location

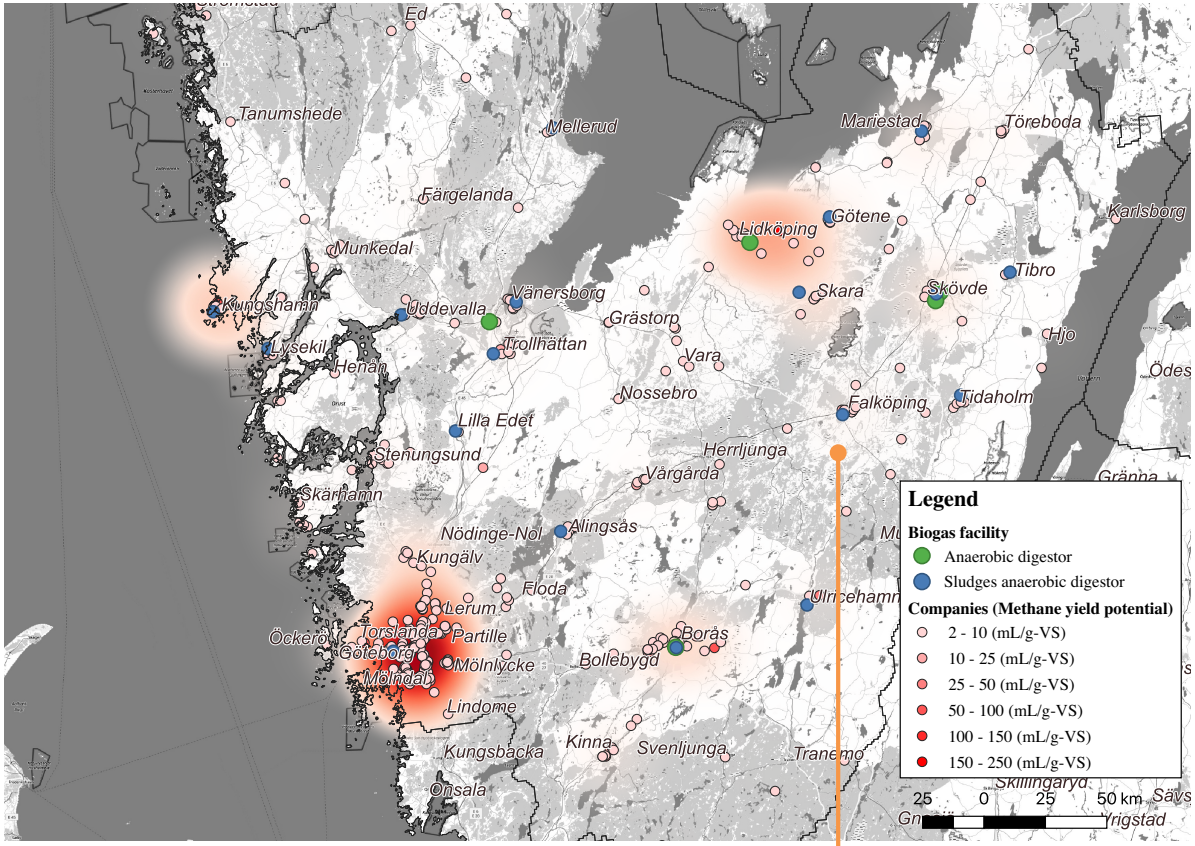
For each company:

Raw Data:
Company name
Industrial Activity
Company Size

Estimated:
Amounts of waste
Types of waste

Plugins:
Methane Yield

Example for Biogas production



Company: A
NACE 1071 – bread production
11 tons of animal and food waste
1 ton of paper waste

Methane yield potential: 2.2mL/g-VS

CHALMERS

Industrial Symbiosis
MATCHMAKING TUTORIAL

Leonardo Rosado and João Patrício
6th of March 2020

Supported by Circu-Mat project from European Institute of Innovation & Tecnhology - Raw Materials KIC