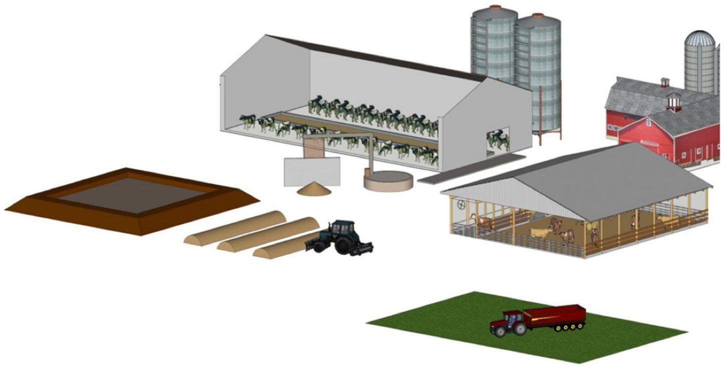

RufaS: Manure module progress

Modeling greenhouse gas emissions from dairy housing and manure management system

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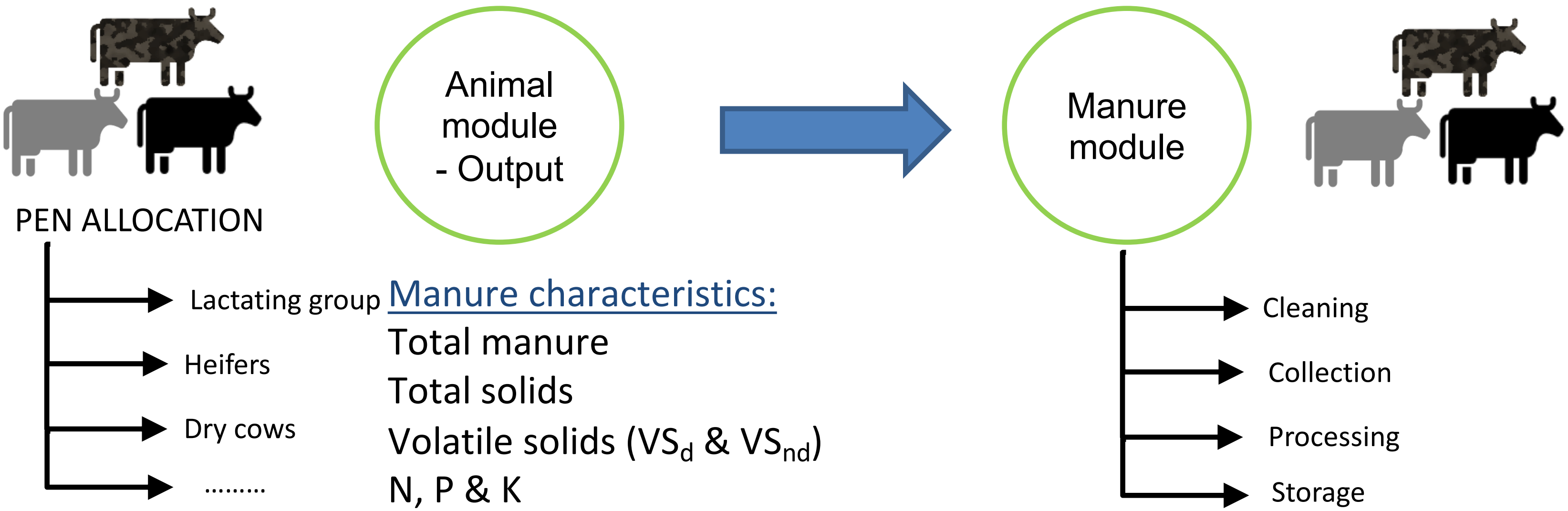
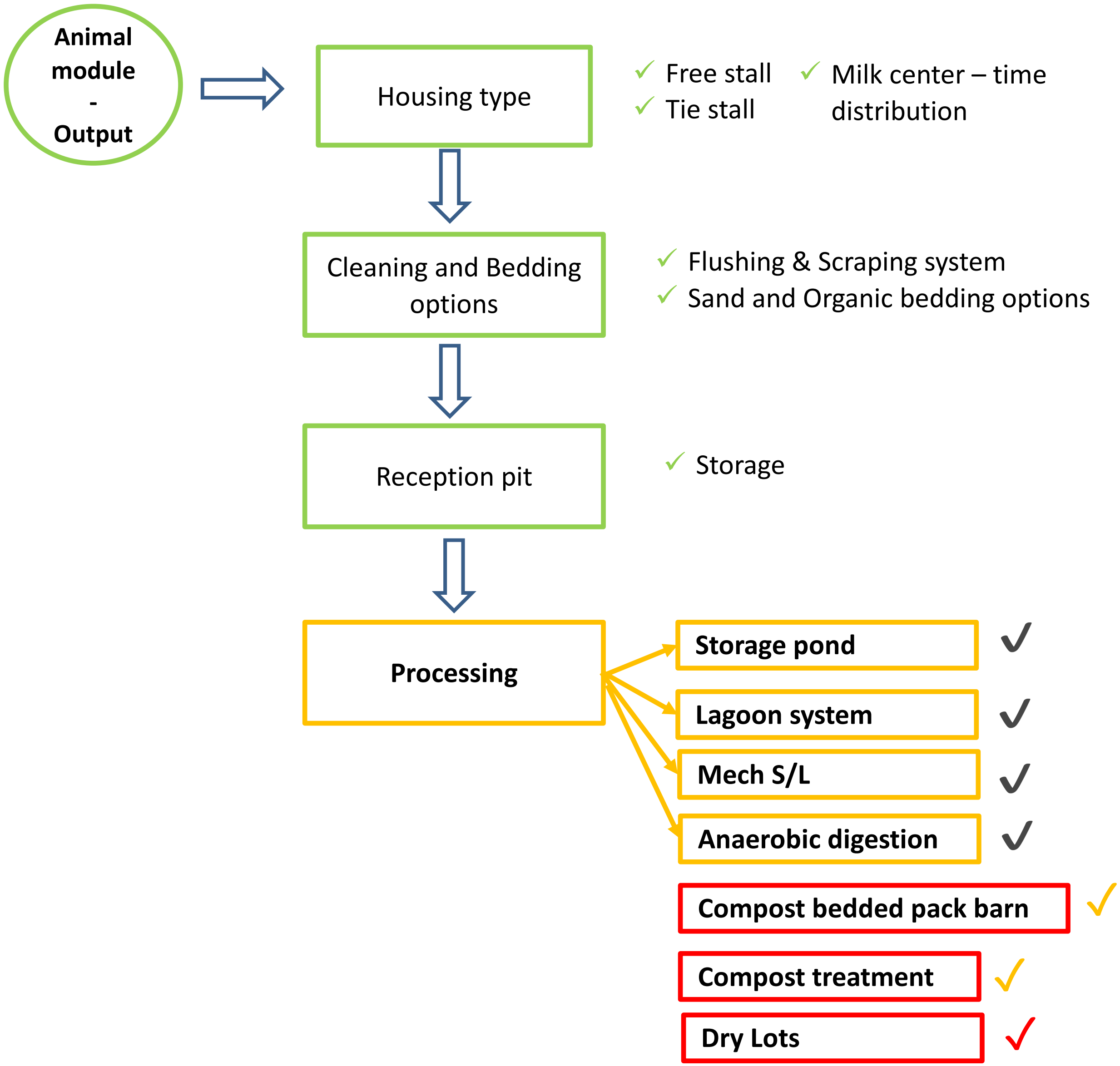
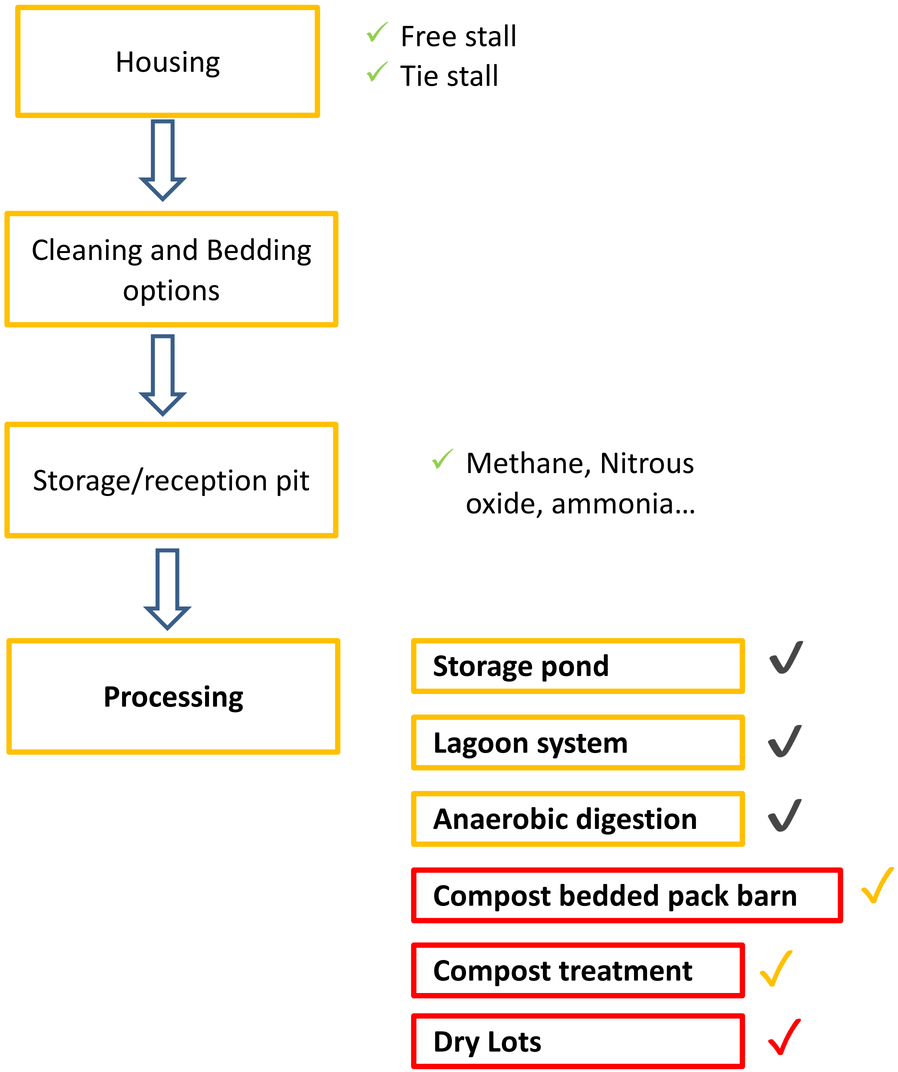
Manure module



Manure module
(Collection & Processing)



Manure module
(Gas emissions – Pseudo code)



Gas emissions - Algorithms

- Floor emissions:

$E_{CH4\ floor}$	**max(0.0, 0.13 T) * A_{barn} / 1000**
E_{CH4},floor =	daily rate of CH_4 emission from the barn floor, kg CH_4/day
T =	ambient barn temperature, °C
A_{barn} =	area of the barn floor covered with manure, m^2

	Value		
Temp	0	25	°C
Below 0, no emissions (Methane)			
A_{barn} Soiled manure Area			
Tie stall	1.2		m^2 / cow
Free stall	3.5		m^2 / cow
For, growing animals	1	2.5	m^2 / head

Compost bedded pack barn			
For, growing animals		5	m^2 / head

Rotz and Oenema, 2006.	**NH_3 Volatilization N**	**TAN * c * ρ / r * M * Q**
	NH_3 Volatilization =	NH_3–N loss (kg N/m^2/d)
	TAN =	total ammoniacal N in the manure solution (kg N/m^2)
	c =	time conversion (86400 s/d)
	ρ =	manure specific density (assumed to be 1000 kg/m^3)
	r =	resistance of NH3 transport from the manure surface to the free atmosphere (s/m)
	M =	manure solution mass per unit area of exposed surface (kg/m^2)
	Q =	dimensionless equilibrium coefficient for the NH_3 gas in the air for a given concentration of TAN in the solution
Henry's law of distribution, the equilibrium coefficient can be defined as:	Q =	K_h * K_a
	K_h =	Henry's law coefficient
	K_a =	disassociation coefficient of ammonium
Ka = disassociation coefficient of ammonium. These two coefficients are a function of temperature and pH (Sherlock and Goh, 1985):	K_h =	$10^{(1478 / (T + 273) - 1.69)}$
	K_a =	$1 + 10^{(0.09018 + 2729.9} / (T + 273) - pH)$
	T =	manure solution temperature (°C)
	pH =	manure solution acidity
	r =	HSC (1 − 0.027 (20 − T))
	HSC =	housing-specific constant (s/m).

Emission of CH_4 from slurry or liquid manure storages is predicted as: (slurry storage with c curst on the surface)				**Sommer et al., 2004**	
	$E_{CH4,man}$=	$((24 * V_{s,d} * b_1)/1000) * \exp[\ln(A) - (E/RT)] + ((24 * V_{s,nd} * b_2)/1000) * \exp[\ln(A) - (E/RT)]$	0.002101572	**kg CH_4/day**	
		2.10	**g CH_4/day**		
	b1	1			
	b2	0.01			
	ln(A)	43.33		0.0244035	
	E	112700		47.04	
	R	8.314		0.02	
	Temp (manure) °K	288.15	273.15		
	$V_{s,d}$ =	$V_{s,tot} B_o / [E_{CH4,pot}]$	VS	7.7	kg VS / animal / day
		3546.6	VS	2814.2	kg VS / animal / year
				1294.5	
	$V_{s,tot}$ =	$M_{manure} * P_{TS} * P_{VS} - V_{s,loss}$	Manure	70.3	kg/ animal / day
		4917351130	TS	9.07	kg/ animal / day
			VS	7.71	kg/ animal / day
	$V_{s,nd}$ =	$V_{s,tot} - V_{s,d}$	VS loss	0.6	
		4163.4	Bo	0.2	kg CH_4/kg VS
			fraction VSd	46%	
	$V_{s,nd}$ =	$V_{s,tot} - V_{s,d}$			
		4163.4			
	$E_{CH4,cov}$ =	$E_{CH4,man} * (1 - \eta_{eff})$			

- We plan, to integrate the algorithms into the manure processing
- VS_d and VS_{nd} in daily time steps

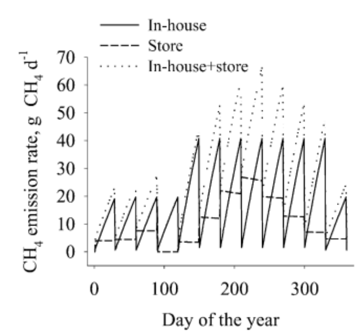


Figure 3. Prediction of variation in daily CH_4 emissions from cattle slurry during storage in-house and outside. Daily, 1 kg VS was added to the in-house slurry store. Table 3 gives the parameters for the emission estimates.

All Together

```
"default":
{
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    "separator": "sedimentation",
    "storage": "storage_pond"
},
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{
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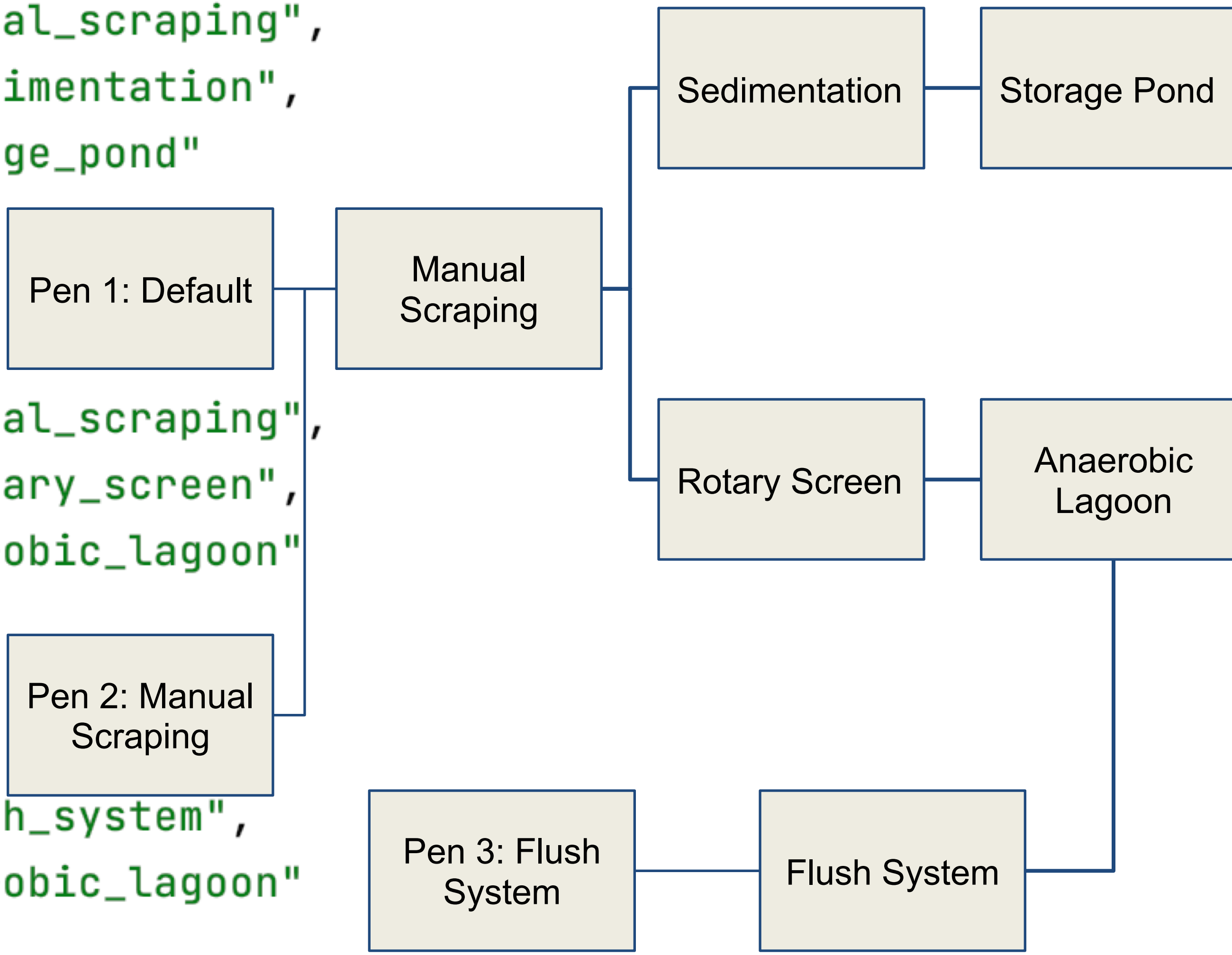

Next Steps:

- **Manure Processing & Gas emissions algorithms**
- Merge the gas emissions algorithms to the housing and manure processing methods.
- Complete Compost bedded pack barn and composting treatment methods.
- Preparing new housing and treatment scenario.

- **Code development**
- We have coded the parts of the MMS and working on putting it all together.
- Complete the remaining coding of the algorithms developed.
- Debugging – revisiting the storage/treatment sequences – interpreting these interactions in the process level.

Questions/Discussions:

- If we have all of the practices described and their combinations, will we be able to represent the majority of US dairy manure systems?
- What should we add to our list for development once this is completed?
- What is the plan for model evaluation? (do we have data for evaluating this model yet?)
- How the model should be divided up into unit processes?
- Organization of the methods – selection of multiple processing methods vs default assumptions
- What level of customization of individual dairy operations is needed for different applications? Archetypical vs. exact representation of a farm?
- Impact of water during cleaning (water volume datasets) – flushing & scraping: (emissions – decomposition of volatile solids and N)
- Bedding options: Sand / Organic materials – mixed with the manure while storage or S/L separation – Total solids and volatile solid contribution in the emissions.

THANK YOU….

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