Co-Development of a Tool to Aid the Assessment of Biomass Potential for Sustainable Resource Utilization: An Exploratory Study with Danish and Swedish Municipalities

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Table S1. *Quantity potentials on biomass in Denmark*

DENMARK		
Biomass	**Data source**	**Calculation basis**
Pig slurry	Number of pigs [58]	Quantity per pig [59]
Cattle manure	Number of cattles [58]	Quantity per cattle [59]
Poultry manure	Number of poultry [58]	Quantity per poultry [59]
Fish waste from aquaculture	Quantity of fish [58]	Waste per quantity [60]
Roadside grass	Length [61]	Width Yield [62]
Food waste from companies	Municipal input	Quantity based on companies' industry affiliation and number of employees [63]
Food waste from households	Type of household [64]	Quantity per type of household [65,66]
Wheat straw	Area per type wheat [67]	Yield of straw per wheat yield [68]
Green house waste	Area of greenhouse [61]	Quantity per area of greenhouse[69–72]
Garden waste	Municipal input	Actual input
Wood waste	Area of forest [73]	Yield distributed on type of wood [74,75]
Hay	Area per type hay [67]	Yield [76]
Plant waste from water course	Area of watercourse [73]	Yield [77]
Beach cast seaweed	Length [78]	Yield [78]

Table S2. *Formula for quantity potentials on biomass in Denmark*

Biomass	Estimation - yearly
Pig slurry	$\sum Quantity_{pigs} * Slurry_{Barn\ System}$
Cattle manure	$\sum Quantity_{cattles} * Manure_{Barn\ system}$
Poultry manure	$\sum Quantity_{poultry} * Poultry_{Barn\ system}$
Fish waste from aquaculture	$\sum Weight_{fisht\ type, whole\ fish} * waste\ proportion$
Roadside grass	$\sum Length_{road\ type} * width_{road\ type} * yield_{road\ type}$
Food waste from companies	$\sum Number\ of\ employees_{industry\ affiliation} * Food\ waste\ production_{industry\ affiliation}$
Food waste from households	$\sum Quantity_{household\ type} * food\ waste\ production_{household\ type}$
Wheat straw	$\sum Yield_{straw\ type} * acreage_{straw\ type}$
Green house waste	$\sum Waste_{crop} * acreage_{crop}$
Garden waste	$Total\ quantity\ gathered\ in\ municipality$
Wood waste	$Acreage * waste\ production$
Hay	$\sum Yield_{hay\ type} * acreage_{hay\ type}$
Plant waste from water course	$Length * waste\ production$
Beach cast seaweed	Quantity per municipality

DENMARK

Table S3. *Quantity potentials on biomass in Sweden*

SWEDEN		
Biomass	**Data source**	**Calculation basis**
Pig slurry	Number of pigs [79]	Quantity per pig [59]
Cattle manure	Number of cattles [79]	Quantity per cattle [59]
Poultry manure	Number of poultry [79]	Quantity per poultry [59]
Fish waste from aquaculture	N/A	Waste per quantity [60]
Roadside grass	Length [74,80]	Width and yield [62]
Food waste from companies	Municipal input	Quantity based on companies' industry affiliation and number of employees [63]
Food waste from households	Type of household or number of citizens [81]	Quantity per type of household or citizens [65,66,82]
Wheat straw	Area per type wheat [83]	Yield of straw per wheat yield [68]
Garden waste	Municipal input	Actual input
Wood waste	Area of forest [74]	Yield distributed on type of wood [74,75]
Hay	Area per type hay [83]	Yield [76]
Plant waste from water course	Length of water course [84]	Yield and width [74,77]
Beach cast seaweed	Length [78]	Yield [78]

Table S4. *Formula for quantity potentials on biomass in Sweden*

SWEDEN	
Biomass	**Estimation - yearly**
Pig slurry	$\sum Quantity_{pigs} * Slurry_{Barn\ System}$
Cattle manure	$\sum Quantity_{cattles} * Manure_{Barn\ system}$
Poultry manure	$\sum Quantity_{poultry} * Poultry_{Barn\ system}$
Fish waste from aquaculture	$\sum Weight_{fisht\ type,whole\ fish} * waste\ proportion$
Roadside grass	$\sum Length_{road\ type} * width_{road\ type} * yield_{road\ type}$ $* regional\ growth\ estimation$
Food waste from companies	$\sum Number\ of\ employees_{industry\ affiliation}$ $* Food\ waste\ production_{industry\ affiliation}$
Food waste from households	$\sum Quantity_{household\ type} * food\ waste\ production_{household\ type}$
Wheat straw	$\sum Yield_{straw\ type} * acreage_{straw\ type}$
Green house waste	$\sum Waste_{crop} * acreage_{crop}$
Garden waste	$Total\ quantity\ gathered\ in\ municipality$
Wood waste	$Acreage * waste\ production * regional\ growth\ estimation$
Hay	$\sum Yield_{hay\ type} * acreage_{hay\ type}$
Plant waste from water course	$Length * waste\ production * regional\ growth\ estimation$
Beach cast seaweed	Quantity per municipality

Table S5. *Carbon flow calculations on different applications*

CARBON FLOW	
Application	**Assumptions**
Waste incineration (CHP)	Heat and power
Anaerobic digestion (Gas grid/CHP)	Gas grid or heat and power
Fodder	No calculated
Biomass (HOP/CHP)	Heat and/or power
Fertilizer/Soil improvement	No emission
Not collected	Methane emission
Application unknown	Unknown flow
Composting	Methane emission [85,86]
Pyrolysis (HOP)	Storage and district heating (T. P. Thomsen, Personel communication)
Bedding	Assumed no emission
Sold	Not accounted for

CHP: Combined Heat and Power
HOP: Heat only plants

Table S6. – *Nutrient flow (Nitrogen, Phosphorous, and potassium) on different applications*

NUTRIENT RECOVERY	
Application	**Assumptions**
Waste incineration (CHP)	Not recovered
Anaerobic digestion (Gasgrid/CHP)	No loss [87]
Fodder	Counted in fertilizer/soil improvement
Biomass (HOP/CHP)	Not recovered
Fertilizer/Soil improvement	No loss
Not collected	Not recovered
Application unknown	Not recovered
Composting	10 % nitrogen loss [88]
Pyrolysis (HOP)	100 % Nitrogen loss [89]
Bedding	Counted in fertilizer/soil improvement
Sold	Not recovered

CHP: Combined Heat and Power
HOP: Heat only plants

Table S7. Dry matter, volatile solids and nutrients (nitrogen, phosphorous and potassium) in biomass

Biomass	Extra classification	Dry Matter [%]	Volatile Solid of Dry Matter [%]	Nitrogen[b] [kg/tons]	Potassium[b] [kg/tons]	Phosphorus[b] [kg/tons]	Source
Pig slurry[a]	Sows, gilts and boars	4,5	87	3,8	1,7	0,8	NPP+DM: [59] VS: [90]
Pig slurry[a]	Pigs over 30 kg except sows, gilts and boars	6,6	87	4,8	2,6	1,0	NPP+DM: [59] VS: [90]
Pig slurry[a]	Piglets between 7 and 30 kg mellem 7 og 30 kg	5,0	87	3,3	2,1	0,9	NPP+DM: [59] VS: [90]
Cattle manure[a]	Male	10,8	76	10,8	3,5	0,9	NPP+DM: [59] VS: [91]
Cattle manure[a]	Heifers	12,3	76	12,3	7,1	0,9	NPP+DM: [59] VS: [91]
Cattle manure[a]	Cows	12,1	76	12,1	8,3	0,8	NPP+DM: [59] VS: [91]
Fish waste from aquaculture		50,0	95	15,5	0,6	20,0	DM: [92] (Fish sediment) NPP: [93]
Wheat straw		89,5	76	9,1	20,5	0,8	DM: [94] NPP: [91] VS+DM: [95]
Green house waste		89,5	76	9,1	20,5	0,8	DM+VS: [94] (Garden waste) NPP: [96] (Wheat Straw)
Garden waste		30,0	90				DM + VS: [94]
Wood waste		93,0	86	1,4	1,2	0,1	VS: [97] (Pine wood, 1 mm) DM: [98] (Mixed Hardwood chips) NPP: [99]
Hay		89,5	76	9,1	20,5	0,8	VS+DM: [95] NPP: [96]
Plant waste from water course		31,0	90	1,0	9,9	2,3	DM+VS: [94] NPP: [100] (Verge grass)
Beach cast seaweed		58,0	90	1,8	3,2	0,2	DM+VS: [94] NPP: [101] (Appendix 7)

Roadside grass	Minor road (spring)	18,7	92	0,3	0,9	0,3	DM+VS: [62] NPP: [100]
Roadside grass	Main road (spring)	26,3	89	0,4	1,3	0,4	DM+VS: [62] NPP: [100]
Roadside grass	Highway (spring)	25,7	94	0,4	1,2	0,4	DM+VS: [62] NPP: [100]
Roadside grass	Minor road (autumn)	18,7	85	0,3	0,9	0,3	DM+VS: [62] NPP: [100]
Roadside grass	Main road (autumn)	24,5	77	0,3	1,1	0,4	DM+VS: [62] NPP: [100]
Roadside grass	Highway (autumn)	28,4	90	0,4	1,3	0,5	DM+VS: [62] NPP: [100]
Food waste		30,0	85	5,4	2,0	0,7	TS, VS: [94] NPP: [102] (Analysis report)
Poultry manure[a]	Meat production	48,0	87	18,4	9,0	5,5	NPP+TS: [59] VS: [103]
Poultry manure[a]	Egg production	40,0	87	22,8	17,6	7,0	NPP+TS[59] VS: [103]

NPP: Nitrogen, Potassium, and Phosphorous
VS: Volatile Solids
DM: Dry Matter
[a] Varies depending on chosen animal setup for pigsty's, cowsheds, and poultry farms.
[b] Dry matter dependent

Table S8. *Biomethanepotential and gross calorific value in biomass*

Biomass	Extra classification	Biomethane-potential [nm3/tons vs]	Gross calorific value (HHV) [MJ/kg TS]	Source
Pig slurry	Sows, gilts and boars	230	12,8	BMP: [104] (Scrutiny figure 1: "So" - 30 days digestion) HHV: [105]
Pig slurry	Pigs over 30 kg except sows, gilts and boars	200	12,8	BMP: [104] (Scrutiny figure 1: "So" - 30 days digestion) HHV: [105]
Pig slurry	Piglets between 7 and 30 kg mellem 7 og 30 kg	260	12,8	BMP: [104] (Scrutiny figure 1: "So" - 30 days digestion) HHV: [105]
Cattle manure	Male	250	16,9	HHV: [106] BMP: [107]
Cattle manure	Heifers	250	16,9	HHV: [106] BMP: [107]
Cattle manure	Cows	250	16,9	HHV: [106] BMP: [107]
Fish waste from aquaculture		600	20,0	BMP: [94] HHV: [108] (Supplementary material)
Wheat straw		228	17,2	HHV: [109] BMP: [110] (After hammer mill)
Green house waste		175	18,4	BMP: [94] (Garden waste) HHV: [111] (Hay)
Garden waste		175	19,7	BMP: [94] HHV: [111] (Hay)
Wood waste		65	19,0	HHV: [112] (Wood trimmings incl. Bark) BMP: [97] (Pine wood, 1 mm)
Hay		306	18,4	BMP: [62] HHV: [111]
Plant waste from water course		400	18,0	BMP: [94] HHV: [113] (Verge grass)
Beach cast seaweed		99	23,5	BMP: [101] (On land <2 from shore. Eelgrass (50-80 %), dead man's rope (0-10 %), toothed wrack (0-10

Roadside grass	Minor road (spring)	306	18,0	BMP: [62] HHV: [113]
Roadside grass	Main road (spring)	306	18,0	BMP: [62] HHV: [113]
Roadside grass	Highway (spring)	306	18,0	BMP: [62] HHV: [113]
Roadside grass	Minor road (autumn)	306	18,0	BMP: [62] HHV: [113]
Roadside grass	Main road (autumn)	306	18,0	BMP: [62] HHV: [113]
Roadside grass	Highway (autumn)	306	18,0	BMP: [62] HHV: [113]
Food waste		340	15,9	BMP: [94] HHV: [115]
Poultry manure	Meat production	259	17,1	BMP: [103] HHV: [116] (Supplementary material)
Poultry manure	Egg production	259	14,0	BMP: [103] HHV: [116] (Supplementary material)

Table S9. *Content of carbon, hydrogen, oxygen, nitrogen and sulphur in biomass*

Biomass	Extra classification	Carbon [% af DM]	Hydrogen [% af DM]	Oxygen [% af DM]	Nitrogen [% af DM]	Sulphur [% af DM]	Source
Pig slurry	Sows, gilts and boars	43,7	4,2	33,5	2,5	0,5	[117]
Pig slurry	Pigs over 30 kg except sows, gilts and boars	43,7	4,2	33,5	2,5	0,5	[117]
Pig slurry	Piglets between 7 and 30 kg mellem 7 og 30 kg	43,7	4,2	33,5	2,5	0,5	[117]
Cattle manure	Male	44,7	5,9	38,2	2,1	0,3	[105]
Cattle manure	Heifers	44,7	5,9	38,2	2,1	0,3	[105]
Cattle manure	Cows	44,7	5,9	38,2	2,1	0,3	[105]
Fish waste from aquaculture		44,9	6,2	35,5	12,9	0,5	[108] (Supplementary material)
Wheat straw		47,5	5,7	48,3	0,6	0,1	[118]
Green house waste		44,8	5,0	42,5	1,6	0,1	[111] (Hay)
Garden waste		46,9	6,1	40,6	0,9	0,4	[119]
Wood waste		49,2	6,4	35,4	0,3	0,1	[112] (Wood trimmings incl. Bark)
Hay		44,8	5,0	42,5	1,6	0,1	[111]
Plant waste from water course		44,6	5,9	38,9	1,9	0,1	[120] (Verge grass)
Beach cast seaweed		21,6	2,4	26,9	1,2	0,0	[121]
Roadside grass	Minor road (spring)	44,6	5,9	38,9	1,9	0,1	[120]

Roadside grass	Main road (spring)	44,6	5,9	38,9	1,9	0,1	[120]
Roadside grass	Highway (spring)	44,6	5,9	38,9	1,9	0,1	[120]
Roadside grass	Minor road (autumn)	44,6	5,9	38,9	1,9	0,1	[120]
Roadside grass	Main road (autumn)	44,6	5,9	38,9	1,9	0,1	[120]
Roadside grass	Highway (autumn)	44,6	5,9	38,9	1,9	0,1	[120]
Food waste		48,1	5,9	40,7	0,7	0,0	[115]
Poultry manure	Meat production	37,4	5,0	28,2	4,6	0,7	[116] (Supplementary material)
Poultry manure	Egg production	37,4	5,0	28,2	4,6	0,7	[116] (Supplementary material)

DM: Dry Matter
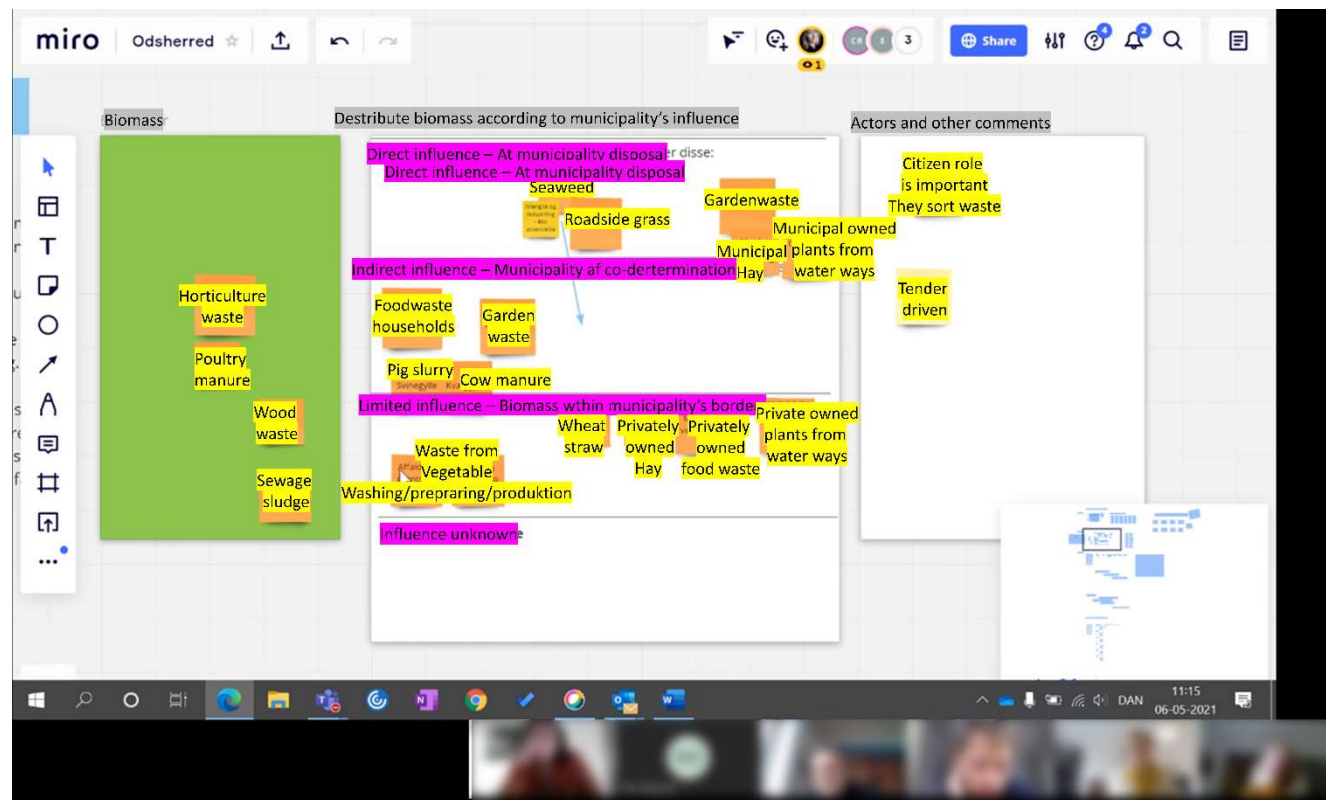
Figure S1. W3: Participants characterizing the municipalities influence over biomass in MIRO. Image translated from Danish to English.

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