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Carbon Considerations in Biosolids Management

DC Water Carbon Footprint Model

October 27th, 2017

District of Columbia Water and Sewer Authority

Why did we build the model?

Started as an effort to see how different aspects of the biosolids management program affected carbon emissions, and evolved into a tool that measures the entire DC Water carbon footprint to:

- measure improvements in carbon footprint
- show farmers the benefits of land application
- set a precedent for models to include land application of biosolids
- measure how future projects will affect our footprint
- use in negotiations next time we are asked to cut our nitrogen loads to the Potomac
  - EPA Air and EPA Water need to discuss conflicting goals
  - Could lead to discussions of watershed approaches to N management

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How did we build the model?

- Leveraged capital money from our ENR project
  - rationalized it by stating that we would measure impact of the process on CO_2e emissions
  - and use it in negotiations next time
- Worked with Brown & Caldwell (John Willis) to develop the model
- Based loosely on IPCC model, with some extras
  - land application of biosolids
  - measured CH_4 at plant and in sewers
  - Methanol CO_2 release in nit/denit

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DC Water is modeling carbon balance for base year, current year, and future projects

Table 1. Summary of Annual Emission Estimates, Calendar Year: 2008		
Emission Source	Annual Emissions Estimate Metric Tons CO2e	Scope 1 and 2 Percent Contribution
Scope 2		
Electricity	146,920	88%
DSS	11,053	7%
DWS	9,163	5%
DWT	126,704	76%
Scope 1		
Natural Gas	2,967	2%
CS	197	0.1%
DSS	371	0.2%
DWS	441	0.3%
DWT	1,924	1%
FLEET	34	0.02%
Vehicle (fuel usage)	2,586	2%
Compressed Natural Gas (CNG)	0.064	0.00004%
Diesel Fuel No. 1 and 2	1041	0.6%
Motor Gasoline	1545	0.9%
Refrigerants	142	0.08%
Nitrification/Denitrification (process emissions)		
CO2 from Addition of Methanol	12,007	7%
N2O from Dentrification	443	0.3%
Effluent Discharge (process emissions)	2,009	1%
Total with Scope 1 and 2	**167,074**	
Scope 3		
Biosolids Hauling (fuel usage/distance travelled)	4,107	
Chemical Hauling (distance travelled)	1,450	
Lime Production	14,883	
Methanol Production	6,747	
N2O Emissions from Land Application of Biosolids	52,548	
Methane Emissions from Landfilling Biosolids	7	
Total with Scope 3	**246,815**	
Carbon Credits		
Carbon Sequestration Land Application	26,844	
Carbon Sequestration Land Application with Composting	13,576	
Carbon Sequestration Landfill	2	
Avoided N2O Emissions from Replacement of Inorganic Fertilizers	52,548	
Fertilizer Credits Direct Applied Biosolids (N and P)	9,006	
Fertilizer Credits Composted Biosolids (N and P)	1,692	
Total	**103,668**	
GRAND TOTAL	**143,147**	

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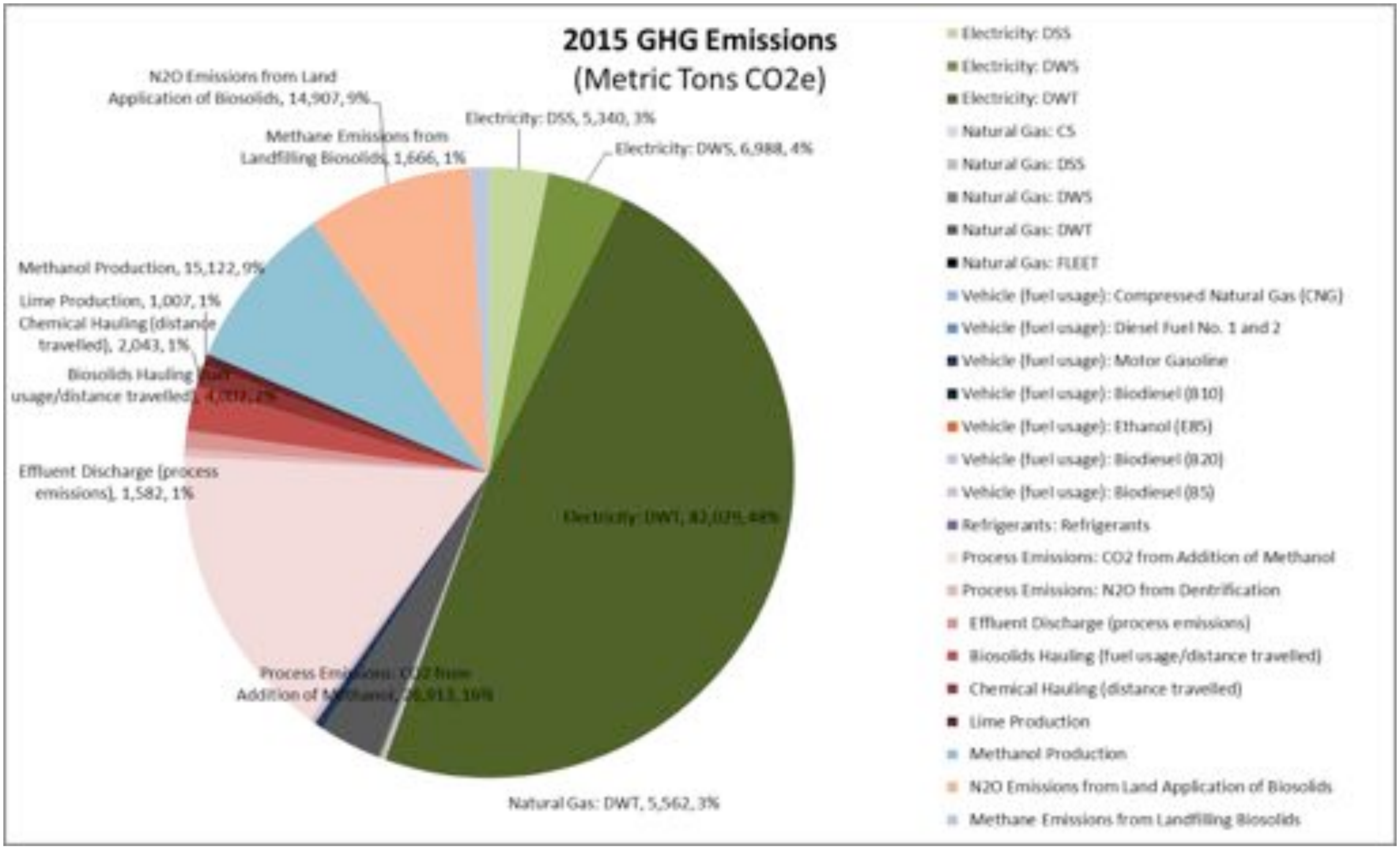
Model breaks down emissions by department, type



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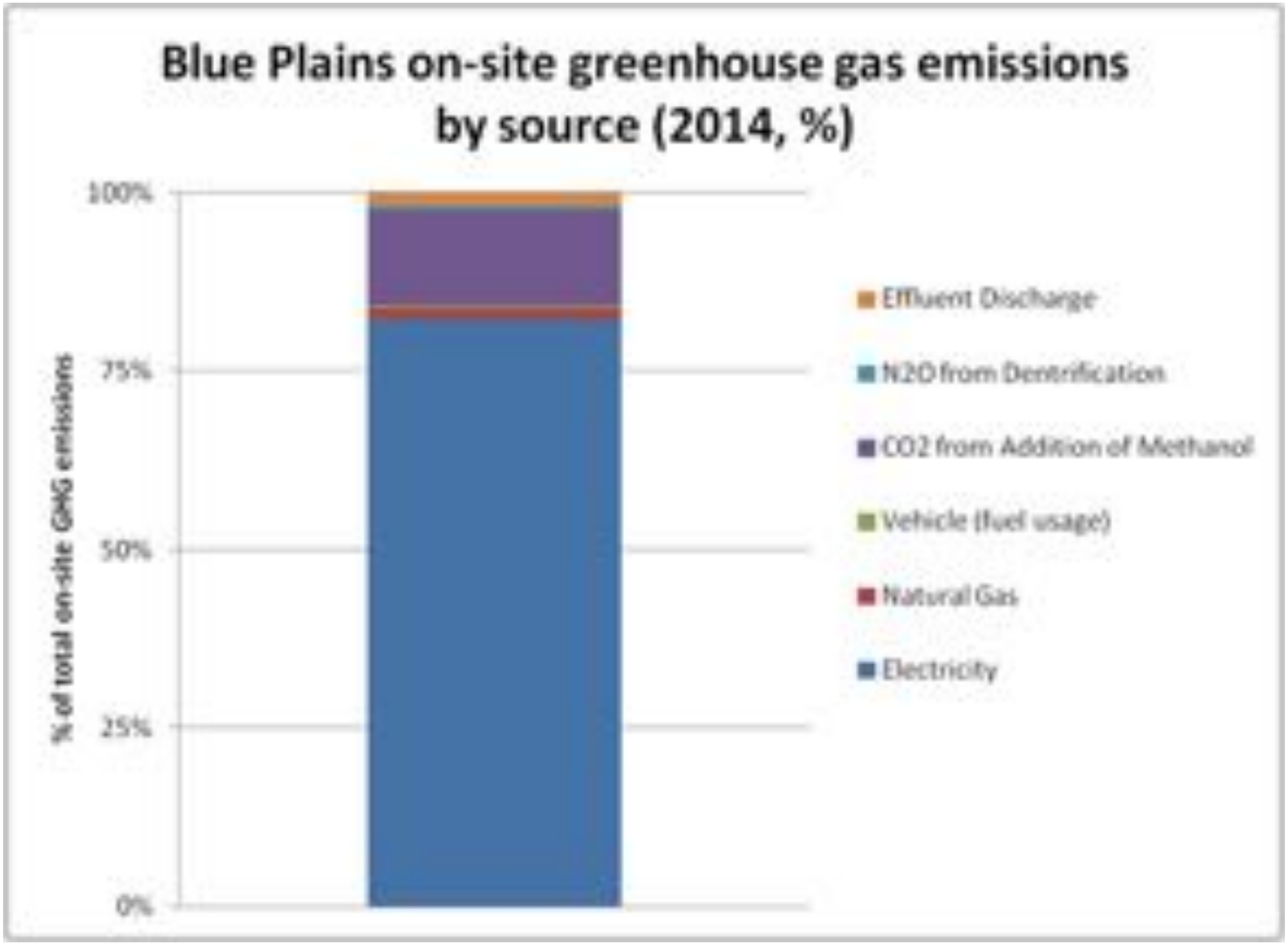
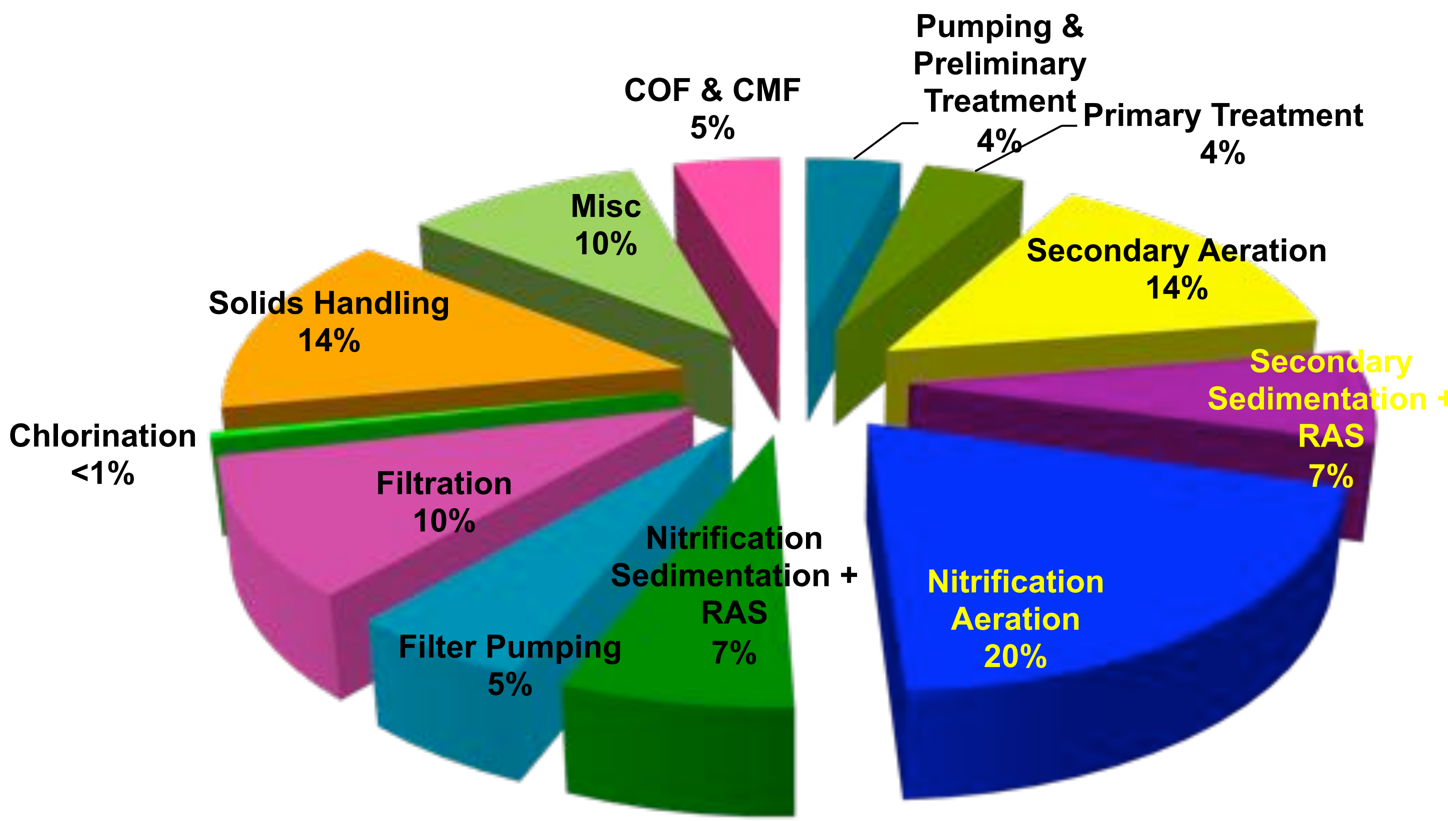
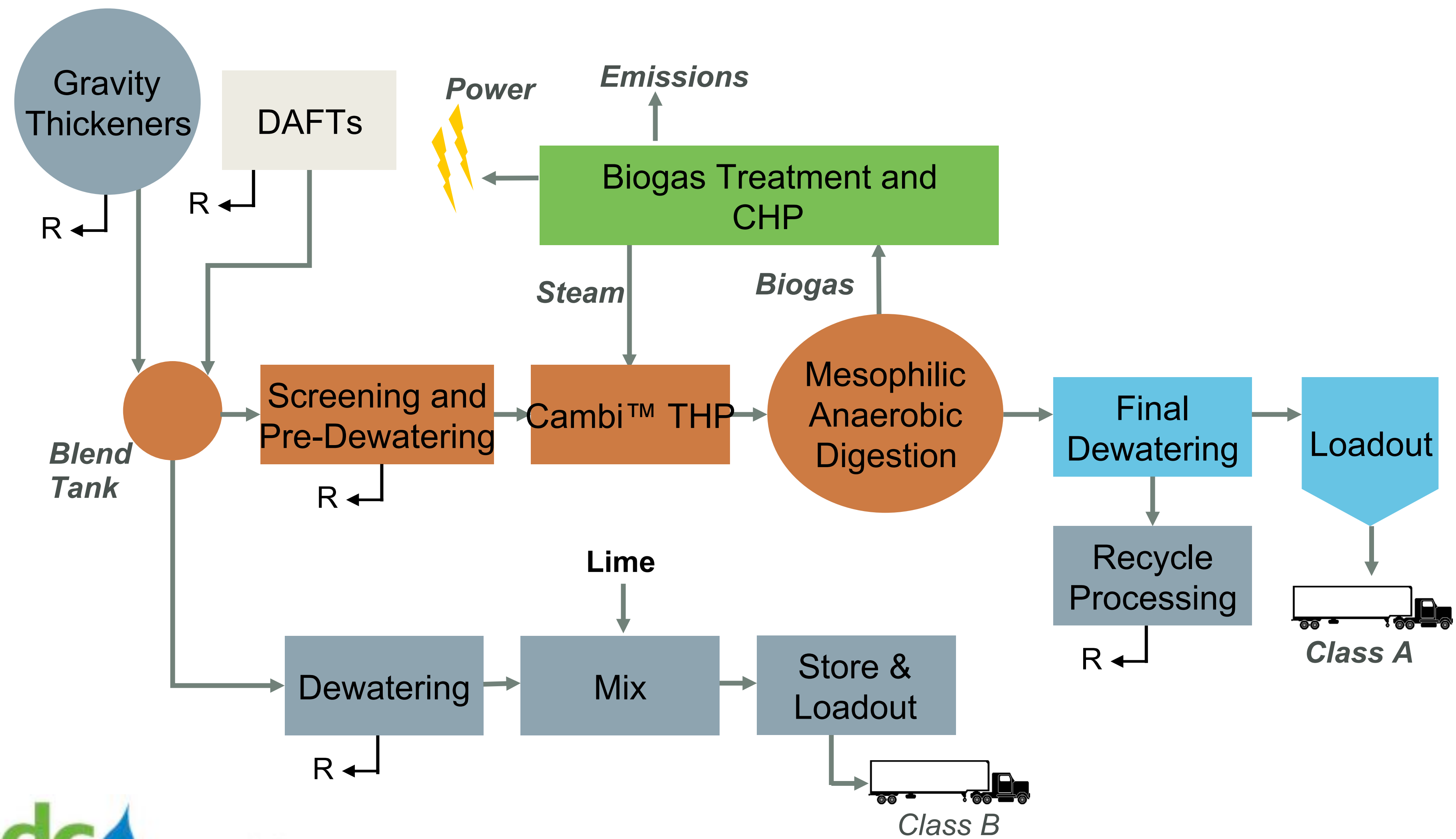


Blue Plains on-site greenhouse gas emissions by source (2014, %)
100%
75%
50%
25%
0%
% of total on-site GHG emissions
Effluent Discharge
N2O from Dentrification
CO2 from Addition of Methanol
Vehicle (fuel usage)
Natural Gas
Electricity

Breakdown of Electricity Consumption Blue Plains



Process Schematic of DC Water's New Biosolids Program



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Thermal Hydrolysis Process

Pulper

- Influent solids 15 to 18.5 %TS
- Preheated to 140-210°F with recycle steam
- Mixing pumps

Reactors

- Batch process
- Heated to 302-356°F
- 54-138 psi
- 22-30 minute detention time

Flash Tank

- Depressurization
- Cools down to 158-239°F
- 8-12 %TS to digesters

Program Benefits

Resource Recovery

Reduce biosolids quantities by more than 50%

Improve product quality (Class A and more)

Generate 10 MW of clean, renewable power

Cut GHG emissions dramatically

Save millions of dollars annually

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Post digestion carbon footprint

Pros:

- ~58,000 MT CO_2e reduction
- Reductions in:
  - Hauling
  - Polymer
  - Lime (eliminated)
- 10 MW green power produced

Cons:

- <biosolids so <C sequestered and fertilizer avoided
- >ammonia N, so >methanol and power for ENR

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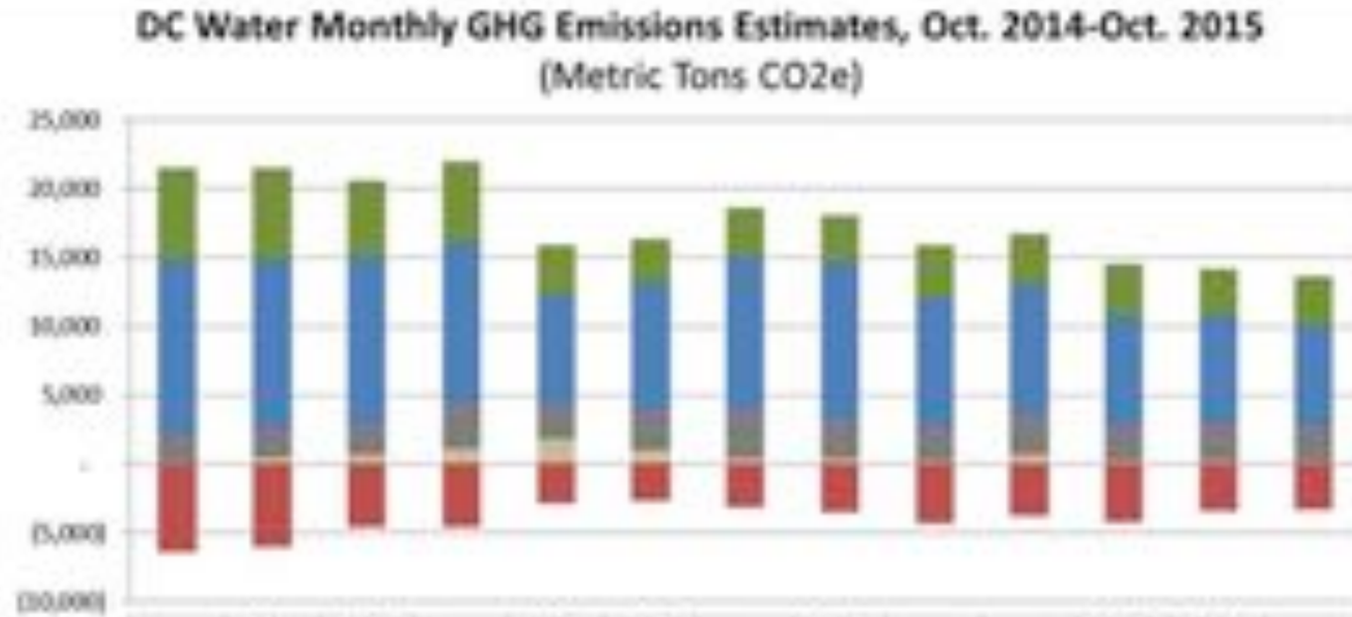
Digesters effect on carbon footprint

Emission Source	2007-2008 Average Annual Emissions Estimate, Metric Tons CO_2e	Projected Annual Emissions after Cambi Digestion Upgrades[A], Metric Tons CO_2e	Overall Predicted Reduction, Metric Tons CO_2e
Scope 1			
Natural Gas	2,976	2,976	0
Vehicle (fuel usage)	2,788	2,788	0
Refrigerants	125	125	0
Nitrification/Denitrification (process emissions)[B]	3,472	4,687	-1,215
Effluent Discharge (process emissions)	1,736	1,736	0
Total of Scope 1	**11,096**	**12,312**	**-1,215**
Scope 2			
Electricity[C]			
DSS	10,237	10,237	0
DWS	10,178	10,178	0
DWT[D,E,F]	133,387	85,356	48,031
Total of Scope 2	**153,802**	**105,771**	**48,031**
Total of Scopes 1 and 2	**164,898**	**118,083**	**46,816**
Scope 3			
Biosolids Hauling (fuel usage/distance traveled)[G]	4,154	1,853	2,301
Lime Production	14,547	727	13,819
Methanol Production[B]	7,167	9,676	-2,509
N2O Emissions from Land Application[H]	50,437	35,306	15,131
Methane Emissions from Landfilling Biosolids	290	149	142
Scope 3 GHG Emission Offsets			
Carbon Sequestration Land Application[K,*]	-28,886	-28,886	0
Carbon Sequestration Land Application with Composting[K,*]	-12,837	-12,837	0
Carbon Sequestration Landfill[K,*]	-56	-56	0
N2O Offsets from Avoided Chemical Fertilizers	-50,437	-35,306	-15,131
Fertilizer Credits Direct Applied Biosolids (N and P)[H]	-6,812	-4,768	-2,044
Fertilizer Credits Composted Biosolids (N and P)[H]	-1,054	-738	-316
Total Scope 3 Emission Offsets	-23,487	-34,880	**11,393**
GRAND TOTAL (Scopes 1, 2, and 3 reduced by identified Scope 3 GHG Emission Offsets)	141,412	**83,203**	58,209

Carbon footprint before, during, and after digester start-up



	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15
Biosolids Processing & Land App	6,598	6,626	5,586	5,796	3,501	3,107	3,516	3,342	3,827	3,631	3,781	3,377	3,502
Electricity	12,693	12,449	12,226	11,755	8,107	9,392	11,359	11,619	9,412	9,520	8,306	7,982	7,105
Vehicle (fuel usage)	127	89	86	98	98	78	95	71	77	104	92	80	70
Process Emissions	1,977	1,883	2,079	3,173	2,340	2,727	3,280	2,614	2,424	2,810	2,420	2,566	2,739
Natural Gas	139	485	650	1,549	1,856	1,061	360	388	173	679	173	197	167
Carbon Credits	(6,352	(6,056	(4,608	(4,583	(2,844	(2,690	(3,180	(3,527	(4,336	(3,775	(4,256	(3,367	(3,317

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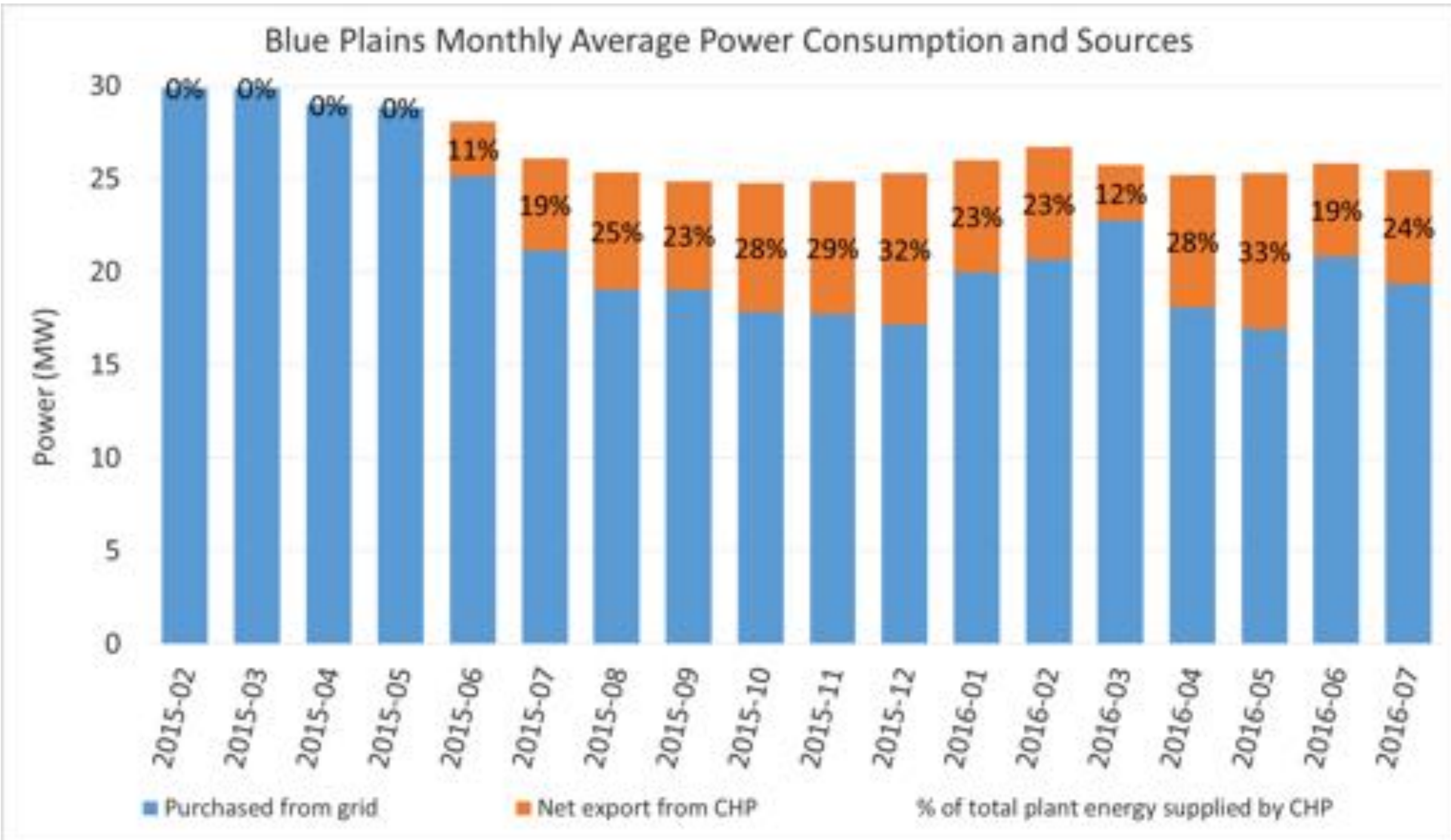
Power draw from the grid and onsite generation



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Why is Methanol an "issue"?

- We "assume" that CO_2 from aeration basins is **BIOGENIC**
- Methanol is made from Natural Gas (which is a fossil fuel)
- So that CO_2 evolving from methanol addition **is a Scope-1 GHG emission**
- Prior to **ICLEI's US Community Protocol (2012) Method WW.9**,

None of the protocols addressed this possibility

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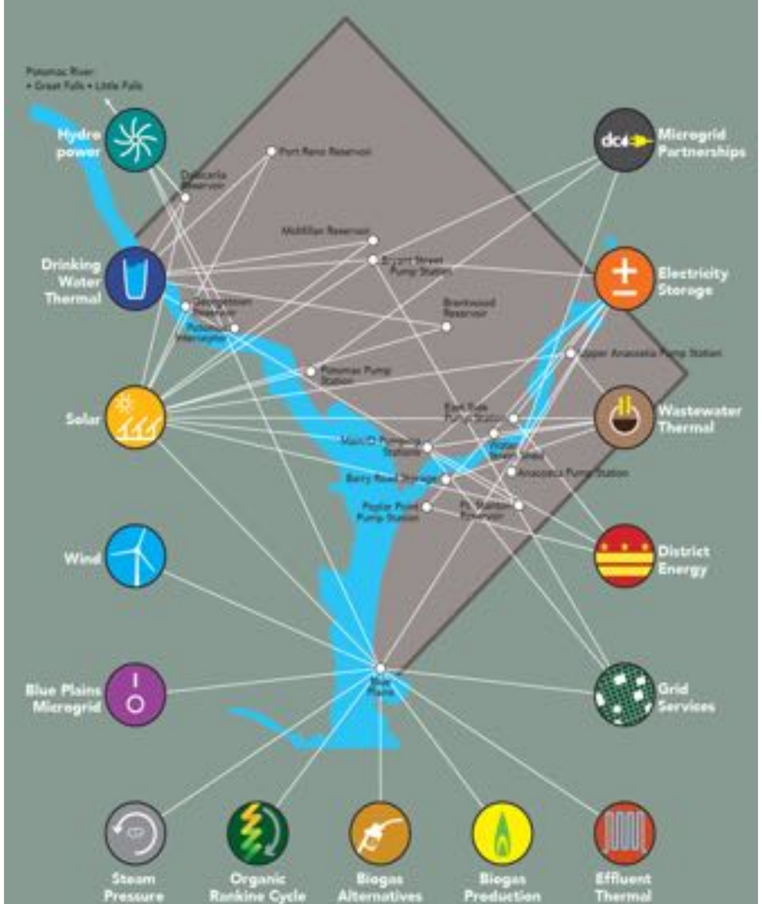
dc ENERGIZED

DC Water's Energy Opportunities

DC Water has identified opportunities to add renewable generating capacity, enhance energy resiliency, and reduce carbon emissions in the District. This map highlights potential locations.



Sewer Heat Recovery Potential

- Stable daily temperatures (2°F cycle)
- Significant seasonal cycle (58°F - 78°F)
- Significant variation site-to-site
- Weather has varying impact
- **For each 1 MGD, ~1 MW of thermal energy**
- **200 MGD baseflow = 200 MW available**
- Possibly “sweetspots”

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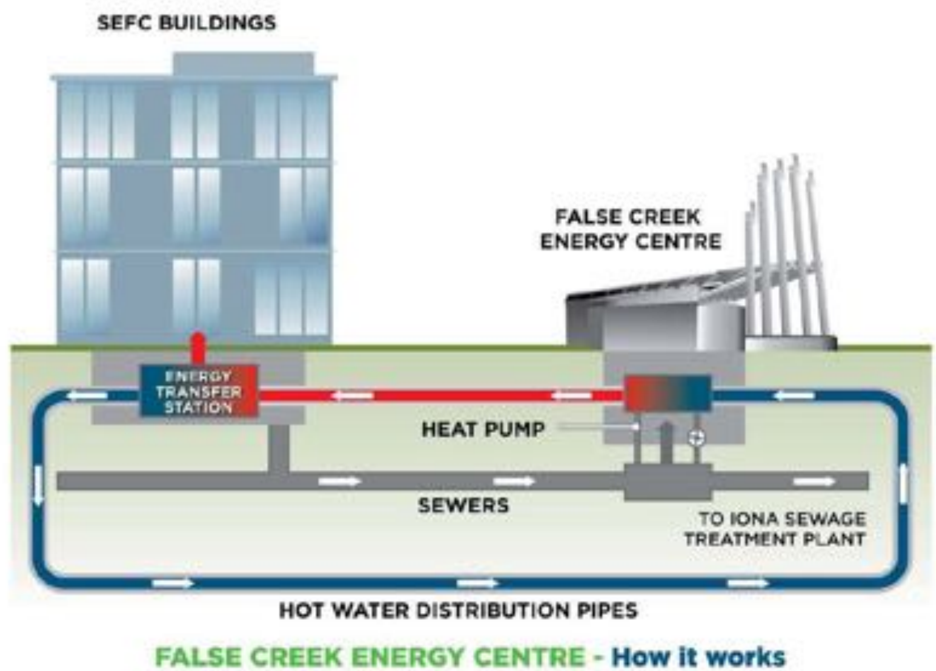
Sewer Heat Recovery

Gateway Theatre
Utility room supplies 50,000 ft^2 building in Vancouver, BC



CITY OF VANCOUVER

Southeast False Creek
Providing 3 MW of heat energy to local neighborhood via hot water pipeline

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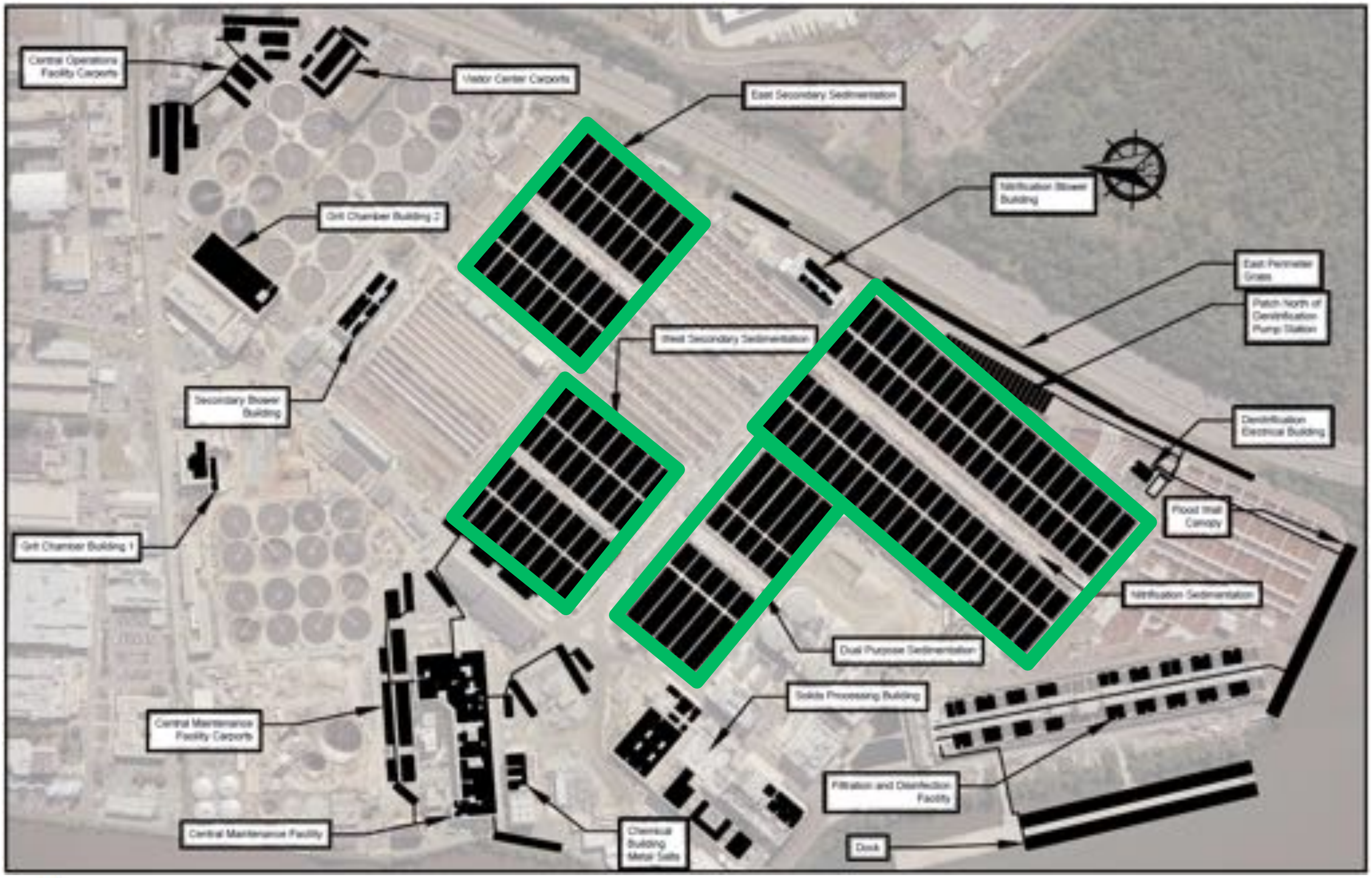
Solar Project for Blue Plains



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Offsite Solar Potential

FORT STANTON : 2.0-2.5 ACRES (500kW)

FORT RENO : 6.0-7.8 ACRES (1 MW+)

BRENTWOOD RESERVOIR: 2.0-2.75 ACRES (500kW+)

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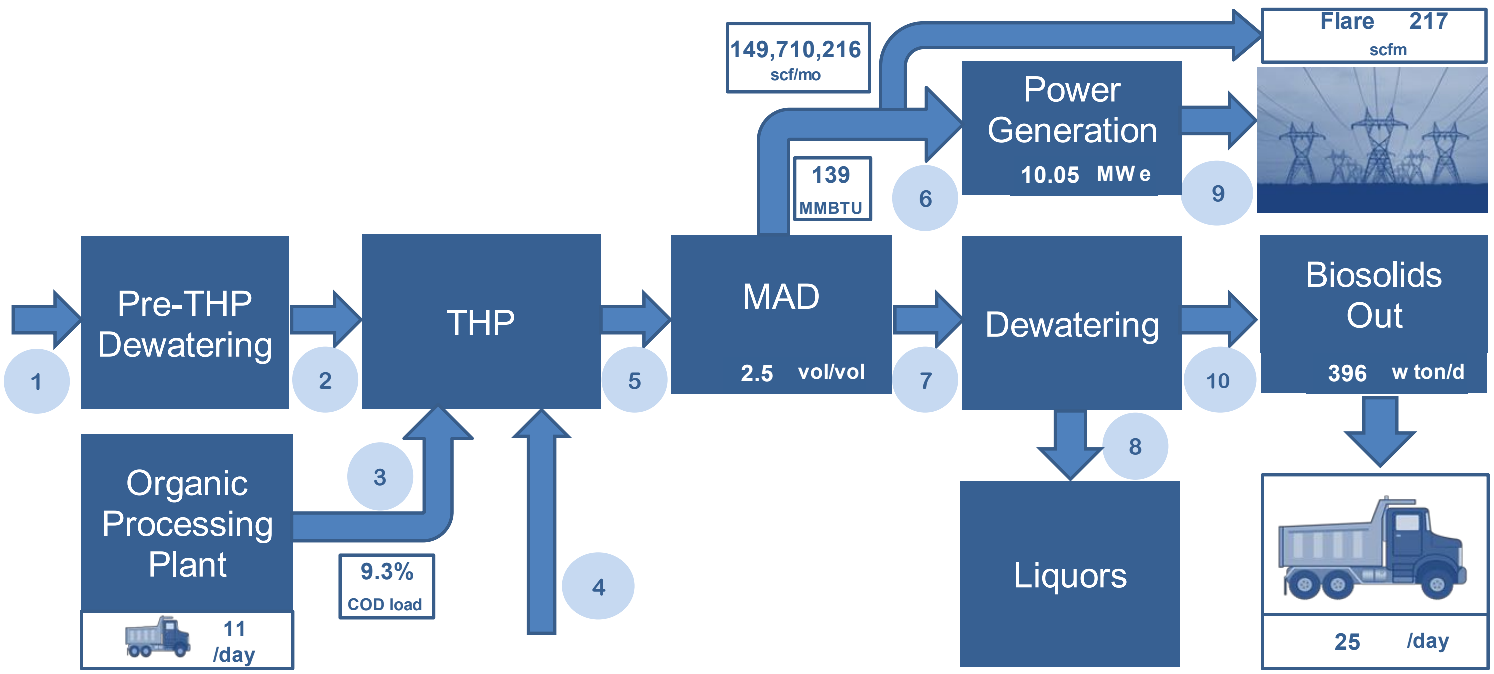
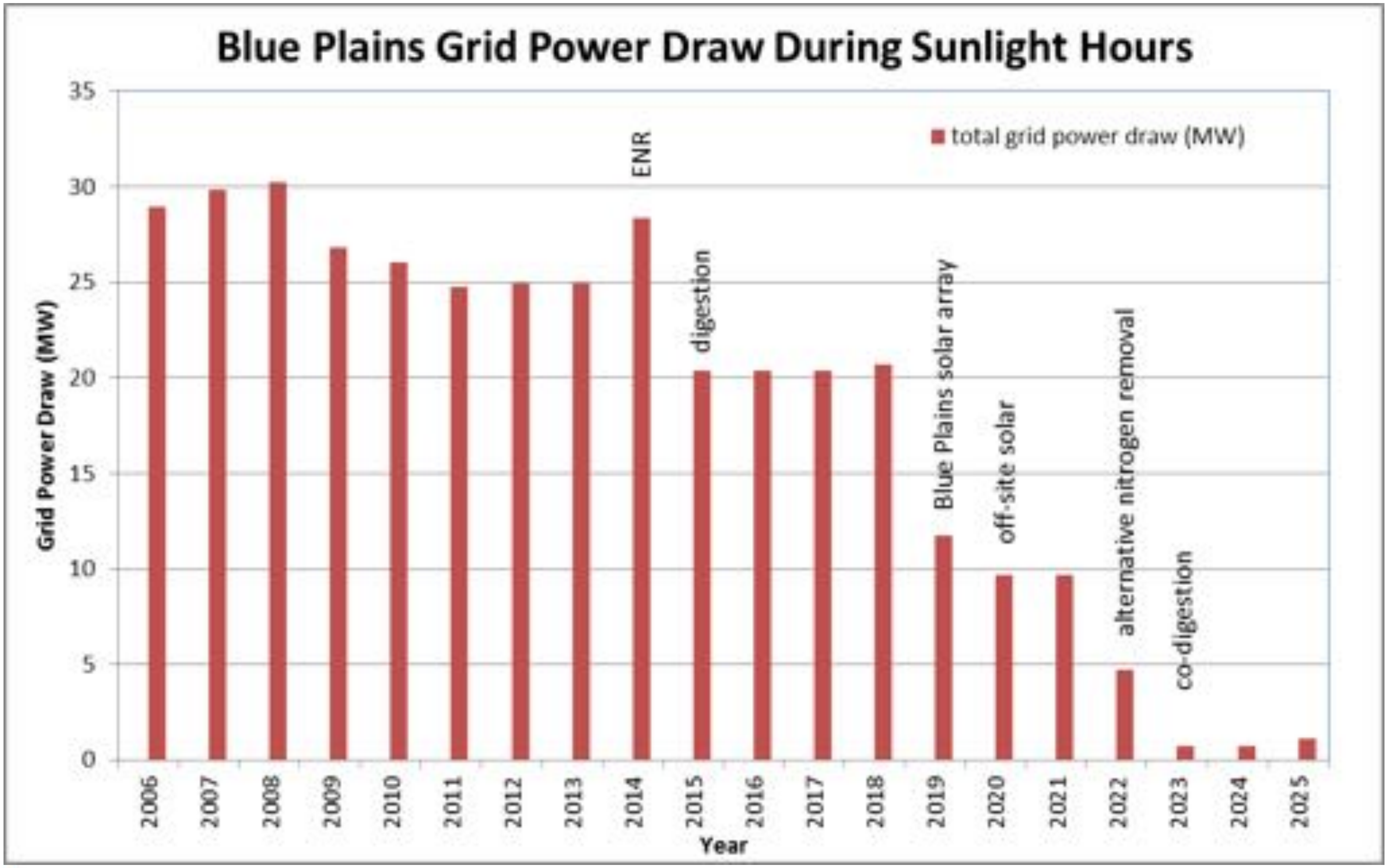
Co-digestion model – sewage solids with food waste



	Stream	1	2	3	4	5	6	7	8	9	10
	Name	Raw sludge	THP sludge feed	Organic Waste	Trim Water	MAD feed	Biogas	DW feed	Liquors	Power output	Biosolids output
TDSd	tDS.d [US]	290	284	28		312		133			131
%DS	%	5%	17%	14%		10%		4.3%			33%
%VS	%	75%	75%	80%		75%		48%			48%
Wet	m3/hr	242	72	8		130		130	114		16
DS	lbs/d	580000	568400	56000		624400		266624	5332		261291
VS	lbs/d	435000	426300	44800		471100		128219	2564		5236
COD	kgs/hr	14234		1500		15734			5413		
Trim Water	gpm				106						
Ammonia	lbs/d	3424	3424	204		3628		18486	18486		
Ammonia	mg/l	267	899	462		526		2775	2775		
Biogas	scfm						3418				
Biogas	MMBTU						139				
Power output	MW e									10.05	

Capacity	
Pre TH DW	50%
Turbines	82%
MAD	70%
THP	64%
DW	43%

Potential Grid Power Draw Reductions



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Overview of DC Water Collection System: Geography

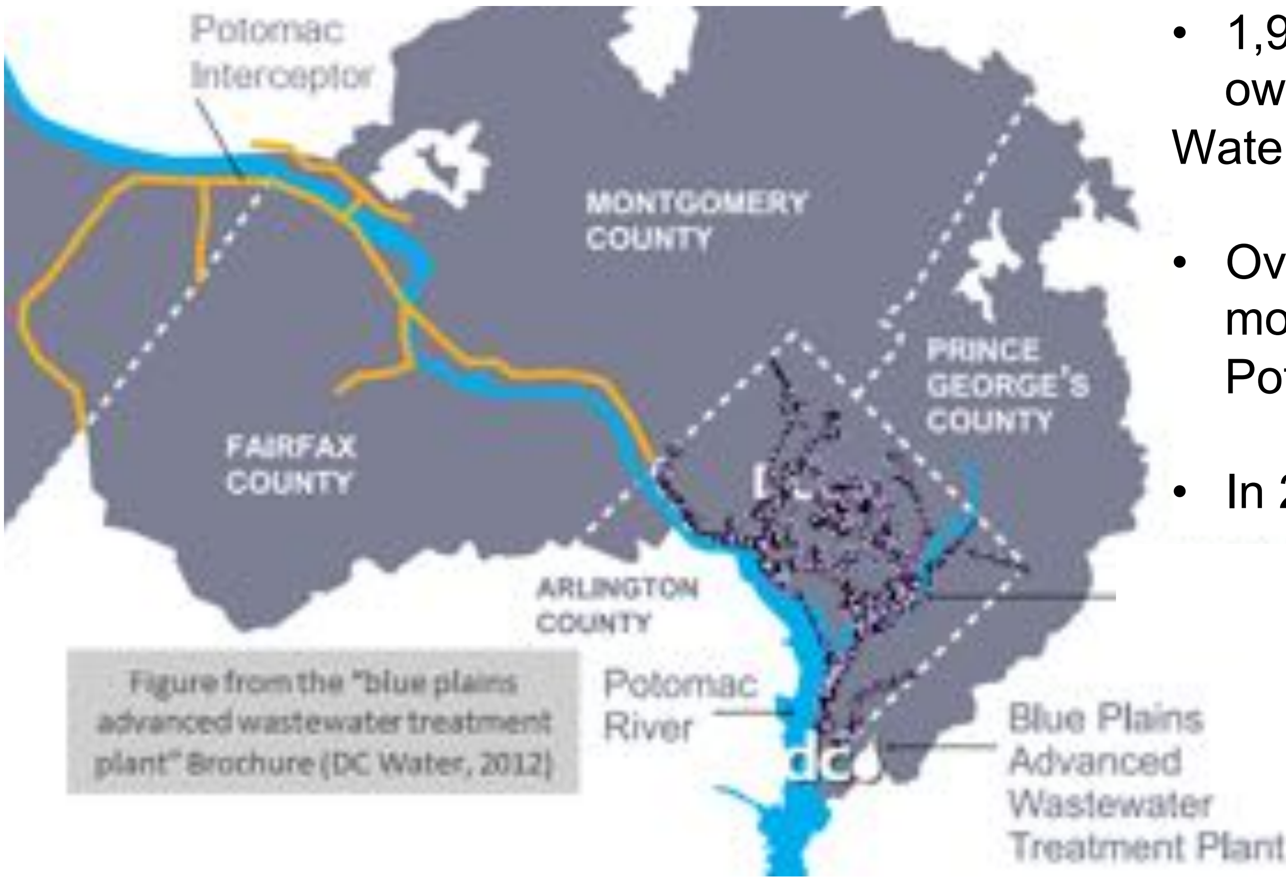

Figure from the "blue plains advanced wastewater treatment plant" Brochure (DC Water, 2012)

- 1,900 miles of Sewer are owned/operated by DC Water
- Over 500 miles are modelled, including the Potomac Interceptor
- In 2014 (modeled year):
  155mgd outside DC
  151mgd within DC
  306mgd total

Collection-System Methane Methodology uses Two Models

- Gravity-Sewer Model:

$$r_{CH4\text{-}GS} = 0.419 \times 1.06^{(T-20)} \times Q^{0.26} \times D^{0.28} \times S^{-0.135}$$

r_{CH4},	= CH_4 emission rate in kg CH_4/(m²·day)
T	= Temperature in °C
Q	= Flow in m^3/s
D	= Pipe diameter in m
S	= Slope in m/m

Developed and verified under the DC Water/WERF Project

- Forcemain/Surcharged-Sewer Model:

$$r_{CH4\text{-}FM} = 3.452 \times D \times 1.06^{(T-20)}$$

Verified previously under other projects

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Relative Significance of each Emissions Source (as %)

Description	2014 BP GHG Emissions Inventory withOUT Sewer CH_4, MT CO_2e/yr	2014 BP GHG Emissions Inventory WITH Sewer CH_4, MT CO_2e/yr	Percentage of Scope-1 Emissions by Source	Percentage of Scopes-1 and -2 Emissions by Source
Scope 1				
Natural Gas	2,369	2,369	6.4%	1.5%
Vehicle Fuel	1,581	1,581	4.3%	1.0%
Refrigerants	0	0	0.0%	0.0%
CO_2 from Addition of Methanol	16,953	16,953	45.6%	11.0%
Process N_2O	798	798	2.1%	0.5%
Effluent Discharge N_2O	2,690	2,690	7.2%	1.7%
Sewer CH_4	0	12,793	34.4%	8.3%
Total Scope 1:	24,389	37,183	100.0%	24.1%
Scope 2				
Total Scope 2:	117,174	117,174	NA	75.9%
Totals of Scopes 1 and 2				
Total Scopes 1 and 2:	141,563	154,356	NA	100.0%

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EIA Data for US National GHG Emissions

Develope
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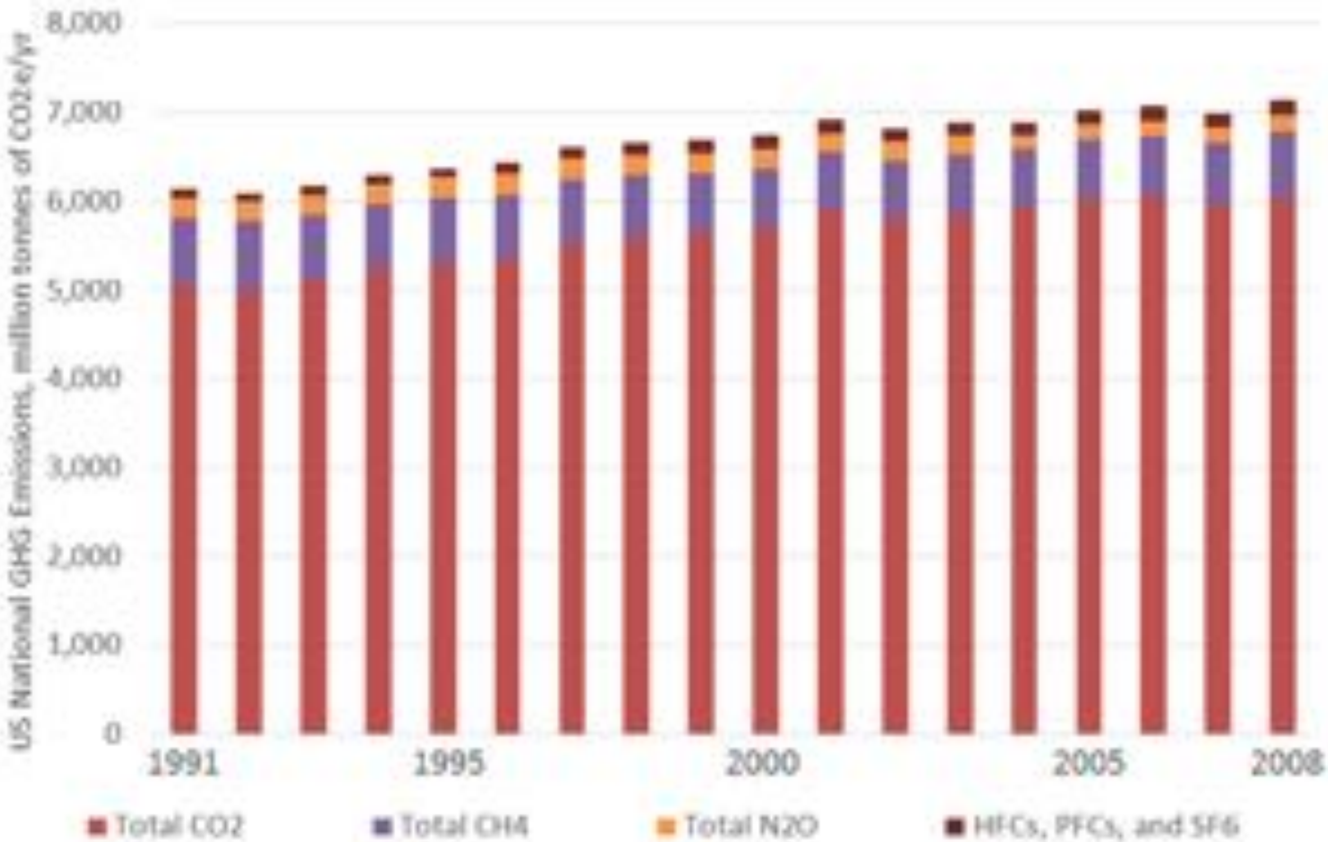
according
to IPCC,
2006



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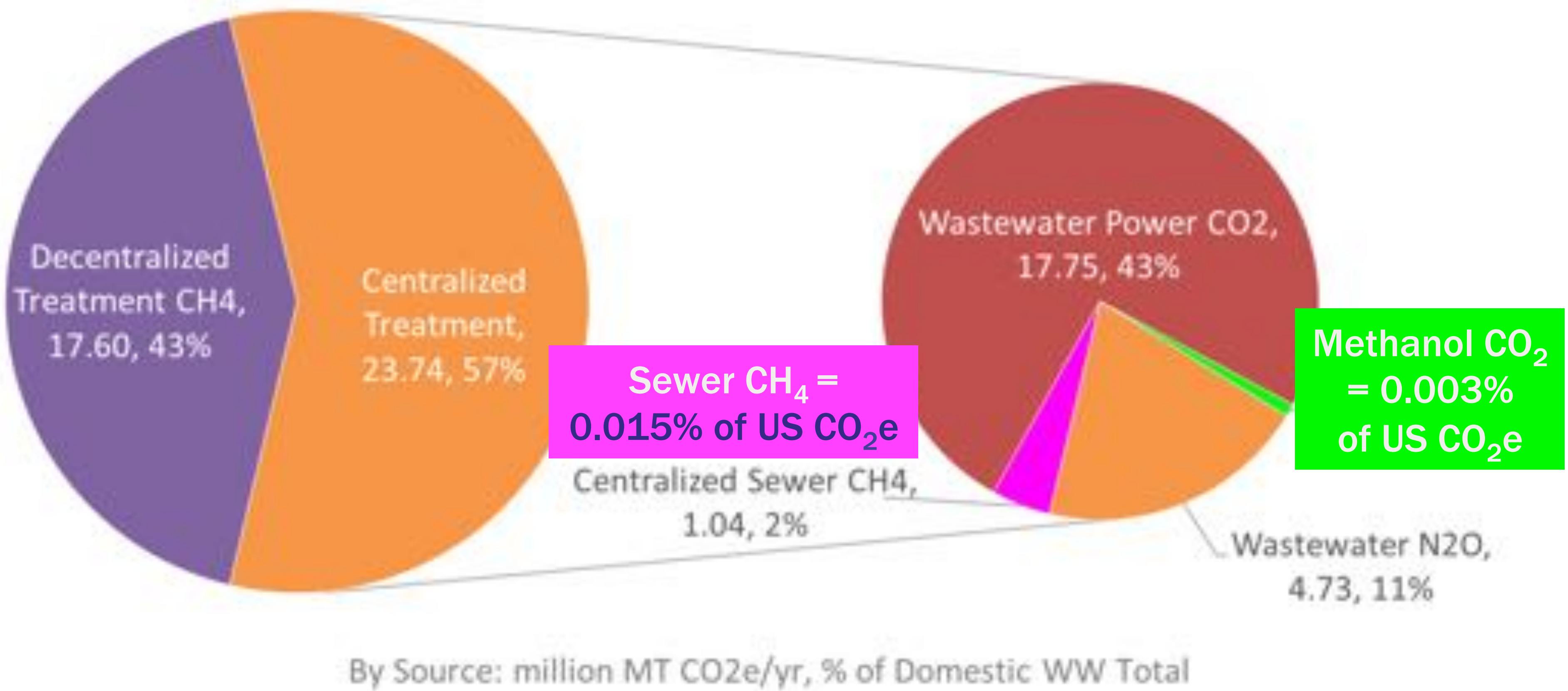
US Domestic WW GHG Emissions by %



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Conclusions

- Biosolids programs can have a significant, positive effect on a resource recovery facility carbon footprint
- Tracking our carbon footprint can help develop tools to make wise changes within our processes and practices
- Methanol use and sewer methane emissions are potentially big contributors to our footprint, but overall are a very small percentage of the US CO_2e emissions
- We should strive toward acceptance of land app in national and international models

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